PANIMALAR ENGINEERING COLLEGE

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

QUESTION BANK

SEVENTH SEMESTER (2017-2018)

BLOOM'S TAXONOMY LEVELS (BTL)

Level 1 – Remembering (R)

Level 2 – Understanding (U)

Level 3 – Applying (A)

Level 4 – Analyzing (AZ)

Level 5 – Evaluating (E)

Level 6 – Creating (C)

EC6701 -RF AND MICROWAVE ENGINEERING

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UNIT: 1 TWO PORT RF NETWORK THEORY

PART A

1. Define microwave. **(R)**

Microwaves are *electromagnetic waves (EM)* with wavelength ranging from *1cm to 1mm.* The corresponding frequency range is *1 GHz* (=10^9 Hz) *to 300GHz* (=10^{11}Hz). Therefore signals, because of their inherently high frequencies, have relatively short wavelengths, hence the name "micro" waves.

2. What are the major bands available in microwave frequencies? **(R)**

The microwave frequencies span the following three major bands at the highest end of RF spectrum.

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

3. Describe IEEE microwave frequency bands. **(R)**

Frequency	Microwave band designation
3-30MHz	HF
30-300MHz	VHF
0.3-1GHz	UHF
1-2GHz	L
2-4GHz	S
4-8GHz	C
8-12GHz	X
12-18GHz	Ku
18-27GHz	K
27-40GHz	Ka
40-300GHz	Millimeter
>300GHz	SubMillimeter

4. Enumerate the basic advantage of microwaves. **(R)**

- Fewer repeaters are necessary for amplification.
- Minimal cross talk exists between voice channels.
- Increased reliability and less maintenance are important factors.
- Increased bandwidth availability

5.Write the applications of microwaves. **(R)**

- Microwave becomes a very powerful tool in microwave radio spectroscopy for analysis.

- Microwave landing system (MLS), used to guide aircraft to land safety at airports.
- Special microwave equipment known as diathermy machines are used in medicine for heating body muscles and tissues without hurting the skin.
- Microwave ovens are a common appliance in most kitchens today.

6. Define scattering matrix. **(R)**

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

7. What are scattering coefficients? **(R)**

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

8.Why, the S- parameters are used in microwaves? **(U)**

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 network.
- 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 analyzed using scattering (or) S parameters which linealy relate the reflected wave's amplitude with those of incident waves.

9. Write the properties of [S] matrix. **(R)**

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

10.Write the unitary property for a lossless junction. **(R)**

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

11. Define two-port network. **(R)**

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

12.State the reciprocity theorem. **(R)**

The theorem state that when some amount of electromotive force (or voltage) is applied at one point (e.g., in branch k, v_k) in a passive linear network,

that will produce the current at any other point (e.g., branch m, i_m). The same amount of current (in branch k, i_k) is produced when the same electromotive force (or voltage) is applied in the new location (branchm, v_m); that is

$$V_k/i_m = v_m/i_k$$

13. Define lossless network. **(R)**

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.

14) What is the zero property of S-matrix? **(R)**

It states that, "for a passive lossless N-port network, the sum of the products of each term of any row or any column multiplied by the complex conjugate of the corresponding terms of any other row or column is zero".

15. Write the unitary property for a lossless junction. **(R)**

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

16. Define non-reciprocal devices. **(R)**

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

17.What is wire? (R)

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

18.Mention the many forms of wire. **(R)**

Wire in a circuit can takes on many forms,

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

19. Write about the skin effect in a wire. **(AZ)**

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

$$R=\rho l/A$$

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

20. Give a short note on straight-wire Inductance in wire. **(R)**

In the wire medium, surrounding any current carrying conductor, there exists a magnetic field. If the current (I) is AC, this magnetic field is alternately expanding and contracting. This produces an induced voltage in the wire that opposes any change in the current flow. This opposition to change is called "self inductance".

21. Define a resistor. **(R)**

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

22.Mention the purpose of resistors. **(R)**

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.

23.Name the types of resistors. **(R)**

Types of resistors:

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

24. What do you meant by capacitors? **(R)**

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

25. Define Quality-factor (Q) of Capacitor. **(R)**

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".

26. What is an Inductor? **(R)**

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

27. Write the applications of inductors. **(R)**

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

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

UNIT-1 PART B

1. Explain in detail about low frequency parameters. **(AZ)**
2. How microwave junction can be described by scattering matrix. Derive the scattering matrix relation between the input and output of an nxn junction? **(AZ)**
3. Discuss about various losses available in microwave? **(U)**
4. Explain the symmetry property in a reciprocal network. **(AZ)**
5. Explain the unitary property in a lossless junction. **(AZ)**
6. Explain the transmission matrix for 2-port networks. **(AZ)**
7. State and explain the properties of S-parameters. **(AZ)**
8. Draw the high frequency equivalent of resistors, Inductors and capacitors and explain. **(U)**
9. Obtain the relation between [S] , [Z] and [Y] matrix. **(E)**
10. The S parameters of a two port network is given by
    $S_{11} = 0.2\angle 90°$, $S_{12} = 0.5\angle 90°$, $S_{21}=0.5\angle 0°$, $S_{22}=0.2\angle 90°$
    i) Determine whether the network is lossy or not
    ii) Is the network is symmetrical and reciprocal? Find the insertion loss of a network. **(E)**
11. The impedance matrix of a certain lumped network is given by
    $Z_{11} = 4$, $Z_{12} = 2$, $Z_{21} = 2$, $Z_{22} = 4$. Find the S matrix. **(AZ)**
12. Evaluate the S parameters from the Z parameters.
    $Z_{11} = 2+3j$, $Z_{12} = 5j$, $Z_{21} = 3j$, $Z_{22} = -j$, $Z_o = 50$ohms **(AZ)**
13. Given $Y_{11} = 3.1$, $Y_{12} = 1$, $Y_{21} = 1$, $Y_{22} = 3.2$. Find the S matrix **(E)**

UNIT-2

RF AMPLIFIERS AND MATCHING NETWORKS

PART A

1) Write the function of matching networks? **(R)**

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

2) What is function of input and output matching networks? **(R)**

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? **(R)**

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. **(R)**

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

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

5) Define unilateral power gain. **(R)**

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

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

The available power gain for load side matching ($T_L = T^*_{out}$)is given as,

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

7) Define Operating Power Gain. **(R)**

The operating power gain is defined as "the ratio of power delivered to the load to the power supplied to the amplifier".

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

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

i. If |T|>1, then the magnitude of the return voltage wave increases called *positive feedback*, which causes instability (oscillator).
ii. If |T|<1, then the return voltage wave is totally avoided (amplifier). It's called as *negative feedback.*

9) Define unconditional stability. **(R)**

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

10) Define noise figure. **(R)**

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

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

11) Define Unilateral figure of merit. **(R)**

$$U = \frac{|S_{12}||S_{21}||S_{22}||S_{11}|}{(1-|S_{11}|^2)(1-|S_{22}|^2)}$$

This figure of merit should be as small as possible.

UNIT-2 PART B

1. Discuss various aspects of amplifier-power relations' for RF transistor amplifier design. **(AZ)**
2. Explain stability considerations for RF transistor amplifier design. **(AZ)**
3. Explain various stabilization methods. **(AZ)**
4. Discuss gain considerations for RF amplifier. **(E)**
5. Write short notes on Microstrip line matching network. **(E)**
6. Explain in detail about T and Pi matching network. **(AZ)**
7. Find the noise figure expression of a multistage amplifier. **(AZ)**
8. A MESFET operated at 5.7 GHz has the following S parameters
   $S_{11} = 0.5\angle{-60°}$, $S_{12} = 0.02\angle{0°}$, $S_{21}=6.5\angle{115°}$, $S_{22}=0.6\angle{-35°}$
   Verify the circuit, whether it is unconditionally stable or not. **(E)**

UNIT-3

PASSIVE AND ACTIVE MICROWAVE DEVICES

PART A

1. Define a microwave junction. **(R)**

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

2. What is termination and mention its application. **(R)**

Terminations are used in coaxial line, strip lines and waveguides to absorb the incident power without appreciable reflection and radiation.

3. What is attenuator? **(R)**

Attenuators are passive device used to control power levels in a microwave system by partially absorbing the transmitted signal.

4. Why is magic tee referred to as E-H tee? **(U)**

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

5. What is phase shifter? **(R)**

Phase shifter is a device which provides variable insertion phase in a microwave signal path without altering the physical path length.

6. What is power divider? **(R)**

A power divider is a device to split the input power into a smaller amounts of power at multiple ports (N) to feed N number of branching circuits with isolation between the output ports.

7. What is tuning screw? **(R)**

A tuning screw is used as a tuning device for impedance matching with waveguide components with a complex load Z_L on account of its shunt reactance.

8. What is PIN diode? **(R)**

A PIN diode consists of a high resistivity intrinsic semiconductor layer between two highly doped p+ and n+ semiconductor (Si, GaAs) layers. The device act as an electrically variable resistor related to the i layer thickness. It is used as microwave swich.

9.What is waveguide? **(R)**

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

10.What is H-plane Tee? **(R)**

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

11. What is E-plane Tee? **(R)**

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

12. Define tee junction. **(R)**

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

13. Name some uses of waveguide tees. **(R)**

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.

14.What are the types of waveguide tees? **(R)**

The two types of waveguide are

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

15.Define difference arm. **(R)**

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

16.What is sum arm? **(R)**

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

17.Write the applications of magic tee. **(R)**

A magic tee has several applications,

i. Measurement of impedance
ii. As duplexer
iii. As mixer
iv. As an isolator

18.What is hybrid ring? **(R)**

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

19. What do you meant by hybrid junction? **(R)**

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

20. Give a note on directional couplers. **(R)**

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

21.Define coupling factor(C). **(R)**

The coupling factor of a directional coupler is defined as the ratio of the incident power 'P_i' to the forward power 'P_f' measured in dB

$$\text{Coupling factor (dB)} = 10\log 10 P_i/P_f$$

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

22. Define directivity of directional coupler. **(R)**

The directivity of a directional coupler is defined as the ratio of forward power 'P_f' to the back power 'P_b' expressed in dB.

$$D\ (dB) = 10\log 10 P_f/P_b$$

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

23.What do you meant by isolation? **(R)**

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

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

Isolation (dB) equals coupling plus directivity.

24. Define Isolator. **(R)**

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

25. What is circulator? **(R)**

A circulator is a multiport junction in which the wave can travel from one port to next immediate port in one direction only. They are useful in parametric amplifiers, tunnel diode, amplifiers and duplexer in radar.

26.Write the characteristics of a three port tee junction. **(R)**

a) A short circuit may always be placed in one of the arms of a three port junction in such a way that no power can be transferred through the other two arms.
b) If the junction is symmetric about of its arms, a short circuit can always be placed in that arm so that no reflections occur in power transmission between the other two arms.
c) It is impossible for a general three port junction of arbitrary to present matched impedances at all three arms.

27.Mention the different types of directional couplers. **(R)**

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

28. Define non-reciprocal devices? **(R)**

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

29. What is circulator and Isolator **(R)**

A circulator is a multiport junction in which the wave can travel from one port to next immediate port in one direction only. They are useful in parametric amplifiers, tunnel diode, amplifiers and duplexer in radar.

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

30. Write the properties of ferrites. **(R)**

Properties of ferrites:

1. Ferrites possess strong magnetic properties.
2. Ferrites are most suitable for use in microwave device in order to reduce the reflected power.
3. Ferrites possess high resistivity, hence they can be used up to 100 GHz
4. Ferrites also exhibit non-reciprocal property.

31. Write the types of ferrite device. **(R)**

Types of ferrite device:

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

- Gyrator
- Isolator
- Circulator

32.What is gyrator? **(R)**

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

33.What do you meant by Faraday rotation? **(R)**

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

34. Define 4-port circulator. **(R)**

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

35. Derive the [S] matrix for 3 port circulator. **(R)**

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

$$[S] = \begin{matrix} 0 & 0 & S13 \\ S21 & 0 & 0 \\ 0 & S32 & 0 \end{matrix}$$

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

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

Therefore, [S]matrix for 3 port circulator is

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

36. Write the applications of circulator. **(R)**

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

37. Name some uses of isolators. **(U)**

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

38. Define Faraday rotation isolator. **(R)**

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

39. Define ferrites. **(R)**

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

40. Explain how a reverse biased pn junction exhibits a capacitor? **(U)**

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

41. Discuss how the capacitor varies with reverse bias voltage. **(A)**

The depletion region increases as reverse voltage applied to diode increases. Since capacitance varies inversely with dielectric thickness.
The junction capacitance will decrease as the voltage across pn junction increase.

42.What are the applications of varactor diode? **(R)**

i. The varactor diode is used in TV receivers, HFC circuit adjustable, band pass filters.
ii. Used in phase locked loop (PLL) and frequency locked loop (FLL).
iii. In frequency modulation.
iv. In high frequency multipliers.

43. Define varactor diode. **(R)**

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

44. What is transferred electron effect? **(R)**

Some materials like GaAs exhibit a negative differential mobility when biased above a threshold value of the electric field. The electrons in the lower – energy band will be transferred into the higher-energy band. The behavior is called transferred electron effect and the device is called transferred electron device or Gunn diode.

45. What is negative resistance in Gunn diode? **(R)**

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.

46.What are the various modes of operation of Gunn diode? **(R)**

1) Gunn oscillation mode.
2) Stable amplification mode.
3) LSA oscillation mode.
4) Bias circuit oscillation mode.

47. What are the elements that exhibit Gunn Effect? **(R)**

The elements are

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

48. Compare voltage and current controlled modes. **(U)**

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

49. What are the modes available in negative resistance device? **(R)**

Two modes are available in negative resistance devices. They are

- Voltage- controlled modes
- Current controlled modes

50.Write disadvantages of the source generation of solid-state microwave devices. **(R)**

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

51. Why Gunn diode amplifier is called travelling domain amplifier? **(U)**

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

52. Mention the applications of Gunn diode amplifier. **(R)**

Gunn diodes have been used in conjunction with circulator coupled

networks in the design of high level wideband transferred electron amplifiers that have a voltage gain bandwidth product in excess of 10dB for frequencies from 4 to about 16GHz.

53. Define Gunn oscillation mode. **(R)**

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

54. What is meant by stable amplification mode? (R)

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

55. Define LSA mode. **(R)**

This mode is defined in the region where the product of frequency time's length is about 10^7cm/s and the quotient of doping divided by frequency is between2 x 10^4 and 2 x 10^5.

56. Mention the name of domain modes available in Gunn oscillation mode. **(R)**

Transit-time domain mode ($f_L = 10^7$cm/s)
Delayed domain mode (10^6cm/s<f_L<10^7cm/s)
Quenched domain mode (f_L>2 x 10^7cm/s)

57. Define inhibited mode. **(R)**

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

58. Define avalanche transit time devices. **(R)**

Avalanche transit – time devices are p –n junction diode with the highly doped p and n regions. They could produce a negative resistance at microwave frequencies by using carrier impact ionization Avalanche breakdown and carriers drift in the high field intensity region under reverse biased condition.

59. What are modes available in avalanche device? **(R)**

There are three modes of avalanche device

(1) IMPATT – Impact Ionization Avalanche Transit Timed Device
(2) TRAPATT – Trapped Plasma Avalanche Triggered Transit Device and
(3) BARITT – Barrier Injected Transit Time Device.

60. What are the factors exhibit differential negative resistances in IMPATT? **(R)**

The IMPATT diodes exhibit a differential negative resistance by two effects.

(1)The impact ionization avalanche effect, which causes the carrier current I_0 (t) and the ac voltage to be out of phase by 90^0.
(2) The transit- time effect, which further delays the external current I_e(t) relative to the ac voltage by $90^{0.}$

61. Mention the disadvantage of IMPATT diodes. **(R)**

The major disadvantages of the IMPATT diodes are

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

(2)Tend to be noisy due to the avalanche process and to the high level of operating current. (3)A typical noise figure is 30dB which is worse than that of Gunn diodes.

62. Mention the applications of IMPATT diodes. **(R)**

a) Microwave generators
b) Modulated output oscillators
c) Receiver local oscillators
d) Parametric amplifier pumps
e) IMPATT diodes are also suitable for negative resistance amplification.

63. Write the classification of electronic circuits. **(R)**

Electronic circuits are broadly classified into three categories based on the circuit technology.

(1)Discrete circuit
(2)Integrated circuit
(3)Monolithic Microwave Integrated circuit (MMIC)

64. What do you meant by discrete circuit? **(R)**

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

65. Define IC. **(R)**

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

66. Write the classification of ICs. **(R)**

Due to components availability within chip, the integrated circuits are categorized as follows

- Small Scale Integration (SSI) circuit
- Medium Scale Integration (MSI) circuit
- Large Scale Integration(LSI) circuit
- Very Large Scale Integration (VLSI) circuit
- Ultra Large Scale Integration(ULSI) circuit

67. What are the advantages of MMICs over discrete circuits? **(R)**

MMICs offer the following advantage over discrete circuits

- Small in size& weight
- High reliability
- Improved reproducibility
- Improved performance
- Eventual cost reduction when produced in large quantities

68. Name the difference between MMICs and conventional ICs. **(R)**

MMICs are quire different from the conventional ICs

I. The conventional IC's contain very high packing densities; whereas the packing density of a MMIC is typically low.

II. Hybrid Integrated Circuit: An MMIC consists of two or more integrated circuit types together with discrete elements and is referred to as a hybrid integrated circuit

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

69. What are the applications of MMICs? **(R)**

- MMICs are currently being used for variety of applications including space and military because they meet the requirements for shock, temperature conditions and severe vibration.
- MMICs have been the advances in the development of microwave solid-state devices.

70. Name the circuits used in hybrid MMICs. **(R)**

Three general types of circuits can be utilized for hybrid MMICs

I.Distributed microstrip lines.

II. Lumped-element

III. Thin-film circuits

71. Mention the materials used in MMICs. **(R)**

The basic materials for monolithic microwave integrated circuits are broadly divided into four categories.

i. Substrate materials
ii. Conductor materials
iii. Dielectric materials
iv. Resistive materials

72. Define substrate. **(R)**

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

73. What are hybrid integrated circuits? **(R)**

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

74. What is called as film integrated circuit? **(R)**

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

75. Write the ideal characteristics of substrate material. **(R)**

The ideal characteristics of substrate material are,

- High dielectric constant
- Low dissipation factor or loss tangent.
- High purity and constant thickness.
- High surface smoothness High resistivity

- High thermal conductivity
- Dielectric strength.

76. Write the ideal characteristics of conductor material. **(R)**

The ideal characteristics of conductor material,

- High conductivity
- Low temperature coefficient of resistance
- Good adhesion to the substrate
- Good etch ability and solder ability
- Easily deposited or electroplated.

77. What is the need for dielectric materials? **(R)**

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

78. Mention some of the properties of dielectric materials. **(R)**

The properties of dielectric materials are,

i. Good re productivity
ii. Capability of handling high voltages
iii. Ability to undergo processes with developing pin holes
iv. Low RF dielectric loss.

79. What is the need of resistive materials? **(R)**

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

80. Write some of the properties of resistive materials

i. Good stability
ii. Low temperature coefficient of resistance
iii. Adequate dissipation capability
iv. Sheet resistivity's in the range of 10 to 1000ohm per square.

81. Why monolithic technology is not well suitable for microwave integrated circuits? **(U)**

Monolithic technology is not well suited for microwave integrated circuits because the processing difficulties, low yields and poor performance have seriously limited their applications.

82. Name the commonly used dielectric substrates for fabricating microstrip. **(R)**

The commonly used dielectric substrates for fabricating micro strip are Al_2O_3, SiO, SiO_2 Si_3N_4 and Ta_2O_5.

83. What are the different techniques used to fabricate MMIC? **(R)**

i. Diffusion and ion implantation
ii. Oxidation and film deposition
iii. Epitaxial growth
iv. Lithography
v. Etching and photo resist
vi. Deposition

84. What is the need of diffusion and ion-implantation? **(R)**

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

85. Write the advantages of ion-implantation method? **(R)**

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

86. Mention the group's thin films. **(R)**

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

87. Write the types of epitaxy. **(R)**

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

88. What is lithography? **(R)**

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

89. Name the different types of lithography. **(R)**

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

90. Write the difficulties of MMICs. **(R)**

1. Once MMICs fabricated, there is no provision for adjusting any device parameters such as tuning screws variable short etc.
2. Accurate design of circuit is complex.
3. Low value of Q, the high frequency stability are very difficult
4. Low power handling capacity than waveguides.

UNIT-3 PART B

1. Explain the operation of H-plane tee and E- plane tee and derive the S matrix for it. **(AZ)**
2. Explain the operation of Magic tee and derive the S matrix for it. **(AZ)**
3. Explain the operation of Directional coupler and derive its S parameter. **(AZ)**
4. Explain the operation of circulator. **(AZ)**
5. Explain the operation of isolator. **(AZ)**
6. Explain the operation of Attenuator. **(AZ)**
7. Explain the operation of phase shifter. **(AZ)**
8. Explain in detail about impedance matching devices. **(AZ)**
9. Explain the operation of power divider.**(AZ)**

10. Explain the operation of crystal diode and schottkey diode. **(AZ)**
11. Explain the operation of didode mixer. **(AZ)**
12. Explain the operation of PIN diode switch. **(AZ)**
13. Explain the construction and working of varactor diode with neat diagram. **(AZ)**
14. Explain in detail about Gunn diode with neat diagram using RHW theory **(AZ)**
15. Describe the modes of operation for Gunn diode? **(AZ)**
16. What are avalanche transit time device? Explain the operation, construction and applications of IMPATT. **(AZ)**
17. Explain the fabrication techniques of a monolithic microwave integrated circuit. **(U)**
18. List out the basic materials required for the manufactured of MMIC. (R)
19. 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 matched impedance. The auxiliary output readings are 450mWatts and 0.710µwatts. **(E)**
20. A 6dB attenuator is specified as having a VSWR of 1.2. Assuming that the device is reciprocal, find the S parameters. **(AZ)**
21. A directional coupler is having coupling factor of 20dB and directivity of 40dB. If the incident power is 100mW, what is the coupled power? **(E)**
22. Power at the input port is 900mw. If this power is incident on a 20 dB coupler with directivity of 40dB, What is the coupled power and transmitted power. **(E)**
23. What are the S parameters of the rotary type attenuator with rotation angle of 30°. **(AZ)**

UNIT-4

MICROWAVE GENERATION

PART A

1) What is transit time? **(R)**

The time taken by an electron to travel from the cathode to the anode plate of an electron tube is known as transit time

2) Write the classification of microwave tubes. **(R)**

They are classified into two types

1) O – type microwave tube or linear beam
2) M – type microwave tube

3) Name the two configuration of klystron. **(R)**

There are two basic configurations of Klystron tubes

1) Reflex Klystron – It is used as low power microwave oscillator
2) Two cavity (or) Multicavity Klystron – It is used as low power microwave amplifier.

4) What is drift space? **(R)**

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

5) Define velocity modulation. **(R)**

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

6) Define bunching. **(R)**

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 cycles of gap voltage undergo an decrease in velocity, As a result of these, electron bunch together in drift space. This is called bunching.

7) State the power gain, power output and efficiency of two – cavity klystron amplifier. **(R)**

a. EFFICIENCY: about 40%
b. POWER OUTPUT: Average power is up to 500KW and pulsed power is up to 30 MW at 10GHz
c. POWER GAIN: about 30 dB.

8) Why the output cavity is called as catcher cavity? **(U)**

The output cavity catches energy from the bunched electron beam. Therefore, it also called as catcher cavity.

9) Mention the application of two – cavity klystron. **(R)**

a. Used in Troposphere scatter transmitters.
b. Satellite communication ground stations.
c. Used in UHF TV transmitters.
d. Rader transmitters.

10) Define electronic efficiency of a klystron amplifier. **(R)**

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

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

11) Define reflex klystron. **(R)**

The reflex klystron is an oscillator with a built in feedback mechanism. It uses the cavity for bunching and for the output cavity.

12) What do you meant by apple gate diagram? **(U)**

The electrons passing through the buncher grids are accelerated / retarded / passed through with unchanged initial dc velocity depending upon when they encounter the RF signal field at the buncher cavity gap at positive / negative / zero crossing phase of the cycle, respectively, as shown by distance-time plot. This is called the apple gate diagram.

13) Mention the same characteristics of reflex klystrons. **(R)**

- Frequencyrange:1 to 25GHz
- Power output: It is a low-power generator of 10 to 500mW
- Efficiency: About 20 to 3o%

14) State the applications of reflex klystrons. **(R)**

1. This type is widely used in the laboratory for microwave measurements.
2. In microwave receivers as local oscillators in commercial and military applications.
3. Also plays a role in airborne Doppler radars as well as missiles.

15) Write a short note on **(R)**

i. O – type tubes and
ii. M – type tubes.

O – type tubes:

Klystrons ant TWTs are liner beam tubes in which the accelerating electric field is in the same direction as the static magnetic field used to focus the electron beam. Here the electron beam travel in a straight line.

M – type tubes:

Magnetrons are crossed field devices where the static magnetic field is perpendicular to the electric field. In this tube, the electrons beam travel in a curved path.

16) Define electronic efficiency of a reflex klystron oscillator. **(R)**

The electronic efficiency of a reflex klystron oscillator is defined as

$$\text{Effieciency} = P_{ac} / P_{dc}$$

17) What is meant by microwave resonators? **(R)**

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

18) Define resonant frequency. **(R)**

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

$f_r = 2W_e$ or $2W_m$

19) What are drawbacks available in klystrons?

i. Klystrons are essentially narrowband devices.

ii. In klystrons and magnetrons, the microwave circuit consists of a resonant structure which limits the bandwidth of the tube.

20) What is TWTA? **(R)**

A traveling wave tube amplifier (TWTA) circuit uses a helix slow – wave non resonant microwave guiding structure. It is a broadband device.

21) What is the need of slow – wave structures? **(R)**

Slow – wave structures are special circuits that are used in microwave tubes to reduce the wave velocity in a certain direction so that the electron beam and the signal wave can interact.

22) Give the comparison between TWTA and klystron amplifier. **(U)**

Comparison between TWTA and klystron amplifier is,

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

23) What are the characteristics of TWT **(R)**

Frequency range	3GHz and higher
Bandwidth	about 0.8GHz
Efficiency	20 to 40%
Power output	up to 10kW average
Power gain	Up to 60 dB

24) Write the applications of TWT **(R)**

- Medium power satellite
- Higher power satellite transponder output
- Radar transmitters

25) What are the advantages of TWT? **(R)**

- Bandwidth is large
- High reliability
- Hig h gain
- Higher duty cycle

26) What is the use of attenuator in TWT? **(R)**

Attenuator is used to prevent oscillations.

27) Name four types of slow wave structures. **(R)**

- Helical line
- Folded back line
- Inter digital line
- Zigzag line

28) Why magnetron is called as cross field devices? **(U)**

In a magnetron, the dc magnetic field and dc electric field are perpendicular to each other and hence magnetron is called as a cross field device.

29) What are the types of magnetron? **(R)**

There are three types of magnetrons:

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

30) Write short notes on negative resistance magnetron. **(U)**

Negative – resistance magnetrons ordinarily operate at frequencies below the microwave region. This type of magnetron uses a static negative resistance between two anode segments but has low efficiency and is useful only at low frequencies.

31)Write the different configurations available in traveling wave magnetrons. **(R)**

a) Cylindrical magnetron
b) Linear magnetron
c) Coaxial magnetron
d) Voltage – tunable magnetron
e) Inverted coaxial magnetron
f) Frequency-agile magnetron

32) Write short notes on Coaxial magnetron & Voltage – tunable magnetron **(U)**

a)Coaxial magnetron:

The coaxial magnetron is composed of an anode resonator structure surrounded by an inner – single, high-Q cavity operating in the TE_{011}.

b) Voltage tunable magnetron:

The voltage tunable magnetron is a broadband oscillator with frequency changed by varying the applied voltage between the anode and sole.

33) State the characteristics of coaxial magnetron. **(R)**

i. Minimum peak power of 400kW at a frequency range from 8.9 to 9.6GHz.
ii. Its duty cycle is 0.0013.
iii. Nominal anode voltage is 32kV.
iv. Peak anode current is 32A.

34) State the power output and efficiency of magnetron. **(R)**

a. A magnetron can deliver a peak power output of up to 40MW with the dc voltage of 50KV at 10GHz.
b. The average power output is 800KW.

c. The magnetron possesses a very high efficiency ranging from 40 to 70%.
d. Magnetrons are commercially available for peak power output from 3KW and higher.

35)Write the applications of magnetron. **(R)**

The magnetron are widely used on,

- Radar transmitters
- Industrial heating
- Microwave ovens.

36) What is π - mode of operation? **(R)**

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

$$\varphi = \pi$$

37) What is the formula for cyclotron angular frequency? **(R)**

$$\omega_c = eB / m$$

Where,

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

38) What is Amplitron? **(R)**

The trade name of the Backward-wave crossed field amplifier is Amplitron.

39) What is CARCINOTRON? **(R)**

The backward wave crossed field oscillator is CARCINOTRON.

40) What are the limitations of conventional vaccum tubes? **(R)**

a) Lead inductances
b) inter electrode capacitance effects
c) Transit angle effects
d) Gain bandwidth product limitation

UNIT-4 PART B

1. Explain the operation and derive an expression for the efficiency of a two cavity klystron amplifier. **(AZ)**
2. Draw and explain the operation of Reflex klystron oscillator. **(AZ)**
3. Explain the working of a TWT amplifier with neat sketch. **(AZ)**
4. Explain the construction and working of cylindrical magnetron and derive Hull – cutoff condition. **(AZ)**
5. Explain the construction and working of Linear Magnetron. **(AZ)**
6. Explain the operation of backward-wave crossed field amplifier. **(U)**
7. Explain the operation of backward-wave crossed field oscillator. **(U)**
8. An X band pulsed cylindrical magnetron has the following parameters Anode voltage V_o = 26kV, Beam Current I_o = 27A, Magnetic Flux

density B_o = 0.336Wb/m^2, Radius of cathode cylinder a = 5cm, Radius of vane edge to center b = 10cm, Determine cyclotron angular frequency, cut off voltage for a fixed B_o and cut off magnetic density for a fixed V_o **(AZ)**

9. A two cavity klystron has the following parameters V_o = 1000v, R_o= 40kohms, I_o= 25mA, f = 3GHz, Gap spacing in either cavity (d) = 1mm, Spacing between two cavities L = 4 cm, Effective shunt impedance R_{th} = 30kohms. Calculate input gap voltage, voltage gain and efficiency. **(AZ)**

UNIT-5

MICROWAVE MEASUREMENTS

PART A

1. What is VSWR meter? **(R)**

A VSWR meter is a sensitive high gain, high Q, low noise voltage amplifier tuned normally at a fixed frequency of 1 KHz at which the microwave signal is modulated. The input of the VSWR meter is the detected signal output of the microwave detector and the output of the amplifier is measured with a square –law calibrated voltmeter which directly gives the VSWR reading V_{max}/V_{min} for an input of V_{min}, after the meter is adjusted to unity VSWR for an input corresponding to V_{max}.

2. What do you meant by slotted line? **(U)**

Slotted line is a fundamental tool for microwave measurements. Slotted line consists of a section of waveguide or coaxial line with a longitudinal slot. The slot is roughly 1mm wide and allows an electric field probe to enter the waveguide for measurement of the relative magnitude of field at location of the probe.

3. Name two methods to measure impedance. **(R)**

Slotted line
Reflecto meter

4. Define power. **(R)**

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

5. What are the methods to detect microwave power? **(R)**

a. Bolometer
b. Calorimeter method

6. Define microwave sensor. **(R)**

The microwave power meter consists of a power sensor, which converts the microwave power into heat energy. The corresponding temperature rise provides a change in the electrical parameters resulting in an output current in low frequency circuitry and indicates the power.

7. Mention the sensors used for microwave power measurements. **(R)**

The sensors used for microwave power measurements are the schottky barrier diode, bolometer and the thermocouples whose resistance changes with the applied power.

8. Define bolometer. **(R)**

A bolometer is a power sensor whose resistance changes with temperature as it absorbs microwave power. The types of bolometer are, the barretter and the thermistor.

9. What are drawbacks of using power meter with single bridge? **(R)**

a) The change of resistance due to a mismatch at the microwave input port results in incorrect reading

a) The thermistor is sensitive to changes in the ambient temperature resulting in false reading.

10. What do you meant by thermocouple sensor? **(R)**

A thermocouple sensor is a junction of two dissimilar metals or semiconductors. It generates an emf when two ends are heated up differently by absorption of microwaves in a thin film tantalum – nitride resistive load deposited on a Si substrate which forms one electrode of the thermocouple. This emf is proportional to the incident microwave power to be measured.

11. Name the method used for high power microwave measurements. **(R)**

High power microwave measurements can be conveniently done by the calorimetric method which involves conversion of the microwave energy into heat, absorbing this heat in a fluid and then measuring the temperature rise of the fluid.

12. What is calorimetric direct heating method? **(R)**

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

13. What is calorimetric indirect heating method? **(R)**

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

14. Mention the drawbacks in calorimeter measurements.**(U)**

The main disadvantage in calorimeter measurements are the thermal inertia caused by the lag between the application of microwave power and the parameter readings.

15. What are the classifications of power measurements? **(A)**

The classifications of power measurements are

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

16. Distinguish between thermistor and barretter? **(U)**

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

17. What is spectrum analyzer? **(R)**

A Spectrum analyzer is a broadband superheat receiver which provides a plot of amplitude versus frequency of the received signal.

18. What is network analyzer? **(R)**

A network analyzer measures both amplitude and phase of a signal over a wide frequency range within a reasonable time.

19. What is wave meter? **(R)**

Wave meter is a cylindrical cavity with a variable short circuit termination which changes the resonance frequency of the cavity by changing the cavity length. It is used to measure the microwave frequency.

20. Mention the different types of dielectric constant measurement. **(R)**

There are two types to measure dielectric constant. Wave guide method and cavity perturbation method.

21. Distinguish between low frequency measurements and microwave measurements. **(U)**

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

22. What is the significance of VSWR measurement? **(U)**

VSWR and the magnitude of voltage reflection coefficient are very important parameters which determines the degree of impedance matching

UNIT-5 PART B

1. Explain the operation of Network analyzer. **(AZ)**
2. Explain the operation of spectrum analyzer. **(A)**
3. Write short notes on
   a. Low VSWR
   b. High VSWR measurements **(AZ)**
4. Explain the attenuation loss measurement with neat diagram? **(AZ)**
5. Explain the methods of measuring dielectric constant. **(AZ)**

6. Explain the methods of measuring S parameters. **(AZ)**
7. Explain about power meter using double bridge? **(AZ)**
8. Explain high power measurements by calorimetric method? **(AZ)**
9. Explain the method of measuring impedance of a given load, with suitable diagram? **(E)**
10. Explain about frequency measurement with neat diagrams. **(E)**
11. Explain the methods to measure Q factor. **(A)**
12. Calculate the SWR of a transmission system operating at 10GHz. Assume TE_{10} wave transmissions inside a wave guide of dimensions a = 4 cm, b = 2.5 cm. The distance measured between twice minimum power points = 1 mm on a slotted line. Repeat the above problem for various distance and compare the results. **(C)**
13. Mention the possible errors in the VSWR measurements **(E)**

ASSIGNMENTS

ASSIGNMENT – 1 [UNIT I]

1. Find the S matrix of a length *l* of a lossless transmission line terminated by matched impedance. **(C)**
2. A shunt impedance Z is connected across a transmission line with characteristic impedance Z_0. Find the S matrix of the junction. **(E)**
3. A series reactance Z = jX is connected between two lines with different characteristic impedance Z_1 and Z_2. Fine the S matrix of the junction. **(E)**
4. A series reactance Z = jX is inserted in a infinite length transmission line of characteristic impedance Z_0. Find the S parameter for the junction. Prove that S matrix is unitary. **(E)**
5. a) If a lossless two port network is reciprocal, show that $|S_{21}|^2 = 1 - |S_{11}|^2$ **(AZ)**

   b)If a lossless two port network is non reciprocal, show that it is impossible to have unidirectional transmission, where $S_{12} = 0$ and $S_{21} \neq 0$. **(AZ)**
6. A reciprocal two port microwave device has a VSWR of 1.5 and an insertion loss of 2 dB. Find the magnitudes of S parameters of the device. **(A)**
7. Find the Z parameters of the two port T network. **(E)**
8. Find the ABCD parameters of a two port network consisting of a series impedance Z between ports 1 & 2. **(E)**
9. Show that the admittance matrix of a lossless N port network has purely imaginary elements. **(A)**
10. Does a non reciprocal lossless network always have a purely imaginary impedance matrix. **(A)**
11. The scattering parameters of a certain two port network were measured to be S_{11}= 0.3+j0.7, S_{12}=S_{21}, S_{22} = 0.3-j0.7. Find the impedance parameters for this network, if the characteristic impedance is 50Ω **(A)**

ASSIGNMENT – 2 [UNIT II]

1. 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 V_s =5V∟0° and source impedance Z_s = 40 Ω. The output is utilized to drive an antenna, which has a impedance of Z_L = 73 Ω. Assuming that the S parameters of the amplifier are measured with reference to a Z_0 = 50 Ω characteristic impedance. Find the following quantities: Transducer gain G_T, Unilateral transducer gain G_{TU}, Available gain G_A, Operating power gain G, Power delivered to the load P_L, available power from the source P_A, and incident power to the amplifier P_{inc} **(E)**
2. Derive the stability factor k. **(C)**
3. Using the transistor BFG505W operated at f = 750MHz with S parameters as S_{11} = 0.56∟-78°, S_{21} = 0.05∟33°, S_{12} = 8.64∟122°, S_{22}=0.66∟-42°, attempt to stabilize the transistor by finding a series resistor or shunt conductance for the input and output ports. **(AZ)**
4. Find the expression for the center and radius of constant gain circles. **(E)**
5. Derive the matched source reflection coefficient expression. **(AZ)**
6. A MESFET operated at 5.7GHz has the following S parameters. S_{11} = 0.5∟-60°, S_{21} =6.5∟115°, S_{12} = 0.02∟0°, S_{22}=0.6∟-35°. a) Determine if the circuit is unconditionally stab le. b) Find the maximum power gain under optimal choice of reflection coefficient, assuming unilateral design (S_{21}= 0) **(AZ)**
7. A BJT with Ic = 10mA, VCE = 6V is operated at a frequency of f = 2.4GHz. The corresponding S parameters are S_{11} = 0.3∟30°, S_{21} = 2.5∟-80°, S_{12} = 0.2∟-60°, S_{22}=0.2∟-15°. Determine whether the transistor is unconditionally stable and find the values for source and load reflection coefficient that provide maximum gain. **(AZ)**
8. Prove that $|S_{11} - S_{22}^{*}\Delta|^2 = |S_{12}S_{21}|^2 + (1-|S_{11}|^2)\,(|S_{22}|^2-|\Delta|^2)$. (AZ)
9. The S parameters for a BJT at a particular bias point and operating frequency are as follows. S_{11} = 0.6∟157°, S_{21} = 2.18∟61°, S_{12} = 0.09∟77°, S_{22}=0.47∟-29°. Check the transistor stability, stabilize it if necessary, and design an amplifier for maximum gain. **(C)**
10. A small signal BJT amplifier operated at 4 GHz is appropriately biased and has the following S parameters. S_{11} = 0.57∟-150°, S_{21} = 2.0∟56°, S_{12} = 0.12∟45°, S_{22}=0.35∟-85°. If a unilateral design approach is pursued, estimate the transducer gain error involved. **(E)**

11. Design a microwave amplifier using a GaAs FET whose S parameters at f = 10GHz are S_{11} = 0.79∟100°, S_{21} = 6.5∟-73°, S_{12} = 0.2∟-21°, S_{22}=0.74∟152°. For a constant $VSWR_{in}$ = 6.5, find the transducer gain that results in lowest $VSWR_{out}$. **(C)**

12. A transistor has the following S parameters. S_{11} = 0.61∟152°, S_{21} = 1.89∟55°, S_{12} = 0.1∟79°, S_{22}=0.47∟-30°. Design an amplifier for minimum noise figure if F_{min} = 3dB,
Γ_{opt} = 0.52∟-153° and R_n = 9Ω. **(C)**

ASSIGNMENT – 3 [UNIT III]

1. Show that using S matrix a lossless non reciprocal two port microwave device cannot be constructed. **(E)**

2. Prove that it is impossible to construct a perfectly matched, lossless, reciprocal three port junction. **(E)**

3. A matched isolator has insertion loss of 0.5dB and isolation of 25dB. find the scattering coefficients. **(A)**

4. The input power to a lossless matched directional coupler is 100mw. If the coupling coefficient is 20dB and directivity is 30dB. Find the output power at the other ports. **(AZ)**

5. A three port circulator has an insertion loss of 1dB, an isolation of 20dB, and a VSWR of 1.2. Find the output power at ports 2 and 3 for an input power of 100mw at port 1. **(AZ)**

6. A varactor diode has the junction capacitance 0.5pF with V=0, the barrier potential 1.1 V and n = 0.3. Calculate the junction capacitance and cut off frequency for a reverse voltage of 0.8V, if the substrate resistance Rs = 0.7 resistance R_s = 0.7Ω. **(AZ)**

7. A GaAs Gunn diode has a drift length of 10µm. Determine the intrinsic frequency of the diode oscillation (v_d= 10^7cm/s). **(AZ)**

8. The drift velocity of electron is $2*10^7$cm/s through the active region of length $10*10^{-4}$cm. Calculate the natural frequency of the diode and critical voltage. **(E)**

9. Design the width of the i-region for an Si Read diode for operation at 10GHz. **(E)**

10. An IMPATT diode has a drift length of 2µm. Determine the drift time of the carriers and the operating frequency. **(E)**

11. Design a quarter wave matching transformer to convert the 50Ω impedance of the output lines to 30Ω. Determine the magnitude of the S parameters for this circuit, using a 30Ω terminating impedance. **(C)**

12. Explain why the Gunn diode in not a high power and/or high efficiency mode. **(C)**

13. IMPATT diodes may fail to operate if proper heat sink are not provided- Explain. **(C)**

ASSIGNMENT – 4 [UNIT IV]

1. A two cavity klystron amplifier has the following parameters: V_0 = 1000 V, R_0 = 40kΩ, I_0 = 25mA, f = 3GHz, Gap spacing in either cavity d = 1mm, Spacing between the two cavities L = 4cm, Effective shunt impedance, excluding beam loading R_{sh} = 30kΩ. a) Find the input gap voltage to give maximum voltage V2, b) Find the voltage gain, neglecting the beam loading in the output cavity, c) Find the efficiency of the amplifier, neglecting beam loading, d) Calculate the beam loading conductance and show that neglecting it was justified in the preceding calculations. **(E)**

2. A A two cavity klystron amplifier has the following parameters: Beam voltage V_0 = 20kV, Beam current I_0 = 2A, f = 8GHz, Beam coupling coefficient $\beta_0=\beta_i$ = 1, dc electron beam current density ρ0 = 10^{-6} c/m^3, signal voltage V_1 = 10V(rms), shunt resistance of the cavity R_{sh} = 10kΩ, total shunt resistance including load R= 30kΩ. Calculate the plasma frequency, the reduced plasma frequency for R = 0.5, induced current in the output cavity, induced voltage in the output cavity, output power delivered to the load, power gain and electronic efficiency. **(E)**

3. A reflex klystron operates under the following conditions: V_0 = 600V, L = 1mm, R_{sh} = 15kΩ, f_r = 9GHz. The tube is oscillating at f_r at the peak of the n = 2 mode or 1 3/4 mode. Assuming that the transit time through the gap and beam loading can be neglected. Find the value of the repeller voltage V_r, Find the direct current necessary to give a microwave gap voltage of 200V, what is the electronic efficiency under this condition? **(C)**

4. A linear magnetron has the following operating parameters: Anode voltage V_0 = 10kV, cathode current I_0 = 1A, Magnetic flux density B_0 = 0.01Wb/m^2, Distance between cathode and anode d = 5cm. Compute the

Hull cutoff voltage for fixed B_0, the Hull magnetic flux density for a fixed V_0. **(E)**

5. An Amplitron has the following operating parameters: Anode voltage V_0 = 15kV, Anode current I_0 = 1A, Magnetic flux density B_0 = 0.2Wb/m^2, operating frequency f = 8GHz, characteristic impedance Z_0 = 50Ω. Determine the dc electron beam velocity, electron beam phase constant, cyclotron angular frequency, cyclotron phase constant, gain parameter. **(AZ)**
6. A circular carcinotron has the operating parameters: Anode voltage V_0 = 20kV, Anode current I_0 = 3.5A, Magnetic flux density B_0 = 0.3Wb/m^2, operating frequency f = 8GHz, characteristic impedance Z_0 = 50Ω, D factor D = 0.8, b factor b = 0.5. Compute the dc electron velocity, electron beam phase constant, delta differentials, propagation constants, oscillation condition. **(AZ)**
7. A helix travelling wave tube operates at 4GHz under a beam voltage of 10kV and beam current of 500mA. If the helix impedance is 25Ω and the interaction length is 20cm, Find the output power gain in dB. **(E)**
8. A TWT operates under the following parameters: beam voltage V_0 = 3kV and beam current I_0 = 30mA, characteristic impedance of helix Z_0 = 10Ω, circuit length N = 50, operating frequency f = 10GHz. Determine the gain parameter C, the output power gain A_p (dB) and all four propagation constant. **(AZ)**
9. The CFA operates under the following parameters: Anode dc voltage V_{ao} = 2kV, Anode dc current I_{ao} = 1.5A, Electronic efficiency η_e = 20%, RF input power P_{in} = 80w. Calculate the induced RF power, total RF output power, power gain in dB. **(AZ)**
10. A pulsed cylindrical magnetron is operated with the following parameters: Anode voltage 25kV, Beam current 25A, Magnetic density 0.34Wb/m^2, radius of the cathode cylinder 5cm, radius of the anode cylinder 10cm. calculate the angular frequency, cut off voltage and cut off magnetic flux density. **(AZ)**

ASSIGNMENT – 5 [UNIT V]

1. The signal power at the input of a device is 10mw. The signal power at the output of the same device is 0.20mw. Calculate the insertion loss in dB of this component. **(AZ)**

2. A crystal detector generates a signal if 10mV for an incident microwave power of -25dBm. What is the detector sensitivity in mV/mw? Why is the signal amplitude modulated by a 1kHz square wave before it is applied to a crystal detector? **(E)**
3. Calculate the VSWR in dB in a waveguide when the load is a 3dB attenuator terminated by a short circuit. **(AZ)**
4. The reflection coefficient of a load is 0.5L-30° . Using the smith chart determine the normalized admittance of the load. **(E)**
5. A waveguide with a load is matched by tuning screw located at a position 1. What impedance will be presented by the waveguide to the generated if the screw is moved by half guide wavelength towards the load from position 1. **(E)**
6. A microwave signal is modulated by a rectangular pulse of width 1 µsec. If the average power is 200w and the pulse repetition rate is 500 pulses per second. Calculate the value of peak power. **(AZ)**
7. In attenuation measurement of a matched attenuator the microwave source is modulated by 1 kHz square wave. The VSWR meter is peaked to 0 dB with the 30dB range without attenuator in the circuit. When the attenuator is inserted, the VSWR meter reads a value of 2 dB on the VSWR scale in the 40dB range. Find the attenuation provided by the attenuator. **(E)**
8. A coaxial slotted line is used to measure VSWR of the local at 2 GHz by double minimum method. If the distance between the position of twice minimum power is 0.5cm, find the value of VSWR on the line and the magnitude of the voltage reflection coefficient. **(E)**
9. In a reflectometer set up, two identical directional couplers are used to measure the incident and the reflected power. If the power level of the reverse coupler is 12dB down from the level of the forward coupler, what is the VSWR on the line? **(C)**
10. A rectangular waveguide is terminated with unknown load. By using a slotted line, load VSWR is found to be equal to 2 and distance between two successive minima is 1.5cm. When the load id replaced by a short, the position of a given minima shifts 0.3cm towards the generator. Find the normalized value of the load. **(C)**
11. A slotted line with a short circuit terminator measures two successive minima at 25.3 cm apart. When an unknown load is connected, the VSWR is 3.1 and the minima occurs at 16.5cm from the load. Find the voltage reflection coefficient at the load and the load impedance when the characteristic impedance of the line is 50 ohms. **(C)**

EC 6702

OPTICAL COMMUNICATION AND NETWORKS

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UNIT – I – INTRODUCTION TO OPTICAL FIBERS

PART – A

1. State Snell's Law. (Apr-May 2015) (R)

$\sin \Phi_1 / \sin \Phi_2 = n_2/n_1$

Φ_1 = Incident angle

Φ_2 = Refracted angle

n_1 = Refractive index of medium 1

n_2 = refractive index of medium 2

2. State law of reflection. (R)

The law of reflection states that the angle of incidence is equal to the angle of reflection

i.e $\angle\theta_1 = \angle\theta_2$

3. Define Refraction. (R)

When light ray travels from medium 1 (air) to medium 2 (glass), bending of light ray may occur. This is called refraction.

4. What is critical angle? (R)

When we increase the incident angle with respect to normal, at some incident angle the refracted ray travels along the boundary or surface. Hence Φ_2 becomes 90°. The angel of incidence for which the angle of refraction becomes 90° is called critical angle, $\Phi_c = \sin^{-1}(n_2/n_1)$.

5. What is total internal reflection?(Nov-Dec 2015) (R)

When the incident angle (Φ_1) is greater than the critical angle (Φ_c), the light ray is reflected back to medium-1. There will not be any light transmission (refraction) in medium-2. This is called total internal reflection.

6. Define Numerical Aperture. (Nov-Dec 2014) (R)

Numerical aperture determines the light gathering capacity of the fiber. It is dimensionless. Its value ranges from 0 to 1. Numerical aperture is a figure of merit which represents light gathering or collecting capability of

the fiber. Numerical aperture for step index fiber can be calculated by the following expression.

$$NA = \sqrt{n_1^2 - n_2^2}$$

7. Define Acceptance angle. (Nov-Dec 2014) (R)

Acceptance angle if the maximum angle with which the light ray may enter into the core to be propagated along the fiber.

8. Differentiate between Mono Mode Fiber and Multimode Fiber. (U)

S.No	Mono Mode Fiber	Multi Mode Fiber
1	Only one ray passes	More than one ray passes
2	Ray passes along the axis-axial ray	MMSI – Meridional and Skew MMGI – Paraxial
3	Core diameter is small typically10 - 12μm	Core diameter is large typically 50 - 200μm
4	Intermodal dispersion is not present	Intermodal dispersion is present
5	Fabricating single mode fiber is difficult	Fabricating multimode fiber is easy
6	Coupling efficiency is less	Coupling efficiency is large
7	LED is not suitable source for single mode	LED is suitable for multimode

9. Point out the limitations of Optical Fiber Communication system? (AZ)

- Optical fiber is made up of glass because of the impurities present within the fiber result in absorption leads to loss of light in the Optical fiber.
- Maximum limitation of the bandwidth of the signals can be carried by the fiber due to spreading of pulse.
- It is costly.
- Optical fiber has limited band radius (≈ 10mm)

10. Distinguish between Step Index fiber and Graded Index fiber. (AZ)

S.No	Step Index Fiber	Graded Index Fiber
1	The core has uniform refractive index but step change in core-cladding interface.	The core has high refractive index along the axis which gradually decreases towards the clad-core interface (radially decreases)
2	Axial ray – SMSI, Meridonial rays & Skew - MMSI	Paraxial rays – MMGI
3	Intermodal dispersion is present in MMSI	Intermodal dispersion is reduced in MMGI
4	Numerical Aperture is constant	Numerical Aperture is a function of radius
5	Step index profile	Graded index profile α – profile factor
6	No of modes, $m = v^2 / 2$. Step index supports twice the number of modes than GI	No of modes, $m = v^2 / 4$
7	Fabrication is easy	Fabrication is difficult

11. What is Meridonial Ray?(R)

Meridonial ray is a ray which is passing through fiber axis. Merodonial rays are confined to the meridial planes of the fiber which are the planes that contain the axis of symmetry of the fiber (the core axis)

12. What are Skew Rays?(R)

The rays which are not passing through the fiber axis and taking helical path during the propagation are called Skew rays.

13. What are Leaky Rays? (R)

The Leaky rays are only partially confined to the core of the circular optical fiber and attenuate as the light travels along the optical waveguide.

14. Compare Ray Optics with Wave Optics.(AZ)

S.No	Ray Optics	Wave Optics
1	It is used to represent the direction of light propagation	It is used to analyze mode theory
2	It is used to study reflection and refraction of light	It is used to analyze diffraction and Interference of light waves

15. Define Mode.(R)

Mode is the pattern of distribution of electric and magnetic fields

- Transfers Electric Mode TE_{02}
- Transfers Magnetic Mode TM_{02}

16.List out the ways to minimize leaky modes. (A)

A mode remains guided as long as β satisfies the condition $n_2K<\beta n_1K$.

$n_1,n_2 \rightarrow$ Refractive index of core are cladding $K = 2\pi/\lambda$

$\beta \geq n_2K$ = To prevent power leaks out of the core.

17.Define Phase and group velocity. (Nov-Dec 2015) (R)

The group velocity of a wave is the velocity with which the overall shape of the waves amplitude known as modulation or envelope of wave propagates through space.

$$v_g = \frac{d\omega}{d\beta}$$

The Phase velocity of a wave is the rate at which the phase of the wave propagates in space. This is the velocity at which the phase of any one frequency component of wave travel.

$$v_p = \frac{\omega}{\beta}$$

18. What are the three windows of Optical Communication?(R)

The three wave lengths 850nm, 1300nm and 1500nm are three optical windows of optical communication system. Since only at this wavelength silica fiber loss is minimum.

19.What is meant by linearly Polarized mode? (May-June 2013) (R)

- The field components HE, EH, TE, TM forms linearly polarized modes.
- Linearly polarized modes are labeled LP_{jm} where J and m are integer's designation mode solutions.

20.For n_1 = 1.55 and n_2 =1.52 , Calculate the critical angle and numerical aperture.(May-June 2013) (AZ)

Critical angle $\emptyset_c = \sin^{-1}\left(\frac{n_2}{n_1}\right) = \sin^{-1}\left(\frac{1.52}{1.55}\right) = 78.7°$

Numerical aperture $N_A = \sqrt{n_1^2 - n_2^2}$ = 0.3

21.List any two advantages of single mode fibers.(Nov-Dec 2014) (U)

Single mode fiber has only one ray passes through fiber. Ray passes along the axis-axial ray. Core diameter is small (typically 10 -12 μm). Intermodal dispersion is not present. Coupling efficiency is less.

22.Calculate the critical angle of incidence between two substances with different refractive indices, where n_1 =1.5 and n_2 =1.46. (Apr-May 2015) (AZ)

$$n_1 = 1.5$$
$$n_2 = 1.46$$
$$\emptyset = \sin^{-1}\frac{n_2}{n_1}$$
$$= \sin^{-1}\frac{1.46}{1.5}$$
$$\emptyset = 76.74°$$

23.Calculate the cutoff wavelength of a single mode fibre with core radius of 4 μm and $\Delta = 0.003$ (Nov-Dec 2012) (AZ)

Given a= 4 μm , $\Delta = 0.003$

Assume n_1 = 1.54, Single mode Fibre, V = 2.405

$$V = \frac{2\pi a}{\lambda} n_1 \sqrt{2\Delta} \qquad \left[\because NA = n_1\sqrt{2\Delta}\right]$$

$$2.405 = \frac{2\pi \times 4 \times 10^{-6}}{\lambda}\left(1.54\sqrt{2 \times 0.003}\right)$$

$$\lambda = 1.245 \mu m$$

24. For a Fibre with core refractive index of 1.54 and fractional refractive index difference of 0.01 calculate its numerical aperture. (Nov-Dec 2012) (AZ)

Given n_1 = 1.54 , $\Delta = 0.01$

Numerical Aperture, $NA = n_1\sqrt{2\Delta}$

$$= 1.54\sqrt{2 \times 0.01}$$

25. The refractive indexes of the core and cladding of a silica fiber are 1.48 and 1.46 respectively. Find the acceptance angle for the fiber. (Nov-Dec 2013) (AZ)

Given n_1=1.48, n_2=1.46

$$\phi_a = \sin^{-1}(NA)$$

$$NA = \sqrt{n_1^2 - n_2^2}$$

$$= \sqrt{(1.48)^2 - (1.46)^2}$$

$$= 0.242$$

$$\phi_a = \sin^{-1}(0.242)$$

$$\phi_a = 14.03^0$$

26. Determine the normalized frequency at 820nm for a step index fiber having a 25 μm radius. The refractive indexes of the cladding and the core are 1.45 and 1.47 respectively. How many propagate in this fiber at 820nm? (Nov-Dec 2013) (A)

Given n_1=1.47, n_2=1.45, $\lambda = 820nm$, a=25 μm

$$V = \frac{2\pi a \times NA}{\lambda}$$

$$= \frac{2\pi \times 25 \times 10^{-6} \times NA}{820 \times 10^{-9}}$$

$$NA = \sqrt{n_1^2 - n_2^2}$$

$$= \sqrt{(1.47)^2 - (1.45)^2}$$

$$= 0.2416$$

$$= \frac{2\pi \times 25 \times 10^{-6} \times 0.2416}{820 \times 10^{-9}}$$

$$V = 46.25$$

Modes propagate at 820nm:

$$M = \frac{V^2}{2}$$

$$= \frac{(46.25)^2}{2}$$

$$= \frac{2139.0}{2}$$

$$= 1069.5$$

$$M = 1070 \text{modes}$$

Part – B

1. i) With the help of neat block diagram explain the different components of an optical fiber link. **(Nov-Dec 2013) (U)**
   ii) Compare the optical fiber link with a satellite link. **(Nov-Dec 2013) (AZ)**
2. Derive an expression for Acceptance angle and Numerical Aperture of a fiber with the help of neat figure showing all the details. **(Nov-Dec 2013) (AZ)**
3. i) Explain the differences between meridional and skew rays. **(Nov-Dec 2013) (U)**
   ii) Bring out the differences between phase and group velocities. **(Nov-Dec 2013) (U)**
4. i) Derive the mode equations for a circular fiber using maxwell's equations.**(May-June 2013) (A)**
   ii) Calculate the NA of a fiber having n1 = 1.6 and n2 = 1.49 and another fiber having n1 = 1.448 and n2 = 1.405. Which fiber has greater acceptance angle? **(May-June 2013) (AZ)**
5. i) Explain the ray theory of a fiber with a special mention about TIR, Acceptance angle and NA. **(May-June 2013) (U)**
   ii) Describe single mode fibers and their mode field diameter. What are the propagation modes in them. **(May-June 2013) (U)**
6. i) Starting from maxwell's equation, derive an expression for wave equation of an electromagnetic wave propagating through optical fiber.**(Nov-Dec 2012) (A)**
   ii) Describe the ray theory behind the optical fiber communication by total internal reflection. State the application of snell's law in it. **(Nov-Dec 2012) (U)**

7. i) A SI fiber with silica-core refractive index of 1.458, V=75 and NA=0.3 is to be operated at 820 nm, what should be its core size and cladding refractive index? Calculate the total number of modes entering this fiber. **(Nov-Dec 2012) (AZ)**

   ii) Derive the expression of linearly polarized modes in optical fibers and obtain the equation for V-number. **(Nov-Dec 2012) (A)**

8. i) Compare the structure and characteristics of step index and graded index fiber.(**U)**

   ii) A graded index fiber with a core with a parabolic refractive index profile (α=2) and diameter of 50μm. The fiber has numerical aperture of 0.2. Estimate the number of the guided modes propagating in the fiber when the transmitted light has a wavelength 1μm. (**AZ)**

9. For multi-mode step-index fibre with glass core (n_1 =1.5) and a fused quartz cladding (n_2 =1.46), determine the acceptance angle (θ_{in}) and numerical aperture. The source to fibre medium is air. **(Apr-May 2015) (A)**

10. Explain the ray propagation into and down an optical fibre cable. Also derive the expression for acceptance angle. **(Apr-May 2015) (U)**

11. Describe a step index and graded index cable. **(Apr-May 2015) (U)**

12. Contrast the advantages and disadvantages of step-index, graded- index, single-mode propagation and multi-mode propagation. **(Apr-May 2015) (U)**

13. Classify fibers and explain them. **(Nov-Dec 2015) (U)**

14. Describe and derive the modes in planar guide. **(Nov-Dec 2015) (AZ)**

15. Define the normalized frequency for an optical fiber and explain its use. **(Nov-Dec 2014) (U)**

16. Explain the features of multimode and single mode step index fiber and compose them. **(Nov-Dec 2014) (U)**

17. A Single mode step index fiber has a core diameter of 7μm and a core refractive index of 1.49. Estimate the shortest wavelength of light which allows single mode operation when the relative refractive index difference for fiber is 1%. **(Nov-Dec 2014) (AZ**)

UNIT – II – SIGNAL DEGRADATION IN OPTICAL FIBERS
PART – A

1. Define attenuation?(R)

When light travels along a fiber, light power decreases exponentially with distance. Consider "P(o)" is the light power at the input end of the fiber and "P(l)" is the light power at the output end of the fiber at a distance 'l'. The attenuation is defined as the ratio between input power and output power.

$$\alpha = \frac{P(0)}{P(l)} \text{ Nepers}$$

2. Express attenuation coefficient in decibel per km.(U)

$$\alpha_{(dB/Km)} = \frac{10}{l}\log\left[\frac{P(0)}{P(l)}\right]$$

3. State Urbach's rule.(R)

$$\alpha_{uv} = ce^{E/E_0}$$

Where, α_{uv} is fiber loss in UV region.
C & E_0 are empirical constants.
E is photon Energy.

4. What is Rayleigh scattering?(May-June 2013)(R)

Rayleigh scattering is caused by inhomogenetics in the glass of a size smaller than the wavelength of light. The inhomogenetics are manifested in certain region of the fiber as refractive index variations present in the glass due to compositional fluctuations (SiO_2 and Ge_2O_3) during manufacturing.

5. Compare Rayleigh scattering and Mie scattering.(AZ)

S.No	Rayleigh Scattering	Mie Scattering
1	Caused due to refractive index variation in the core glass.	Caused by fiber imperfections such as irregularities in the core –cladding interface, core- cladding refractive index difference along the fiber length, diameter fluctuations, strains and bubbles.
2.	When the inhomegenetics size is smaller than the wavelength of light Rayleigh scattering occurs.	When the inhomegenetics size is greater than the Wavelength of light,Mie scattering occurs

3.	Scattering occurs both is forward and backward direction.	Scattering is mainly in the forward direction.
4.	Rayleigh scattering can be reduced by minimizing the compositional fluctuations by using best manufacturer methods.	Mie scattering can be reduced by a. Removing imperfections due to the glass manufacturing process. b. Carefully controlled extrusion and coating of the fiber c. Increasing the fiber guidance by increasing the relative refractive index difference.

6. Compare Linear scattering and Non- Linear scattering.(AZ)

S.No	Linear Scattering	Non-Linear Scattering
1.	Linear scatterings are observed only at low optical power densities below the threshold power levels.	Non-Linear scattering are only observed at high optical power densities above the threshold power levels in long single mode fibers.
2.	There are two types are Linear Scattering namely, a. Rayleigh Scattering b. Mie Scattering	There are two types of Non-Linear scattering namely, a. Stimulated Brillouin Scattering (SBS) b. Stimulated Raman Scattering (SRS)
3.	The Incident light frequency and scattered light frequency is the same. There is no frequency shift during scattering.	The Incident light frequency and scattered light frequency are different. There is a frequency shift during scattering.

7. Compare SRS and SBS. (AZ)

S.No	SRS	SBS
1.	SRS can occur both in forward and backward direction.	It is mainly backward process.
2.	The threshold power level of SRS is three times higher than SBS threshold in a particular fiber.	The SBS threshold power level is less.
3.	The scattering process produces high frequency optical phonon.	The scattering process produces acoustic phonon as well as a scattered photon.

8. What is Macrobending?(R)

Macrobending occurs when a fiber cable turns a corner and macroscopic bends having radius that are large compared with the fiber diameter.

9. What are Micro Bendings?(R)

Micro bending arises when the fibers are incorporated into cables.

10. What are Micro bending losses?(R)

The light power is dissipated through the microbends because if the repetitive coupling of energy between guided modes and leaky modes.

11. How will you minimize the micro bending losses?(R)

Compressible buffer jacket should be used to avoid micro bends. When external forces are applied to this jacket, the jacket will be deformed but the fiber will tend to stay relatively straight.

12. How will you minimize the Macro bending losses?(R)

To minimize Macro bending Losses, Macro bending should be smooth. This can be achieved by,

(a) Designing Fibers with Large Relative Refractive Index differences

(b) Operating at shortest wavelength possible.

13. What are the causes of intrinsic absorption in optical fiber?(R)

The causes for intrinsic absorption in optical fiber are

(a) Intrinsic absorption in the UV region is caused by electronic absorption bands. Basically, absorption occurs when a light particle (photon) interacts with an electron and excites it to a higher energy level.

(b) The main cause of intrinsic absorption in the IR (Infrared) region is the characteristic vibration frequency of atomic bands. In silica glass, absorption is caused by vibration of silicon oxygen (Si-o) bands. The Interaction between the vibrating bond and the electromagnetic field to the bond.

14. What are the causes or extrinsic absorption in Silica Optical Fiber?(R)

(a) Extrinsic absorption is caused by impurities such as Copper, Nickel and Chromium introduced into the fiber material during manufacturing

Process.

(b) It is also caused by the dissolved water (OH ion) in the fiber glass.

15. Write the expression for Critical Radius of Curvature for Macro bending of Fiber Cable? (A)

$$R_C = \frac{3n_1^2\lambda}{4\pi(n_1^2 - n_2^2)^{\frac{3}{2}}}$$

Where

R_c is the critical radius of curvature for macro bending n_1 is refractive index of core
n_2 is refractive index of cladding

16. Define Dispersion?(R)

While, Light pulses are travelling along a fiber the width of the pulses are broadening. This is Called Dispersion.

17. Write the Expression for Dispersion Parameter and Unit of Fiber?(A)

Dispersion parameter, $D = \left| \frac{\lambda^2 d^2 \underline{\beta}}{d\lambda^2} \right| ps\, km^{-1}\, nm^{-1}$

18. List out the types of Dispersion?(A)

(a) Inter-Modal Dispersion
(b) Intra Modal Dispersion
(I) Material Dispersion.
(II) Wave Guide Dispersion.

19. What is Chromatic Dispersion?(R)

Dispersion is sometimes called Chromatic Dispersion to emphasize its wavelength – dependent nature or group – velocity dispersion (GVD) to emphasize the role of group velocity. Material dispersion comes from frequency – dependent response of a material to waves. (Eg) Material dispersion leads to undesired chromatic aberration in a lens on the separation of colours in a Prism.

20. What is Material dispersion? How will you minimize the Material dispersion?(U)

Definition:

Material dispersion can be desirable or undesirable effect in optical application. The Dispersion of light by glass prisms is used to construct spectro radiometers.

Material dispersion can be minimized by using

(a) Narrow spectral width light source like laser. Typically for multimode laser diode the spectral width is around (1 -2) nm and for single mode laser diode, spectral width is around 10^{-2} nm.

(b) Longer wavelength operation, since refractive index variation is small or negligible.

21. What is Waveguide dispersion? How will you minimize waveguide dispersion?(U)

Waveguide dispersion is nothing but for each mode in an optical waveguide, the term used to describe the process by which an electromagnetic signal is distorted by virtue of the dependence of the phase and group velocities on wavelength as a consequence of the geometric properties of a waveguide.

Waveguide dispersion can be minimized

(i) The index differences should be large.

(ii) Short wavelength operation.

22. Write the expression for Material Dispersion Parameters?(A)

$$D_{mat} = \left[\frac{\lambda d^2(n_1)}{d\lambda^2}\right] \text{ps nm}^{-1}\text{ km}^{-1}$$

Where, λ – wavelength, n1 – Core refractive index.

23. Write the expression for Waveguide dispersion Parameters? (A)

$$D_{wg} = \frac{-n_2\Delta}{c\lambda}\left[\frac{vd^2(vb)}{dv^2}\right] \text{ ps nm}^{-1}\text{km}^{-1}$$

Where, λ – wavelength

n2 – Cladding refractive index
Δ – Index difference
C – velocity of light
v – normalize frequency

24. What is meant by PMD?(R)

Polarization Mode Dispersion (PMD) is a source of pulse broadening which results from fiber bi - refrigence and it can become a limiting factor for optical fiber communication at high transmission rates.

25. Define Intermodal Dispersion?(R)

In Multimode fiber, different modes travel along the fiber and they will reach at different time at the output end of the fiber. So, there will be a delay experienced between different modes. Because, of this delay pulse broadening occurs. This is Called Intermodal dispersion.
(Eg.) Axial ray will travel faster than Meridional ray.

26. Write the expression for Intermodal delay between Axial ray and Meridional ray?(A)

$$\delta Ts = \frac{Ln_1\Delta}{C}$$

Where, δTs = Intermodal delay.
L = Length of fiber.
n_1 = Core refractive index.
= index difference.
C = Velocity of light.

27. What is meant by Polarization of light?(R)

The polarization of light describes by a specifying the orientation of the waves electric field at a point in space over one period of the oscillation. When light travels in free space, it propagates as a transverse wave, i.e. the polarization is perpendicular to the wave's direction of travel.

28. What is fiber Bi - refrigence?(R)

Fiber bi-refrigence is the optical property of a material having a refractive index that depends on the polarization and propagation direction of light. These optically anisotropic materials are said to be bi-refringence. The bi-refringence is often quantified by the maximum difference in the refractive index within the material.

29. Define Beat length?(R)

Beat length is defined as the period of interference effects in a bi-refringence medium. When two waves with different linear polarization states propagate in a bi-refringence medium, their phases will evolve differently. It is assumed that the polarization of each wave is along the principle directions of the medium (x – axis (or) y – axis), so that this polarization will be preserved during propagation. This means that the phase relation between both waves is restored after integer multiples called the polarization beat length.

Beat length, $L_b = \frac{2\pi}{\Delta\beta}$

30. Define PMF (Polarization Mode Fiber)?(R)

PMF is an optical fiber in which the polarization of linearly polarized light waves launched into the fiber is maintained during propagation, with less or no cross-coupling of optical power between the polarization modes. Such fiber is used in special application where processing the polarization is essential.

31. Define insertion loss for using couple in fiber optical communication system. (R)

The insertion loss is defined as the loss obtained for a particular port to port optical path.

Insertion loss (ports 1 to 4) = $10 \log_{10} \frac{P_1}{P_4} dB$

32. What are Dispersion Flattened Fibers (DFF)? (R)

DFF is a type of glass optical fiber that provides low pulse Dispersion over a broad portion of the light spectrum and as a result can operate at 1300 nm and 1550 nm wavelength simultaneously.

33. What are Dispersion Shifted Fibers (DSF)? (R)

DSF is a type of optical fiber made to optimize both low dispersion and low attenuation.

DSF is a type of single mode optical fiber with a core-clad index profile tailored to shift the zero-dispersion wavelength from the natural 1300 nm in silica-glass fibers to the minimum loss at 1550 nm.

34. What is meant by Fresnel reflection in Fiber cable?(R)

Fresnel reflection at the air-glass interfaces at the entrance and exit of an optical fiber.

35. List out the advantages of elastic tube splicing?(A)

The advantages of elastic tube splicing are,

a) This type of splicing allows accurate and automatic alignment of axes of the two fibers to be joined.

b) In this method the fibers to be splices do not have to be equal in diameter.

36. List out the advantages of V-groove splicing?(A)

a) There is no thermal stress.
b) No change in refraction index of the two fibers.
c)

37.What are bending losses? Name any two types. (Apr-May 2015) (R)

(i) Micro bending losses - The light power is dissipated through the micro bends because if the respective coupling of energy between guided modes and leaky modes.

(ii) Macro bending losses - Macrobending losses occur when fibres are physically bent beyond the point at which the critical angle is exceeded.

38. What are the types of fiber losses which are given per unit distance?(Nov-Dec 2014) (R)

(i)Absorption
(ii) Scattering
(iii)Bending Loss

39.List the factors that cause intrinsic joint losses in a fiber. (N0v-Dec 2014) (R)

(i)Different core and / or cladding diameters
(ii)Different numerical apertures and / or relative refractive index differences.
(iii)Different refractive index profiles.
(iv)Fiber faults.

40.A fiber has an attenuation of 0.5dB/Km at 1500nm. If 0.5mW of optical power is initially launched into the fibre, what is the power level in after 25Km? (Nov—Dec 2015) (AZ)

$$P_{out}\ (dBm) = P_{in}(dBm) - \alpha\left(\frac{dB}{Km}\right) \times l$$

$$P_{in}(dBm) = 10\log_{10}\frac{P_{in}(dBm)}{1mW}$$

$$= 10\ \log_{10}\frac{(0.5 \times 10^{-3})}{(1 \times 10^{-3})}$$

$$= -3.01\ \text{dBm}$$

$$P_{out}\ (dBm) = -3.01 - (0.5 \times 25)$$

$$P_{out}\ (dBm) = -\ 15.51\ \text{dBm}$$

41.A continuous 12 kms-long optical fiber link has a loss of 1.5dB/km. What is the minimum optical power that must be launched into the fiber to maintain an optical power level of 0.3 μW at the receiving end?(Nov-Dec 2013) (AZ)

Given

$l = 12km,\ \alpha = 1.5dB/km,\ p_{out} = 0.3\mu W$

$$\alpha\left(dB/km\right) = \frac{10}{l}\log_{10}\left(\frac{p_{in}}{p_{out}}\right)$$

$$1.5 = \frac{10}{12}\log_{10}\left(\frac{p_{in}}{0.3\times10^{-6}}\right)$$

$$\frac{1.5\times12}{10} = \log_{10}\left(\frac{p_{in}}{0.3\times10^{-6}}\right)$$

$$1.8 = \log_{10}\left(\frac{p_{in}}{0.3\times10^{-6}}\right)$$

$$anti\log(1.8) = \left(\frac{p_{in}}{0.3\times10^{-6}}\right)$$

$$63 = \left(\frac{p_{in}}{0.3\times10^{-6}}\right)$$

$$p_{in} = 1.8928 \times 10^{-5}$$

$$p_{in} = 18.9\times10^{-6}$$

$$p_{in} = 18.9\mu W$$

42. Define dispersion in multimode fibers. What is its effect? (Nov-Dec 2013) (R)

In multimode fiber many modes are propagating along the fiber at a time. Different modes are taking different ray path and they reach at different time at the output end of the fiber. So a time delay is experienced between modes. This is called intermodal delay and pulse broadening occurs due to intermodal delay is called intermodal dispersion

Effect:

1. It restricts bandwidth of the optical fiber cable.
2. The intermodal dispersion causes the light rays to spread out through the fiber.
3. It accounts for a significant loss occurring in the fiber.

43. What are the two reasons for Chromatic Dispersion? (Nov-Dec 2012) (R)

i. Dispersive Properties of the waveguide material **– Material Dispersion**

ii. Guidance effects within the fiber structure **– Waveguide Dispersion**

44. What are the most important non-linear effects of optical fibre communication? (Nov-Dec 2012) (R)

Non linear effects of Scattering are:

i. Stimulated Brillouin Scattering (SBS)

ii. Stimulated Raman Scattering (SRS)

Part – B

1. Discuss about the design optimization of single mode fiber.**(Nov-Dec 2016) (U)**
2. What is waveguide dispersion? Derive and expression for time delay produced due to waveguide dispersion.**(Nov-Dec 2016) (A)**
3. With necessary diagrams, explain the causes and types of fiber attenuation loss. **(Nov-Dec 2015) (U)**
4. With diagram, derive the expression for intra modal dispersion. **(Nov-Dec 2015) (AZ)**
5. What are the loss or signal attenuation mechanism in a fibre? Explain. **(Apr-May 2015) (U)**
6. Discuss the pulse broadening in graded index fibers. **(U)**
7. Explain in detail about polarization mode dispersion and intermodal dispersion in SM fibers. **(U)**
8. Distinguish between intermodal and intramodal dispersions. Explain them with necessary equations and diagrams. **(Nov-Dec 2013) (AZ)**
9. Describe the linear and non-linear scattering losses in optical fibers. **(Nov-Dec 2012) (U)**
10. Derive expressions for material dispersion and waveguide dispersion and explain them. **(May-June 2013) (AZ)**
11. What is meant by critical bending radius of optical fibers? Explain. **(Nov-Dec 2014) (U)**
12. Explain the following in single mode fiber : Modal birefringence and beat length. **(Nov-Dec 2014) (U)**
13. An LED operating at 850nm has a spectral width of 45nm. What is the pulse spreading is ns/km due to material dispersion? What is the pulse spreading when a laser diode having a 2nm spectral width is used? **(Nov-Dec 2012) (U)**
14. Discuss the attenuation encountered in optical fiber communication due to:

    1.Bending 2. Scattering 3.Absorption. **(Nov-Dec 2013) (U)**

UNIT – III – FIBER OPTICAL SOURCES AND COUPLING

PART – A

1. **What are the advantages of LEDs? (May 2012) (R)**

   - Cheapest light source.
   - Simple driver circuit.
   - No thermal and optical stabilization.

2. **What are the disadvantages of LEDs? (R)**

   - Low output power
   - Wide spectral width (typically 20nm to 40nm)

3. **What are the advantages of laser source over with LED? (R)**

   - High output power.
   - Narrow spectral width (typically 1nm to 2nm for multimode laser).

4. **Give an example each for direct band gap and indirect band gap materials (May 2012) (U)**

   - Examples for direct band gap materials are GaAlAs and InGaAsP.
   - Si,Ge are examples for indirect band gap materials.

5. **Define quantum efficiency of LED (Nov-Dec 2014,May 2012 ,April 2010) (R)**

   The internal quantum efficiency in the active region is the fraction of electron-hole pairs that recombine radiatively.The total recombination rate is sum of radiative recombination rate and non-radiative recombination rate it is given by

   Internal quantum efficiency $\eta_{int} = \frac{R_r}{R_r + R_{nr}}$

6. **Why silicon is not used to fabricate LED or laser diode? (Nov 2011) (U)**

   Silica is an indirect band gap materials so recombination of electron hole pair is less efficient so amount of photons emitted is less and amount of light emitted will also be less so silica is not used to fabricate LED or laser diode.

7. Differentiate between direct band gap material and indirect band gap material.(U)

S.No	Direct band gap material	Indirect band gap material
1.	Direct band gap material, maximum of the valence band and minimum of the conduction band occur at the same value of momentum.	Indirect band gap material, maximum of the valence band and minimum of the conduction band occur at the different value of momentum.
2.	Recombination of electrons and holes to produce photons is more efficient.	Recombination process is less efficient as it must be mediated by phonon. (Third phonon).
3.	Direct band gap materials like GaAs are used to make optical devices like LED's and semiconductor laser.	Indirect band gap materials like silicon are not used to make optical devices but diode, transistor can be fabricated.

8. List out the disadvantages of direct band gap materials.(U)

- Direct band gap materials are not used for making conventional diodes as recombination process is efficient, it produce narrow spectral width.
- As a result, recombination of electrons and holes, then mobile carriers get reduced, there will be decline conduction takes place.

9. Define Hetero junction.(R)

- When two semi conductor materials with different band gap energy are adjoined then it forms a Hetero junction.
- This is used in fiber transmission system as they provide adequate power over large range of application.

10. What are the advantages of double hetero structure optical sources? (April 2011) (R)

- High quantum efficiency.
- High brightness (Radiance).

11. What is population inversion? (R)

Population inversion is the condition in which number of electrons in the conduction band is greater than the number of electrons in the valence band.

12. What is lasing condition?What are the mechanisms behind lasing action. (Nov-Dec 2016) (R)

When the optical gain overcomes the total losses that arise in the laser cavity, lasing occurs.

The mechanisms behind lasing action are:

1) Photon absorption
2) Spontaneous emission
3) Stimulated emission

13. Compare and contrast between surface and edge emitting LEDs. (Nov 2012)(AZ)

S.No	Surface Emitting LED	Edge Emitting LED
1.	Wider spectral width(typically 125nm)	Narrow spectral width (typically 75nm)
2.	Emission pattern is less directional.	Emission pattern is more directional.

13. Define Quantum efficiency of laser diode?(R)

The Quantum efficiency is defined as the number of photons emitted per radioactive electron-hole pair recombination above threshold.

14. Distinguish between direct and external modulation of laser diodes. (Nov 2010) (AZ)

S.No	Direct Modulation	External Modulation
1.	Easy to demonstrate and has low cost.	Complex and expensive.
2.	Low gain.	High gain.

16. Define responsivity of photodiode. (Nov-Dec 2013, April 2010) (R)

The performance of photodiode is often characterized by the responsivity. Responsivity means speed of response of photodiode.

$$R = \frac{I_p}{P_{in}}$$

17. Define quantum efficiency of a photo detector and write the expression (Nov-Dec 2013, Nov-Dec 2011) (R)

The quantum efficiency η is the number of electron hole carrier pairs

generated per incident photon of energy.

$$\eta = \frac{I_p / e}{p_{in} / h\nu}$$

18. Why silicon is preferred for fabrication of photo receiver? (U)

- Silica is used for fabrication photo receiver, because it has larger band gap, it generates low noise and it supports multiple channels as it has larger bandwidth.
- Silicon is available plenty in nature.

19. Why are semiconductor based photo detectors preferred to other types of photo detectors? (April-May 2011) (U)

Semiconductor laser diode generates low noise and they support multiple channels as they have larger band width.

20. What is the significance of intrinsic layer in PIN diodes (Nov-Dec 2012) (R)

To increase absorption region, intrinsic layer is sandwiched between p-type and N- type semiconductors.

21. List out the responsivity values of Silicon, Germanium and Indium Galium Arsenide photodiodes.(A)

Responsivity values are 0.65A/W for silicon at 900nm and 0.45A/W for germanium at $1.3\mu m$. For InGaAs typical values are 0.9A/W at $1.3\mu m$ and 1.0A/W at $1.55\mu m$

22. Define impact ionization or avalanche effect?(R)

In high field region, a photo generated electron or hole can gain enough energy so that it ionizes bound electrons in the valence band upon colliding with them. This carrier multiplication mechanism is known as impact ionization. The newly created carriers are also accelerated by the high electric field, thus gaining enough energy to cause further impact ionization. This phenomenon is the avalanche effect.

23. What are the requirements of photo detector?(R)

- The photo detector must have high quantum efficiency to generate a large signal power.
- The photo detector and amplifier noises should be kept as low as possible.

24. Define quantum noise or shot noise? (R)

The quantum or shot noise arises from the statistical nature of the production and collection of photo electrons when an optical signal is incident on a photo detector.

25. Define dark current?(R)

The photo diode dark current is the current that continues to flow through the
bias circuit of the device when no light is incident on the photo diode.

26. Define Johnson or thermal noise?(R)

When current is flowing continuously across the load resistor, heat will be dissipated. This is called thermal noise.

27. What is known as detector response time? (May 2012)(R)

It is defined as the time taken for the photo detector to respond to an optical input pulse. The response time determines the bandwidth available for signal modulation and data transmission.

28. What are the factors that limit the response time of the photo detectors? (R)

- Transit time of photo carriers within the depletion region.
- Diffusion time of photo carriers outside the depletion region.
- RC time constant of the photo diode and its associated circuit.

29. What are inherent connection problems when joining fibers? (U)

The inherent connection problems when jointing fibers are,

- Different core and/or cladding diameters.
- Different numerical apertures and/or relative refractive index differences.
- Different refractive index profiles.
- Fiber faults(core elliptically, core concentricity etc)

30.Compare PIN and APD?(AZ)

S.No	PIN	APD
1	No internal gain.	Internal gain.
2	Thermal noise current dominates photo detector noise current.	Photo detector noise current dominates thermal noise current.
3	Low responsivity.	High responsivity.
4	Low dark current.	High dark current.
5	Suitable for high intensity application.	Suitable for low intensity application.
6	Required low reverse bias voltage.	Required high reverse bias voltage.

31. List out the different types of mechanical misalignments during fiber connection? (A)

The three possible types of misalignment which may occur when joining compatible optical fibers are,

a) Longitudinal misalignment
b) Lateral misalignment
c) Angular misalignment

32.What is fiber splicing?(R)

Fiber splicing is the process of joining two fibers by melting the fiber ends.

33.Compare splices and connectors.(AZ)

S.No	Splices	Connectors
1	Permanent or semi permanent joints	Temporary joint
2	Splice loss is low	Connector loss is high

34.Define cross talk in couplers? (R)

Crosstalk is a measure of isolation between two input or two output ports.

35.Define power- bandwidth product.(Apr-May 2015) (R)

High output power and high bandwidth are two important parameters in the design of photo-detector. The Product of photo detector bandwidth and power at which bandwidth is measured.

36.Contrast the advantages of PIN diode with APD diode. (Apr-May 2015) (U)

(i) Low dark current
(ii) It is affected but only thermal noise
(iii) No speed limitation due to capacitance effect

37.What is meant by Mechanical splicing? (May-June 2013) (R)

Mechanical splicing, in which the fibers are held in alignment by some mechanical means, may be achieved by including the use of V-groove into which the butted fibers are placed (or) the use of tubes around the fiber ends.

38.Calculate the Band gap energy for an LED to emit $850nm$? (May-June 2013) (A)

Solution: $\lambda = 850nm = 0.85\mu m$

$$E_g = \frac{hc}{\lambda} = \frac{6.625 \times 10^{-34} \times 3 \times 10^{8}}{0.85 \times 10^{-6}} = 2.33 \times 10^{-19} = 1.45\ eV$$

$$E_g = 1.45\ eV$$

39.Define external quantum efficiency.(Nov-Dec 2016). (R)

The external quantum efficiency is defined as the ratio of the photons emitted from the LED to the number of internally generated photons.

40.Write two difference between a Laser diode and a LED. (Nov-Dec 2013) (U)

S.no	Laser Diode	LED
1.	Coherent radiation takes place.	In coherent radiation takes place.
2.	Narrow spectral width	Wider Spectral width

Part – B

1. What is fiber splicing? Discuss about fusion splicing and mechanical splicing. **(Nov-Dec 2016) (U)**
2. Explain the working principle of laser diode and derive its rate equation. **(Nov-Dec 2016) (U)**
3. With neat sketch, explain the working of a light emitting diode. **(Apr-May 2015, Nov-Dec 2013) (U)**
4. Derive an expression for the quantum efficiency of a double hetro-structure LED. **(Apr-May 2015, Nov-Dec 2013) (AZ)**
5. Draw and compare LED and Injection Laser Diode structures. **(Nov-Dec 2015) (AZ)**
6. Discuss about optical detection noise. **(Nov-Dec 2015) (U)**
7. Explain laser modes and lasing conditions. **(U)**
8. Draw the structures of SLED and ELED and explain their principle of operation. **(U)**
9. Explain gain guided and Index guided laser diodes. **(U)**
10. Discuss Burried Hetero structure Laser diode with neat sketch. **(U)**
11. Write short notes on **(U)**
    i) Lensing schemes
    ii) Power Launching and Coupling
12. What are the different types of fiber splices and misalignments. **(R)**
13. What is meant by detector response time? Explain. **(Nov-Dec 2014,Nov-Dec 2012) (U)**
14. Describe the various types of fiber connectors and couplers. **(May-June 2013) (U)**
15. Explain fiber alignment and joint losses. **(May-June 2013) (U)**
16. Describe various fiber splicing techniques with their diagrams. **(May-June 2013) (U)**
17. Describe the three types of fiber misalignment that contribute to insertion loss at an optical fiber joint. **(Nov-Dec 2014) (U)**
18. Describe about connectors, splices and couplers. **(Nov-Dec 2015) (U)**
19. A Photodiode is constructed of GaAs which has a band gap energy of 1.43eV at 300K. Find the long wavelength cut-off. **(Apr-May 2015) (AZ)**
20. What do you understand by optical-wave confinement and current confinement in LASER diode? Explain with suitable structures. **(Nov-Dec 2013) (U)**

UNIT – IV – FIBER OPTIC RECEIVER AND MEASUREMENTS
PART – A

1. What is Mode Coupling and what are its causes?(R)

It is another type of pulse distortion which is common in optical links. The pulse distortion will be increased less rapidly after a certain initial length of fiber, due to this mode coupling and differential mode losses occur.

2. Define Quantum limit (Q). (May-June 2013) (R)

The minimum received power level required for a specific BER of digital system is known as Quantum limit.

3. List out the methods used to measure fiber refractive index profile. (A)

1. Inter-ferometric method
2. Near field scanning method
3. End field scanning method

4. What are the error sources in fiber optic receiver? (May-June 2013, Nov-Dec 2012) (R)

The error sources in fiber optic receiver are

- Shot Noise
- Dark Current
  - Bulk Dark Current
  - Surface Dark Current
- Thermal Noise.
- Amplifier noise

5. What are the different techniques for determining attenuation in optical fiber?(R)

The different techniques for determining attenuation are

i) Cut-back ii) Insertion-loss

6. Write the expression to measure attenuation using cut back method.(A)

$$\alpha_{dB} = \frac{10}{L_1 - L_2} \log_{10} \frac{V_1}{V_2}$$

Where L_1 = original fiber length

L_2 = Cut-back fiber length

V_1 and V_2 are the output voltages

7. Define BER.(Nov-Dec 2016, April-May 2015) (R)

Bit Error rate (BER) $= \frac{N_e}{N_t} = \frac{N_e}{Bt}$

Where , B= $\frac{1}{T_b}$ is the bit rate.

N_e = Number of errors occurring over a specific time interval.

N_t = Number of pulses transmitted during the interval.

8. What is Cut-back method?(Nov-Dec 2016) (R)

The cut back method involves taking a set of optical power measurements over the required spectrum with the help of a long length of fibre which is uncabled having only a primary protective coating. The fibre is then cut back to a point 2m from the input end maintaining the same launch condition.

9.List any two advantages of trans-impedance amplifiers.(Apr-May 2015) (U)

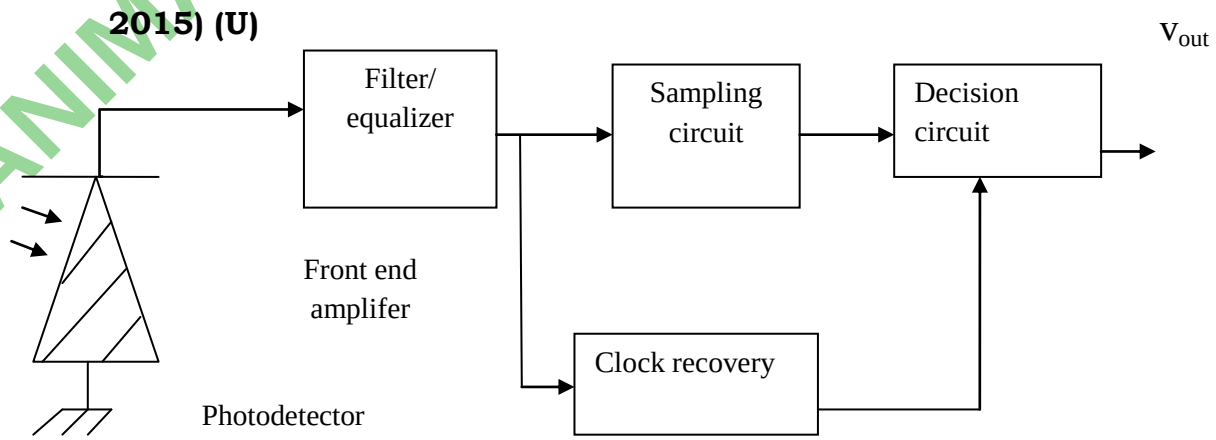
(i) Reduces thermal noise

(ii) Provide wide bandwidth

10.State the significance of maintaining the fiber outer diameter constant.(Nov-Dec 2014) (R)

It is essential during the fiber manufacturing process (at the drawing stage) that the fiber outer diameter (cladding diameter) is maintained constant to within 1%. Any diameter variations may cause excessive radiation losses and make accurate fiber – fiber connection difficult.

11.Draw and describe the operation of fiber optic receiver. (Nov-Dec 2015) (U)



An optical receiver system converts optical energy into electrical signal amplify the signal and process it. Therefore the important blocks of optical receiver are

(i) Photodiode / Front – end

(ii) Amplifier / Linear channel

(iii) Signal processing circuitry / Data recovery.

12.Mention few fiber diameter measurement techniques. (Nov-Dec 2015) (R)

There are two very broad classifications of diameter measurements techniques

(i) Contacting or destructive methods

(ii) Non-contacting and nondestructive methods

13.What is dark current?(Nov-Dec 2012) (R)

The photo diode dark current is the current that continues to flow through the bias circuit of the device when no light is incident on the photo diode.

14.A digital fiber optic link operating at 1310 nm, requires a maximum BER of 10^{-8}. Calculate the required average photons per pulse. (Nov-Dec 2013) (AZ)

Solution:

Given

Probability error $P_r(0) = e^{-\bar{N}} = 10^{-8}$

$\bar{N} = 8\log_e 10 = 18.42 = 18$

An average of 18 photons per pulse ie required for this BER.

15.The photo detector output in a cutback attenuation set up is 3.3V at the far end of the fiber. After cutting the fiber at the near end, 5 m from the far end, photo detector output read was 3.92 V. What is the attenuation of fiber in dB/km? (Nov-Dec 2013) (AZ)

Solution:

Consider fiber cut back length is 2m.

$$\alpha_{dB} = \frac{10}{L_1 - L_2}\log_{10}\left(\frac{V_1}{V_2}\right)$$

$$\alpha_{dB} = \frac{10}{5 - 0.002}\log_{10}\left(\frac{3.92}{3.3}\right)$$

$$= 0.1495$$

Part – B

1. Explain the different methods employed in measuring the attenuation in optical fiber with neat block diagram. **(Nov-Dec 2016) (U)**
2. What are the performance measures of a digital receiver? Derive an expression for bit error rate of a digital receiver. **(Nov-Dec 2016,Nov-Dec 2015) (AZ)**
3. Explain how attenuation and dispersion measurements could be done. **(Nov-Dec 2015, Nov-Dec 2013) (U)**
4. Explain the following. **(U)**
   i) Fiber outer diameter measurement
   ii) Core diameter measurement
5. Draw the three types of front end optical amplifiers (preamplifiers) and explain. **(May-June 2013, Nov-Dec 2012, Nov-Dec 2013) (U)**
6. Explain with a neat block diagram, the measurement of
   i) Numerical aperture and acceptance angle. **(Nov-Dec 2014) (U)**
   ii) Refractive index profile**. (Nov-Dec 2012, Nov-Dec 2014) (U)**
7. With schematic diagram, explain the blocks and their functions of an optical receiver. **(Apr-May 2015, Nov-Dec 2014) (U)**
8. A digital fibre optic link operationg at 850nm requires a maximum BER of 10^{-9}. Find the quantum limit in terms of the quantum efficiency of the detector and the energy of the incident photon. **(Apr-May 2015) (E)**
9. Write detailed notes on the following. **(May-June 2013) (U)**

   (i) Fibre refractive index profile measurement.
   (ii) Fibre cut of wavelength measurement.
10. Draw the block diagram of OTDR. Explain the measurements of any two fiber optic measurements with this. **(Nov-Dec 2014) (U)**
11. Write notes on cut-off wavelength measurement. **(Nov-Dec 2012) (U)**

UNIT – V – OPTICAL NETWORKS AND SYSTEM TRANSMISSION
PART – A

1. What is a Soliton?(Nov-Dec 2014) (R)

Soliton is a self trapped beam and it is a special kind of pulses and does not change in shape during propagation. This is also called as fundamental soliton.

2. What is WDM (Wavelength Division Multiplexing)? ?(Nov-Dec 2014) (R)

A Powerful aspect of an optical communication link is that many different wavelengths can be sent along the fibre simultaneously. The technology of combining a number of wavelengths onto the same fibre is known as Wavelength –Division Multiplexing or WDM.

3. What are the drawbacks of broadcast and select network for wavelength multiplexing?(R)

The problems that arise in broadcast and select networks are:

1. More wavelengths are needed as the number of nodes in the network grows.
2. Without the width spread use of optical booster amplifiers, due to this splitting loss is high.

4. What is optical CDMA? (Nov-Dec 2015) (R)

Optical CDMA is a multiple access technique in which each user is assigned an unique optical code. When a receiver is placed anywhere on the network with a bar code that matches a transmitter that signal line is decoded and extracted from the network.The codes are orthogonal to each other.

5.Distinguish SONET and SDH. (Nov-Dec 2015) (AZ)

SONET	SDH
1. It means synchronous optical network developed by ANSI. 2. Basic signaling unit is OC-I (51.84Mbps) 3. SONET uses the term section, line and path.	1. It means synchronous digital hierarchy developed by ITU 2. Basic signaling unit is STM-1 (155.52 Mbps) 3. SDH uses the term path, multiplex section and regenerator section.

6.Name two popular architectures of SONET/SDH network.(Nov-Dec 2016) (R)

The two popular architectures of SONET/SDH networks are:

i) UPSR - Unidirectional Path Switched Ring, two-fiber.

ii) BLSR – Bidirectional Line Switched Ring, two-fiber or four-fiber.

7.Obtain the transmission bit rate of the basic SONET frame in Mbps.(Nov-Dec 2013) (E)

STS-1 frame rate = (810 bytes/frame)*(8000 frames/sec)

= 51.840 Mbps.

8.Illustrate inter-channel cross talk that occurs in a WDM system.(Nov-Dec 2013) (A)

Inter-channel crosstalk arises when an interfacing signal comes from a neighboring channel that operates at a different wavelength. This nominally occurs when a wavelength selecting device imperfectly rejects or isolates the signals from other near-by wavelength channels.

9.What is a broadcast and select network?(May-June 2013) (R)

In broadcast and select networks, a node sends its transmission to the star coupler on the available wavelength using a laser which produces an optical information stream. The information stream from multiple sources is optically combined by the star and the signal and the signal power of each stream is equally spilt and forwarded to all the nodes on their receiver fiber.

10.What is SONET?(Apr-May 2015) (R)

SONET means synchronous optical network which is developed by ANSI, standardized protocol that transfer multiple digital bit stream synchronously over optical fiber using laser.

11.What were the problems associated with PDH networks?(Nov-Dec 2012) (AZ)

PDH- Plesiochronous Digital Hierarchy

i) It is difficult to “pick out” (drop) a low bit rate stream out of a high bit rate stream it is completely demultiplexing stream.

ii) Expensive and compromises network reliability.

12.Enumerate the various SONET/SDH layers. ?(Nov-Dec 2012) (R)

The various SONET/SDH layers are,

i) Photonic layer
ii) Section layer
iii) Line layer
iv) Path layer.

Part – B

1. Draw the generic configuration of SONET and explain the functions of add drop multiplexer in SONET.**(Nov-Dec 2016)(U)**
2. Discuss in detail about the effect of noise on system performance.**(Nov-Dec 2016) (U)**
3. Explain SONET layers and frame structure with diagram.**(Nov-Dec 2015) (U)**
4. Discuss the performance improvement of WDM and EDFA systems.**(Nov-Dec 2015,Apr-May 2015, Nov-Dec 2014) (U)**
5. Discuss the non-linear effects on optical network performance.**(Apr-May 2015, Nov-Dec 2012) (U)**
6. Explain i)Optical CDMA ii)Optical Wavelength Routing Network.**(Nov-Dec 2012)(U)**
7. Discuss about Ultra High Capacity Networks. **(Apr-May 2015,Nov-Dec 2014) (U)**
8. Explain broadcast and select network in detail. **(Nov-Dec 2013) (U)**
9. What is a 'four-fiber BLSR' ring in a SONET? Explain the reconfiguration of the same during node or fiber failure. **(Nov-Dec 2013) (U)**
10. Explain the following requirements for the design of an optically amplified WDM link. **(Nov-Dec 2013) (U)**

1.Link Band width 2. Optical power requirements for a Specific BER.

ASSIGNMENT QUESTIONS BASED ON BLOOM'S TAXONOMY LEVELS (BTL)

ASSIGNMENT – I

UNIT – 1 INTRODUCTION TO OPTICAL FIBERS

1. A step-index multimode fiber with a numerical aperture of 0.20 supports approximately 1000 modes at an 850-nm wavelength.
   a) What is the diameter of its core? **(A)**
   b) How many modes does the fiber support at 1320 nm? **(A)**
   c) How many modes does the fiber support at 1550 nm? **(A)**

2. (a) Determine the normalized frequency at 820nm for a step-index fiber having a 25μm core radius, n_1=1.48 and n_2=1.46 **(A)**
   (b) How many modes propagate in this fiber at 820nm? **(A)**
   (c) How many modes propagate in this fiber at 1320nm? **(A)**
   (d) How many modes propagate in this fiber at 1550nm? **(A)**
   (e) What percent of the optical power flows in the cladding in each case? **(AZ)**

3. A graded-index fiber with a parabolic index profile (α=2) has a core index n_1=1.480 and the index difference Δ=0.010
   (a) Show that the maximum value of the core radius for single-mode operation at 1310nm is 3.39μm. **(AZ)**
   (b) Show that the maximum value of the core radius for single-mode operation at 1550nm is 4.01μm. **(AZ)**

ASSIGNMENT – II

UNIT – 2 SIGNAL DEGRADATION IN OPTICAL FIBERS

1.(a) An LED operating at 850nm has a spectral width of 45nm. What is the pulse spreading in ns/km due to material dispersion? What is the pulse spreading when a laser diode having a 2-nm spectral width is used? **(A)**
   (b) Find the material-dispersion-induced pulse spreading at 1550nm for an LED with a 75-nm spectral width. **(A)**

2. Consider graded-index fibers having index profiles α=2.0, cladding refractive indices n2 = 1.478, and index differences Δ = 0.01. Compare the ratio M_{eff}/M_{∞} for a 1550-nm wavelength for R = 2.5 cm when α=25 μm and 50 μm. **(AZ)**

3. Calculate the wavelength dispersion at 1320nm in units of [ps/(nm^2-km)] for a single-mode fiber with core and cladding diameters of 9μm and 125 μm, respectively. Let the core index n_1=1.48 and let the index difference Δ=0.22 percent. **(A)**

ASSIGNMENT – III

UNIT – 3 FIBER OPTICAL SOURCES AND COUPLING

1. An engineer has two $Ga_{1-x}Al_xAs$ LEDs: One has a bandgap energy of 1.540eV and the other has x=0.015.
   (a) Find the aluminium mole fraction x and the emission wavelength of the first LED. **(AZ)**
   (b) Find the bandgap energy and the emission wavelength of the other LED. **(AZ)**

2. (a) A GaAlAs laser diode has a 500μm cavity length, which has an effective absorption coefficient of 10cm^{-1} . For uncoated facets the reflectivities are 0.32 at each end. What is the optical gain at the lasting threshold?
   (b) If one end of the laser is coated with a dielectric reflector so that its reflectivity is now 90 percent, what is the optical gain at the lasing threshold? **(A)**
   (c) If the internal quantum efficiency is 0.65, what is the external quantum efficiency in cases (a) and (b)? **(AZ)**

3. A laser emitting at λ_0=850 nm has a gain-spectral width of σ = 32 nm and a peak gain of g(0) = 50 cm^{-1} . Plot g(λ) from Eq.4.41. If α_t = 32.2 cm^{-1}, show the region where lasting takes place. If the laser is 400 μm long and n=3.6, how many modes will be excited in this laser? **(E)**

ASSIGNMENT – IV

UNIT – 4 FIBER OPTIC RECEIVER AND MEASUREMENTS

1. In a avalancHe photodiodes, the ionization ratio k is approximately 0.02 for silicon and 0.35 for indium gallium arsenide. Show that for gains 9, 25, and 100 in Si and gains of 4, 9 and 25 in InGaAs, the excess noise factor $F(M)$ can be approximated to within 10percent by M^x, where x is 0.3 for Si and 0.7 for InGaAs. **(AZ)**

2. An LED operating at 1300nm injects 25μW of optical power into a fiber. If the attenuation between the LED and the photodetector is 40dB and the photodetector quantum efficiency is 0.65, what is the probability that fewer than 5 electron-hole pairs will be generated at the detector in a 1-ns interval? **(AZ)**

3. Consider a quantum-noise-limited analog optical fiber system that uses a *pin* photodiode with a responsivity of 0.85 A/W at 1310nm. Assume the system uses a modulation index of 0.6 and operates in a 40-MHZ bandwidth. If we neglect detector dark current, what is the signal-to-noise ratio when the incident optical power at the receiver is -15dBm? **(AZ)**

ASSIGNMENT – V

UNIT – 5 OPTICAL NETWORKS AND SYSTEM TRANSMISSION

1. An engineer has the following components available:
   (a) GaAlAs laser diode operating at 850nm and capable of coupling 1mW(0dBm) into a fiber.
   (b) Ten sections of cable each of which is 500m long, has a 4-dB/km attenuation, and has connectors on both ends.
   (c) Connector loss of 2dB/connector.
   (d) A *pin* photodiode receiver.
   (e) An avalanche photodiode receiver.

   Using these components, the engineer wishes to construct a 5-km link operating at 20Mb/s. If the sensitivities of the *pin* and APD receivers are -45 and -56 dBm respectively, which receiver should be used if a 6-dB system operating margin is required? **(AZ)**

2. A 90-Mb/s NRZ data transmission system that sends two DS3(45-Mb/s) channels uses a GaAlAs laser diode that has a 1-nm spectral width. The rise time of the laser transmitter output is 2 ns. The transmission distance is 7km over a graded-index fiber that has an 800-MHz.km bandwidth-distance product.
   (a) If the receiver bandwidth is 90 MHz and the mode-mixing factor q=0.7, what is the system rise time? Does this rise time meet the NRZ data requirements of being less than 70 percent of a pulse width? **(AZ)**
   (b) What is the system rise time if there is no mode mixing in the 7-km link; that is, q =1.0? **(U)**

3. A 1550-nm single-mode digital fiber optic link needs to operate at 622Mb/s over 80km without ampliers. A single-mode InGaAsP laser launches an average optical power of 3.0 dBm into the fiber. The fiber has a loss of 0.25dB/km, and there is a splice with a loss of 0.1dB every kilometer. The coupling loss at the receiver is 0.5 dB, and the receiver uses an InGaAs APD with a sensitivity of -39 dBm. Excess-noise penalities are predicted to be 1.5dB. Set up an optical power budget for this link and find the system margin. What is the system margin at 2.5Gb/s with an APD sensitivity of -31 dBm? **(AZ)**

EC6703

EMBEDDED AND REAL TIME SYSTEMS

UNIT- I- INTRODUCTION TO EMBEDDED COMPUTING AND ARM PROCESSORS

PART A

1. Differentiate top-down and bottom-up design. (April2016) (R)

Top-Down: Top down design proceeds from the abstract entity to get to the concrete design. It is most often used in designing brand new systems.

Bottom-Up: Bottom-up design proceeds from the concrete design to get to the abstract entity. It is sometimes used when one is reverse engineering a design, (i.e.) when one is trying to figure out what somebody else designed in an existing design.

2. List the functions of ARM processor in supervisor mode. (April 2014) (R)

Exception, Prioritization, Vectoring, Traps.

3. Enumerate various issues in real time computing. (Nov/Dec 2013) (R)

a. Real -time Response
b. Recovering from failures
c. Working with distributed architecture
d. Asynchronous communication
c. Race condition and timing.

4. Write short notes on ARM Processor.(Nov/Dec 2013) (R)

•ARM – Advanced RISC Machine. (It is a 32-bit Microprocessor)
•ARM is actually a family of RISC architectures that have been developed over many years. The ARM is a 32-bit Reduced Instruction Set Computer (RISC) instruction set architecture developed by Arm holdings.
•ARM processor is mad suitable for Low power application.

5. What are the Instruction set features useful for embedded programming? (May/June 2013) (R)

a. Fixed versus variable length
b. Addressing modes
c. Number of operands
d. Types of operations supported.

6. What are the parameters used to evaluate the CPU performance? (May/June 2013) (R)

a. Pipelining
b. Caching.

7. What is the function of exception? (Nov/Dec 2012) (R)

a. The main function of exception is to detect the error internally.
b. It requires both prioritization and vectoring.

8. How is ARM processor different from other processors? (Nov/Dec 2012) (R)

ARM is a RISC (Reduced Instruction Set Computing) architecture **while** other processor being a CISC (Computer Instruction Set Computing) one.
In the ARM processor, arithmetic and logical operations cannot be perform directly on memory locations, while other processors allow such operations to directly reference main memory.

9. **When is application specific system processor (ASSPs) used in a embedded systems? (May/June 2012) (E)**

ASSP is a processing unit for specific task and for specific application. In embedded system for example image compression and that is integrated through the buses with the main processor in an embedded system.

10. **What are the various in embedded system designs modeling refining (or) partitioning?(May/June 2012) (R)**

i. Structural modeling
ii. Behavior modeling
iii. State machine modeling
iv. Process algebra modeling
v. Logic based modeling
vi. Petri-nets modeling.

11. **What is meant by absolute address?(April 2016) (R)**

An address of an exact location in memory.

12. **Define ACPI. (R)**

Advanced Configuration and Power Interface, an industry standard for power management interfaces

13. **What is meant by aspect ratio? (R)**

In a memory, the ratio of the number of addressable units to the number of bits read per request

14. **Define assembler. (R)**

A program that creates object code from a symbolic description of instructions

15. **What is auto-indexing**

Automatically incrementing or decrementing a value before or after using it.

16. **What is supervisor mode ? (R)**

A CPU execution mode with unlimited privileges

17. **What is meant by co-processor? (Nov/Dec 2013) (R)**

An optional unit added to a CPU that is responsible for executing some of the CPU's instructions.

18. **Compare RISC and CISC. (AZ)**

Complex instruction set computers (CISC) machines provided a variety of instructions that may perform very complex tasks, such as string searching; they also generally used a number of different instruction formats of varying lengths. One of the advances in the development of high-performance microprocessors was the concept of **reduced instruction set computers (RISC).** These computers tended to provide somewhat fewer and simpler instructions. RISC machines generally use **load/store** instruction sets—operations cannot be performed directly on memory locations, only on registers. The instructions were also chosen so that they could be efficiently executed in **pipelined** processors. Early RISC designs substantially outperformed CISC designs of the period. As it turns out, we can use RISC techniques to efficiently execute at least a common subset of CISC instruction sets, so the performance gap between RISC-like and CISC-like instruction sets has narrowed.

19. What are the instructions set characteristics? (R)

Instructions can have a variety of characteristics, including:

- Fixed versus variable length;
- Addressing modes;
- Numbers of operands;
- Types of operations supported

20. What are the assembly language features? (R)

Assembly languages features:

- One instruction appears per line;
- **Labels,** which give names to memory locations, start in the first column;
- Instructions must start in the second column or after to distinguish them from labels;
- Comments run from some designated comment character (; in the case of ARM) to the end of the line.

21. What is meant by data dependencies? (R)

A data dependency is a relationship between the data operated on by instructions.

22. What are the data types in ARM? (R)

The ARM architecture supports two basic types of data:

- The standard ARM word is 32 bits long.
- The word may be divided into four 8-bit bytes.

23. Why microcontroller is used in embedded development. (C)

Microcontroller is composed of most of ADC, timer, memory and application specific module which reduce the power consumption, size and cost of the embedded product.

PART B (16 MARKS)

1. Explain the major levels of embedded system design process with an example. **(April 2016)(U)**
2. Explain the instruction sets and condition codes of ARM processor with an example for each. **(Nov 2015) (U)**
3. Explain in detail about the challenges in embedded computing system design.**(Nov 2014) (U)**
4. Explain in detail about the embedded system design process for a Model Train Controller. **(April 2016)(C)**
5. Why ARM processor is demanded in embedded systems design.**(Nov 2014) (E)**
6. Explain in detail on memory system mechanism. **(Nov2012)(U)**
7. (i)Analyze in detail about the challenges in embedded computing system design.
   (ii)Find out how characters are copied from input to output using interrupts and buffers with the help of a program segment**. (April-2012)(AZ)**
8. i)What are the parameters to be considered while designing an Embedded System Process? **(Nov-2016)(R)**
   ii) State the importance of Structural and Behavioral description in detail.**(R)**
9. i) Draw the architecture of ARM processor.
   ii)List the various blocks of an Embedded System in detail**(R)**
10. i) Mention the major levels of abstraction in design process for GPS moving map.
    ii) Write down the major operations and data flows of a GPS moving map and draw

its Architecture.(R)

11. (i) Evaluate CPU performance.
    (ii)Determine various instruction set preliminaries. **(Nov/Dec 2016) (E)**
12. (i)Explain in detail about the characteristics of embedded computing applications.
    (ii)Explain in detail about supervisor mode, exception and traps. **(AZ)**
14. (i)Explain about caches and memory management units.
    (ii) Analyze the concept of Pipelining. **(AZ)**
14. (i)Write the data operations of an ARM processor
    (ii)Sketch the advanced ARM Processor features in detail **(R)**
15. (i)Discuss with a simple system namely, a model train controller, how will you use the UML to model systems?
    (ii).Summarize the operation of BL instruction; including the state of ARM registers before and after its operations.
    (iii) Discuss how do you return an ARM procedure?
16. i) Discuss about the CPU performance.
    Discuss in detail about Coprocessors. **(Nov/Dec 2016) (U)**
17. i)Demonstrate the operation of ARM processor.
    ii) Illustrate the advanced features of ARM Processor and explain **(A)**

UNIT 2: COMPUTING PLATFORM AND DESIGN ANALYSIS
PART A

1. **What is the bus protocols especially, the four-cycle handshake? (April 2014) (R)**
   Protocols are the set of rules and conditions for the data communication. The basic building block of most bus protocols is the four-cycle handshake. Handshake ensures that when two devices want to communicate. One is ready to transmit and other is ready to receive.The handshake uses a pair of wires dedicated to the handshake; such as **enq** (meaning enquiry) and **ack** (meaning acknowledge). Extra wires are used for the data transmitted during handshake.
2. **What is a data flow graph? (April 2014) (R)**
   A data flow graph is a model of a program with no conditions. In a high level programming language, a code segment with no conditions and one entry point and exit point.
3. **What are CPU buses? (Nov/Dec 2013) , (May/June 2013) (R)**
   Data bus, Address bus, Control bus and System bus.
4. **List out the various compilation techniques. (Nov/Dec 2013) (R)**
   a. There are three types of compilation techniques :
   b. Analysis and optimization of execution time.
      Power energy and program size
   c. Program validation and testing.
5. **State the basic principles of basic compilation techniques. (May/June 2013) (R)**
   a. Compilation combines translation and optimization.
   b. The high level language program is translated in to lower level form of instructions, optimizations try to generate better instruction sequences.
   Compilation = Translation + optimization
6. **Name any two techniques used to optimize execution time of program.(Nov/Dec 2012) (R)**
   Instruction level optimization and Machine independent optimization.
7. **What does a linker do? (Nov/Dec 2012) (R)**
   A linker allows a program to be stitched together out of several smaller pieces. The linker operates on the object files created by the assembler and modifies the assemble code to make the necessary links between files.
8. **What are the four types of data transfer in USB? (May/June 2012) (R)**
   Control transfer
   Interrupt transfer
   Bulk transfer
   Isochronous transfer
9. **Give the limitation of polling techniques. (May/June 2012) (R)**
   It is wasteful of the processors time, as it needlessly checks the status of all devices all the time. It is inherently slow, as it checks the status of all input/output devices before it comes back to check any given one again.
   Priority of the device cannot be determined frequently.

10. What are the components present in a typical embedded computing platform? (R)

A typical computing platform includes several major hardware components:

- The CPU provides basic computational facilities.
- RAM is used for program and data storage.
- ROM holds the boot program and some permanent data.
- A DMA controller provides direct memory access capabilities.
- Timers are used by the operating system for a variety of purposes.
- A high-speed bus, connected to the CPU bus through a bridge, allows fast devices to communicate efficiently with the rest of the system.
- A low-speed bus provides an inexpensive way to connect simpler devices and may be necessary for backward compatibility as well.

11. What is meant by single chip platform? (R)

A single-chip platform makes the development of certain types of embedded systems much easier, providing the rich software development of a PC with the low cost of a single-chip hardware platform. The ability to integrate a CPU and devices on a single chip has allowed manufacturers to provide single-chip systems that do not conform to board-level standards.

12. What is a bus master? (R)

In a typical bus system, the CPU serves as the **bus master** and initiates all transfers. If any device could request a transfer, then other devices might be starved of bus bandwidth. As bus master, the CPU reads and writes data and instructions from memory. It also initiates all reads or writes on I/O devices. We will see shortly that DMA allows other devices to temporarily become the bus master and transfer data without the CPU's involvement.

13. What are the major components of Bus? (R)

The major components on a typical bus include:

- *Clock* provides synchronization to the bus components;
- *R/W'* is true when the bus is reading and false when the bus is writing;
- *Address* is an *a*-bit bundle of signals that transmits the address for an access;
- *Data* is an *n*-bit bundle of signals that can carry data to or from the CPU; and
- *Data ready* signals when the values on the data bundle are valid.

14. What is DMA? (Nov/Dec 2013) (R)

Direct memory access (DMA) is a bus operation that allows reads and writes not controlled by the CPU. A DMA transfer is controlled by a **DMA controller,** which requests control of the bus from the CPU. After gaining control, the DMA controller performs read and write operations directly between devices and memory.

15. What are the signals provided by DMA? (R)

The DMA requires the CPU to provide two additional bus signals:

- The **bus request** is an input to the CPU through which DMA controllers ask for ownership of the bus.
- The **bus grant** signals that the bus has been granted to the DMA controller.

16. What is meant by reentrant of program? (R)

A program is reentrant if can be interrupted by another call to the function without changing the results of either call. If the program changes the value of global variables, it may give a different answer when it is called recursively.

17. What is cache controller?

Cache controller mediates between the CPU and the memory system comprised of the cache and main memory. The cache controller sends a memory request to the cache and main memory. If the requested location is in the cache, the cache controller forwards the location's contents to the CPU and aborts the main memory request; this condition is known as a cache hit. If the location is not in the cache, the controller waits for the value from main memory and forwards it to the CPU; this situation is known as a cache miss.

18. What is TLB?

A cache for address translation is known as a translation lookaside buffer (TLB). The MMU reads the TLB to check whether a page number is currently in the TLB cache and, if so, uses that value rather than reading from memory.

PART-B

1. i)Explain the building blocks for an Embedded System **(April 2016)** (4)
ii) Explain on how on chip memory management schemes can improve higher speed process. (12) (AZ)

2. Describe about Memory devices with suitable examples. (16) (U)
3. List any two factors which may be the cause for delay in peripheral interface (4)
ii) Briefly explain with neat diagrams on how DMA based processor can remove delay for higher speed process. (12)(R)

4. i) Discuss how component interfacing is done in embedded system in detail. (6)
ii) Describe the development environment of an embedded system with suitable diagram? (10)(U)

5. With a suitable example, explain how debugging is carried out using debuggers & compliers? **(April 2016)** (R)

6. (i)Evaluate how Logic analyzer, In circuit Emulator and Co simulator are used as debugging tools with examples. (12)
(ii) Justify the need of model of programs and Program design? **(April 2016)** (E)

7. (i)Elaborate briefly about Assembly and Linking. **(Nov/Dec 2013)** (10)
(ii)Investigate the importance of program Validation and testing? (6)(C)

8. (i)Write about Basic compilation techniques. (8)
(ii) List the various debugging process. **(Nov/Dec 2016)** (R)

9. (i)Describe briefly on the memory management & mapping techniques that

enhance the efficiency of the processor. **(Nov/Dec 2016)** (AZ)

10. Describe need for ICE, JTAG for embedded system development. (12)
Summarize the advantage of vectored addressing of stack? (4)(U)

11. Demonstrate the Model of Programs in detail. **(Nov/Dec 2013)** (8)
Illustrate about basic compilation techniques. (8)(A)

12. With a neat sketch explain the implementation of microprocessor/microcontroller based electronic voting machine also give the method of testing the system. Assume all other required relevant details. **(Nov/Dec 2013)** (AZ)

13. What do you mean by memory system interface with CPU? Explain with examples. **(April 2016)** (R)

14. (i)Illustrate with necessary diagrams about the design pattern, loop transformation and scheduling. (10)
(ii) Frame the key features of clear box testing. (6)(A)

UNIT 3 : PROCESS AND OPERATING SYSTEMS
PART A

1. What are the major inter process communication mechanism? (April 2014) (R)

- Shared memory communication
- Message passing.

2. Define context switching. (April 2014) , (Nov/Dec 2013) , (Nov/Dec 2012) (R)

a. Context switch is the computing process of storing and restoring of a CPU so that execution can be resumed from the same point at a later time.

b. The context switching is an essential feature of multitasking operation system.

3. Define processes. (Nov/Dec 2013) (R)

a. Process is a single execution of a program.

b. If we run the same program two different times, we have created two different processes. Each process has its own state that includes not only its register but also all of its memory.

4. List the process of scheduling policies. (May/June 2013) (R)

Cyclostatic scheduling, Time division multiple access scheduling Round robin scheduling.

5. What are the power optimization strategies used for processes? (May/June 2013) (R)

Avoiding a power-down mode can cost unnecessary power.

Powering down too soon can cause severe performance penalties.

6.What is the use of interrupts service routines?(May/June 2012) (R)

Input/output data transfer for peripheral devices. Input signals to be used for timing purpose.

Real time executives/multitasking Event driven program.

7.What are the three conditions that must be satisfied by the re-entrant function? (May/June 2012) (R)

A function is called re-entrant function when the following three conditions are satisfied All the arguments pass the values and some of the argument is a pointer whenever a calling function calls it. When an operation is not atomic, the function should not operate on any variable, which is declared but passed by reference not passed by arguments in to the function. That function does not call any other function that is not itself re-entrant.

8.Define paged addressing(May/June 2013) (R)

Division of memory into equal-sized pages

9.Define pipe

A POSIX interprocess communication mechanism.

10.Define platform , (Nov/Dec 2012) (R)

Hardware and associated software that is designed to serve as the basis for a number of different systems to be implemented.

11.What is priority inheritance

An algorithm to prevent priority inversion in which a process temporarily takes on the priority of a shared resource.

12. What is priority inversion (May/June 2013) (R)

A situation in which a lower-priority process prevents a higher-priority process from executing.

13.What is procedure?

A programming language construct that allows a single piece of code to be called at multiple points in the program.

14.What is priority-driven scheduling

Any scheduling technique that uses priorities of processes to determine the running process.

15.What is scheduling overhead? , (Nov/Dec 2012) (R)

The execution time required to make a scheduling decision

16.What is nonblocking communication? (May/June 2013) (R)

Interprocess communication that allows the sender to continue execution after sending a message.

17.What is memory management unit ?

A unit responsible for translating logical addresses into physical addresses .

PART-B

1. i)Compare RMS versus EDF. **(Nov/Dec 2016)** (8)
ii) Explain about Windows CE with a neat diagram. (8)(AZ)

2. i) Discuss the strategies behind running periodic processes. **(Nov/Dec 2013) (U)**
ii) Describe process state and scheduling. (8)(U)

3. i) Explain preemptive real time operating systems in detail. (8)
ii) Analyze the special characteristics of Processes and Internet with the help of a suitable diagrams. (8)(AZ)

4. i) Outline about priority based scheduling in detail. (8)
ii) Explain with the help of an example that the knowledge of data dependencies can help use the CPU more efficiently. (8)(AZ)

5. Describe in detail about the inter process communication mechanism**(Nov/Dec 2016)** (U)

(i) Shared Memory communication (4)
(ii) Message passing (4)
(iii)Signals (4)
(iv)Mailboxes (4)

6. i)Enumerate the context switch mechanism for moving the CPU from one executing process to another **(April 2016)(R)**
ii) State how the Kernel determines the order of the processes which has to be

executed. (R)

7. i)Evaluate operating system performance in detail.
ii) Justify the statement "Many Real Time Systems have been designed based on the assumption that there is no cache present, even though one actually exists." (8)(E)

8. i) Demonstrate in detail about power optimization strategies for CPU operation. (8)
ii) Illustrate how the Predictive shut down technique proved itself as more sophisticated. (8)(A)

9. .(i)Enumerate why an automobile engine requires multirate control
(ii) Recall the performance of the Earliest – Deadline – First scheduling with other scheduling algorithms with suitable example. **(Nov/Dec 2016)** (R)

10. (i)What is Real time operating system?
(ii) Mention the special features of POSIX with neat diagram. **(Nov/Dec 2016) (R)**

11. i)Summarize the services of operating system in handling multiple tasks and multiple processes.
ii) Outline the features of preemptive execution with the help of a sequence diagram. **(Nov/Dec 2013)** (U)

12. i) Investigate this statement with the help of an example. "The timing requirements on a set of process can strongly influence the type of appropriate scheduling".
ii) Why do we create a critical section using semaphores in operating system? (C)

13. (i) Illustrate an approach to cooperative multitasking in the PIC16F with the help of a program. What would happen if we put the tasks into Time Handler?
(ii) Examine about CPU usage metrics. (A)

14. (i) Mention in detail about Shared Resources. **(Nov/Dec 2016)**
(ii) Recognize the ARM atomic read/write operation in detail with the help of an example (R)

UNIT-4- SYSTEM DESIGN TECHNIQUES AND NETWORK
PART A

1. **List the OSI layers from lowest to highest level of abstraction. (April 2014)**

   The OSI layers from lowest to highest level of abstraction are described below:

   i. Physical layer
   ii. Data link layer
   iii. Network layer
   iv. Transport layer
   v. Session layer
   vi. Presentation layer
   vii. Application layer.

2. **What is a distributed embedded architecture? (April 2014)**

   In a distributed embedded system several processing elements are connected by a network that allows them to communicate. More than one computer or group of computer and PEs are connected via network that forms distributed embedded systems.

3. **What do you meant by accelerator/hardware accelerator? (Nov/Dec 2013)**

   An accelerator is one important category of processing element for embedded multiprocessor. It is attached to CPU buses to quickly execute certain key function. It provides large performance for many applications with computational kernels. It provides critical speedups for low-battery I/O functions.

4. **What is the use of attached accelerator to CPU? (May/June 2013)**

   The CPU accelerator is attached to the CPU bus. The CPU is also called the host. The CPU talks to the accelerator through the data and control registers in the accelerator.Control register allow the CPU to monitor the accelerator's operation and to give the accelerator commands. The CPU and accelerator will communicate via shared memory. The accelerator perform read and write operation directly. An accelerator interface is functionally equal to an I/O device but it does not perform input or output. CPUs and accelerators perform computations for specification.

5. **What are the merits of embedded distributed architecture? (Nov/Dec 2012)**

   Error identification is easier.
   It has more cost effective performance.
   Deadliness for processing the data is short.

6. **What is the role played by the accelerator in the design of embedded system? (Nov/Dec 2012)**

   One important category of PE for embedded multiprocessor is the accelerator.
   An accelerator is attached to CPU buses to quickly execute certain key functions. It can provide large performance increase, for many applications with computational kernels.

7. **What is priority inheritance? (May/June 2012)**

   Priority inheritance is a method of eliminating priority inversion, using this process scheduling algorithm will increase the priority of a process to the maximum priority of any process waiting for any resource on which the process has a resource lock.

8. **What is activation record (Nov/Dec 2012)**

A data structure that describes the information required by a currently active

9. What is Line Replaceable Unit in avionics?(R)

The certification process is a prime reason why avionics architectures are more conservative than automotive electronics systems. The traditional architecture for an avionics system has a separate unit for each function: artificial horizon, engine control, flight surfaces, etc. These units are known as line replaceable units (LRUs) and are designed to be easily plugged and unplugged into the aircraft during maintenance.

10. What is bus traction (R)

A bus transaction is comprised of a series of one-byte transmissions and an address followed by one or more data bytes. I2C encourages a data-push programming style. When a master wants to write a slave, it transmits the slave's address followed by the data. Because a slave cannot initiate a transfer, the master must send a read request with the slave's address and let the slave transmit the data. Therefore, an address transmission includes the 7-bit address and 1 bit for data direction: 0 for writing from the master to the slave and 1 for reading from the slave to the master

11. What is the use of bus arbitration? (Nov/Dec 2012)(R)

The bus uses this feature to arbitrate on each message. When sending, devices listen to the bus as well. If a device is trying to send a logic 1 but hears a logic 0, it immediately stops transmitting and gives the other sender priority. (The devices should be designed so that they can stop transmitting in time to allow a valid bit to be sent.) In many cases, arbitration will be completed during the address portion of a transmission, but arbitration may continue into the data portion. If two devices are trying to send identical data to the same address, then of course they never interfere and both succeed in sending their message.

12. **What is accelerator execution time? (Nov/Dec 2016)** (R)

A simple accelerator will read all its input data, perform the required computation, and then write all its results.

13. What is motion based coding?(R)

MPEG uses motion to encode one frame in terms of another. Rather than send each frame separately, as in motion JPEG, some frames are sent as modified forms of other frames using a technique known as block motion estimation.

14. What is Eight to fourteen encoding ? (Nov/Dec 2012)

The bits on the CD are not encoded directly. To help with tracking, the data stream must be organized to produce 0-1 transitions at some minimum interval. An eight-to-fourteen (EFM) encoding is used to ensure a minimum transition rate. For example, the eight bits of user data 00000011 are mapped to the fourteen bit code 00100100000000. The data are reconstructed from the EFM code using tables.

15. **What is jog memory? (Nov/Dec 2016)** (R)

A jog memory is used to buffer data to maintain playing during a jog to the drive. The player reads ahead and puts data into the jog memory. During a jog, the audio output system reads data stored in the jog memory while the drive tries to find the proper point on the CD to continue reading.

PART-B

1. Explain in detail about the following **(Nov/Dec 2016)**
   I) MPSoCs (8)
   II) Shared memory multiprocessor. (8) (AZ)

2.i) Explain the design methodology of an embedded computing system in detail. (8)
ii) Analyze the features of SDL Specification language with suitable diagrams. (8)(AZ)

3. i) Give the examples of the component networks in a federated network for an automobile. (8)
ii) Discuss a problem that led to the loss of Unmanned Martian space probe. (8)(U)

4. Discuss in detail about**(Nov/Dec 2016)**
   i) CAN Bus. (8)
   ii)I2C Bus. (8)(AZ)

5. i) Enumerate about Internet enabled Systems in detail. (8)
   ii)Mention the requirements needed to design an embedded system and how to determine them (8)(R)

6. i)With a neat diagram, describe the typical bus transactions on the I2C Protocol. (8)
ii) Discuss the role of distributed embedded architecture available for embedded systems. (8)(U)

7. Discuss in detail about
i) Characteristics of distributed embedded System. **(Nov/Dec 2016)** (U)
ii)Architecture of Distributed Embedded System with neat sketches. (8)(U)

8. (i)State in detail about CAN bus protocol and Ethernet with necessary diagrams? (8)
(ii) List the characteristics of high performance embedded platforms which act as heterogeneous multiprocessors. **(Nov/Dec 2013)** (R)

9. i) Demonstrate the operation of Ethernet enabled system. With a suitable example. (8)
ii)Illustrate scheduling and allocation in an accelerated embedded system with an help of suitable diagrams. (8)(A)
10. i) Demonstrate the single threaded and multithreaded control of an accelerator in the embedded system design. (8)
ii) Illustrate about the cache problem in a system involving an accelerator and suggest a method to overcome it. **(April 2016)** (A)

11. List
   i) The key features of Accelerated based embedded system. (8)
   ii) Characteristics of network based Embedded Systems in detail. (8)(R)

12. i) Justify how Poor Specifications can lead to Poor Quality Code. (8)
ii) Evaluate whether the aspects of a Poorly constructed specification necessarily

lead to Bad Software. (8)(E)

13. i) Propose a method for understanding the architectural design of a complex systems by using CRC Cards. **(Nov/Dec 2016)** (12)
ii) Elaborate the important criterions that can be considered for design reviews in Quality Assurance process. (4)(C)

14. Observe in detail about Quality Assurance Process using the following **(April 2016)**
i)Quality Assurance Techniques (8)
ii) Verifying the Specifications (8)(R)

UNIT 5: CASE STUDY
PART A

1. **What is a PDA? (April 2014) (R)**
   PDA (Personal Digital Assistant) is a device that can be used to receive, display and transcribe information. PDA can run a wide variety of applications.
2. **What is a set-top box or STB or STU? (April 2014) (R)**
   A set top box (STB) or set top unit (STU) is an information appliance device that generally contains a tuner and connects to a television set and an external source of signal, turning the source signal into content in a form that can then be displayed on the television screen or other display device.
   USES :
   a) Cable television and satellite television system.
3. **Write short notes on H/W and S/W co-design. (Nov/Dec 2013) (R)**
   Embedded systems architecture design is the task of selecting and programming a suitable configuration of components for a required system application. Building an embedded system is not an easy task. Every embedded system consist of an embedded hardware and embedded software.
4. **What are FOSS tools for embedded systems? (Nov/Dec 2013) , (May/June 2013) (R)**
   GNU Compiler Collection (gcc) and GNU debugger (gdb) are the most popular FOSS (Free and open source) tools used in embedded systems.
5. **List the major components in the Personal Digital Assistant System? (May/June 2013)**
   Process memory Connectivity
   Power management unit
   User interface.
5. **Why most designers use FOSS tools in embedded system development? (Nov/Dec 2012) (R)**
   Because,
   It makes software portable.
   It speeds up the development process
   It provides good foundation for system development activities.
6. **What is signal servicing function? (May/June 2012) (R)**
   The signal service is a bureau of the government organized to collect from the whole country simultaneously report to local metrological condition upon comparison of which at certain office, predictions concerning the weather are telegraphed to various sections also known as signal publicity display.
7. **Give the steps to destroy a message queue. (May/June 2012) (R)**
   (i) First delete all the element in a message queue.
   (ii) Check if Front = rear = -1, then queue is empty.
   (iii) Otherwise, now call a delete routine to destroy a message queue.

8. **Why multiprocessors are used? (Nov/Dec 2013) (R)**
   The reasons for multiprocessors are the same reasons that drive all of embedded system design: real-time performance, power consumption, and cost.

9. **What is the use of state chart? (May/June 2014) (R)**

The State chart is one well-known technique for state-based specification that introduced some important concepts. The Statechart notation uses an event-driven model. Statecharts allow states to be grouped together to show common functionality. There are two basic groupings: OR and AND.

10. **Differentiate functional and non functional requirement(R)**

A functional requirement states what the system must do, such as compute an FFT. A nonfunctional requirement can be any number of other attributes, including physical size, cost, power consumption, design time, reliability,

11. **What is Concurrent engineering? (May/June 2013) (R)**

Concurrent engineering attempts to take a broader approach and optimize the total flow. Reduced design time is an important goal for concurrent engineering, but it can help with any aspect of the design that cuts across the design flow, such as reliability, performance, power consumption, and so on. It tries to eliminate "over-the-wall" design steps, in which one designer performs an isolated task and then throws the result over the wall to the next designer, with little interaction between the two.

12. **What is successive refinement design methodology? (May/June 2013) (R)**

In this approach, the system is built several times. A first system is used as a rough prototype, and successive models of the system are further refined. This methodology makes sense when you are relatively unfamiliar with the application domain for which you are building the system. Refining the system by building several increasingly complex systems allows you to test out architecture and design techniques.

13. **What is Waterfall method(R)**

The waterfall development model consists of five major phases:requirements analysis determines the basic characteristics of the system; architecture design decomposes the functionality into major components; coding implements the pieces and integrates them; testing uncovers bugs; and maintenance entails deployment in the field, bug fixes, and upgrades.

14. **What is Time-to-market? (Nov/Dec 2013) (R)**

Customers always want new features. The product that comes out first can win the market, even setting customer preferences for future generations of the product. The profitable market life for some products is three to six months—if you are three months late, you will never make money.

15. **What is meant by Quality? (May/June 2013) (R)**

Customers not only want their products fast and cheap, they also want them to be right. A design methodology that cranks out shoddy products will soon be forced out of the marketplace. Correctness, reliability, and usability must be explicitly addressed from the beginning of the design job to obtain a high quality product at the end.

PART-B

1. Evaluate in detail the principle operation of software modem. (16) (E)
2. List the features of PDA and data compressor in detail. (16) (R)
3. Demonstrate in detail about Design Example of Alarm Clock? (16)(A)
4. Briefly explain the working of audio player in detail. (16) (R)

5. How will you design an application for Automatic chocolate vending machine in detail (16)(AZ)

6. Describe the following design stages used in the working of telephone answering machine in detail.(U)

i)Theory of operations and requirements. (4)
ii)Specification (4)
iii)System Architecture (4)
iv)Component designing and testing (2)
v)System integration and testing (2)

7. Develop the working of Engine control unit in detail.(C)

i)Theory of operations and requirements. (4)
ii)Specification (4)
iii)System Architecture (4)
iv)Component designing and testing (2)
v)System integration and testing (2)

8. Explain the working of video accelerator in detail**(Nov/Dec 2016)** (AZ)

i)Theory of operations and requirements. (4)
ii)Specification (4)
iii)System Architecture (4)
iv)Component designing and testing (2)
v)System integration and testing (2)

9. Draw the state diagram of Recording and playback message behavior.(R)

i)Theory of operations and requirements. (4)
ii)Specification (4)
iii)System Architecture (4)
iv)Component designing and testing (2)
v)System integration and testing (2)

10. Summarize the sequence diagram of taking picture with digital still camera**(April 2016)**.(U)

i)Theory of operations and requirements. (4)
ii)Specification (4)
iii)System Architecture (4)
iv)Component designing and testing (2)
v)System integration and testing (2)

11. Analyze the Hardware and Software design for Set-Top Box**(Nov/Dec 2013)**.(AZ)

i)Theory of operations and requirements. (4)
ii)Specification (4)
iii)System Architecture (4)
iv)Component designing and testing (2)
v)System integration and testing (2)

12. Discuss about the design of Data compressor and System on Silicon.(U)

i)Theory of operations and requirements. (4)

ii)Specification (4)
iii)System Architecture (4)
iv)Component designing and testing (2)
v)System integration and testing (2)

13. Write shorts notes on the following **(April 2016)** (AZ)
    i)Data Compressor
    ii)Software Modem (8)
14. Explain the FOSS tools for embedded system development (8)
    Explain the Hardware and Software Co design (8)(R)

ASSIGNMENTS

Assignment – 1 [Unit-I]

1. Survey on different processor architecture and suggest a suitable processor for development of real time processing system.
2. Compare LPC1768 with LPC2148 and suggest for a system which is more concerned on power consumption.
3. Compare ARM, AVR, and PIC processor.

Assignment – 2 [Unit-II]

1. Survey on different FOSS integrated development environment available for embedded software development.
2. Advocate on interpreter over compiler for software development.
3. Suggest a method for choosing suitable programming model for non critical system development.

Assignment – 3 [Unit-III]

1. Why OS is not encouraged in time critical system?
2. How to choose an embedded OS for embedded systems development?
3. Advocate on need of OS in embedded systems development.

Assignment – 4 [Unit-IV]

1. Survey on Qualcomm Snapdragon processor series and summarize the features.
2. Suggest a method of compromising anyone of the four facts in embedded systems development (Time to market, power consumption, cost, size).
3. Survey on different Automation system employed in Industrial Automation and in Medical field.

Assignment – 5 [Unit-V]

1. Summarize the working of Pacemaker with Wireless communication module.
2. Summarize the working of fire alarm systems.
3. Summarize the working of temperature controller in Air conditioner.

IT6005
DIGITAL IMAGE PROCESSING

UNIT I - DIGITAL IMAGE FUNDAMENTALS

PART A

1. Illustrate the term 'Image' (U)

An image may be defined as two dimensional light intensity function f(x, y) where x and y denote spatial co-ordinate and the amplitude or value of 'f 'at any point (x, y) is called intensity or grayscale or brightness of the image at that point.

2. What is a digital image? (R)

An image may be defined as two dimensional light intensity function f(x, y) where x and y denote spatial co-ordinate and the amplitude or value of 'f 'at any point (x, y) is called intensity or grayscale or brightness of the image at that point.
When x,y and the amplitude values of 'f' are all finite discrete quantities it is called a digital image.

3. What is a pixel? (U)

A digital image is composed of a finite number of elements, each of which has a particular location and value. These elements are referred to as picture elements, image elements, pels or pixels.

4. What are the applications of digital image processing? (R)

Digital image processing is applied in the following fields

- Remote sensing via satellite and spacecrafts
- RADAR and SONAR
- Biomedical applications-ECG,EEG,EMG etc.,
- Robotics
- Military applications
- Astronomy etc.,

5. What are the steps involved in DIP? (R)

- Image Acquisition
- Image enhancement and restoration
- Segmentation
- Color image processing
- Morphological processing
- Representation and Description
- Recognition and Interpretation
- Image compression.

6. What is morphological processing? (R)

Morphological processing deals with tools for extracting image components that are useful in the representation and description of shape.

7. Specify the elements of DIP system? (R)

- Image Sensors
- Specialized image processing hardware
- Image processing software

- Computer
- Mass storage
- Image displays

8. Explain the types of digital storage? (U)

- Short term storage for use during processing , ex: computer memory, frame buffers etc.,
- Online storage for relatively fast recall, ex: Magnetic disks or optical media storage
- Archival storage for rare access, ex: Magnetic tapes , juke boxes.

9. What are the membranes that enclose the eye? (R)

- The cornea and sclera
- The choroid and
- The retina

10. Differentiate photopic and scotopic vision. (U)

or

Differentiate cones and rods

Photopic Vision (Cones)	Scotopic Vision (Rods)
Cones are responsible for photopic or bright light vision	Rods are responsible for scotopic or dim light vision
6 to 7 million cones are present in each eye.	75 to 150 million rods are present in each eye.
Each cone is connected to its own nerve end which helps to resolve fine details	Several rods are connected to a single nerve hence the amount of details discernible is less.

11. Define Brightness (or) Subjective brightness. (R) (APR/MAY 2015)

Brightness is a subjective descriptor that is practically impossible to measure. Subjective brightness of an object is the luminance or intensity as perceived by the Human Visual System (HVS).

12. What is brightness adaptation? (U)

HVS (Human Visual System) cannot operate over a large range of brightness simultaneously. Rather ot accomplishes this large variation by changes in its overall sensitivity, this phenomenon is known as brightness adaptation.

13. Define Weber Ratio. (R)

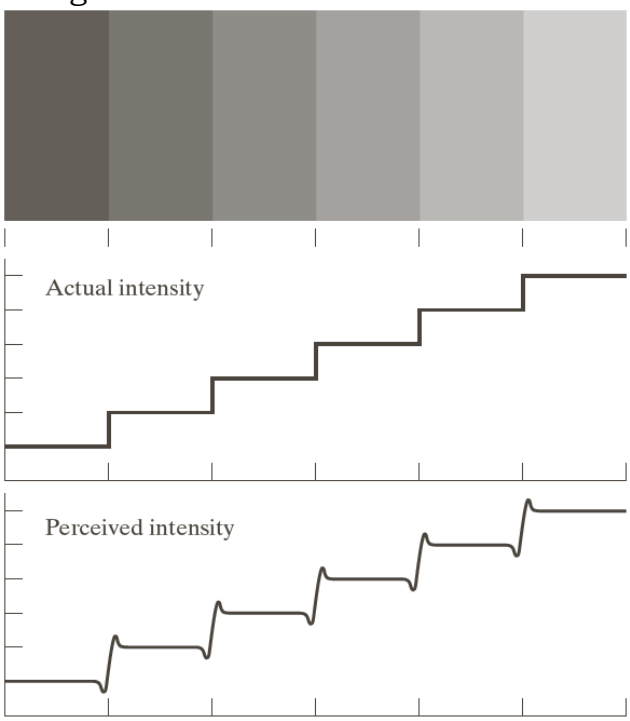
Weber Ratio = $\frac{\Delta Ic}{I}$

Where ΔIc is the increment of illumination discriminable 50% of the time with the background illumination I.

If the ratio is small it means good brightness adaptation, and large value of the ratio represents poor brightness discrimination

14. What is Mach Band Effect? (U) (NOV-DEC 2016) (MAY-JUN 2013/14/15)

It is based on the fact that Human Visual System tends to overshoot or undershoot around the boundary of regions of different intensities.



As shown above, although, the intensity of the stripes is constant, HVS perceive a brightness pattern that is strongly scalloped, especially near the boundaries. .These seemingly scalloped bands are called Mach Band after Ernst Mach (1865)

15. What is simultaneous contrast? (U) (APR/MAY 2015)

This phenomenon is related to the fact that a region's perceived brightness does not depend simply on its intensity. However, they appear to become darker as the background gets lighter.

a b c

Examples of simultaneous contrast. All the inner squares have the same intensity, but they appear progressively darker as the background becomes lighter.

16. Define Radiance and Luminance (R)

Radiance is the total amount of energy that flows from the light source and is usually measured in Watts (W).

Luminance gives a measure of the amount of energy an observer perceives from a light source; unit is lumens (lm).

17. Define hue, saturation and Contrast. (R) (MAY-JUN 2014)

Hue represents dominant color as perceived by an observer.

Saturation refers to relative purity or the amount of white light mixed with a hue.

Contrast is defined as the difference in intensity between the highest and lowest intensity levels in an image**.**

18. What is Pseudo-color image processing? (U)

It is the method in which to a particular monochrome intensity or range of intensities a color is assigned and processed. Thus in pseudo color image processing, full colors are not used.

19. What do you mean by Color model? (R)

A Color model is a specification of 3D-coordinates system and a subspace within that system where each color is represented by a single point.

20. List the hardware oriented color models and their applications. (R)

1. RGB model--- used for color monitors & color video camera
2. CMY/CMYK model---used for color printing
3. HSI model----used for color image processing
4. YIQ model---used for color picture transmission

21. Define Resolutions? (R)

Resolution is defined as the smallest number of discernible detail in an image.

Spatial resolution is the smallest discernible detail in an image, unit is line pairs /unit distance, dots per unit distance or dpi (dots per inch)

Gray level resolution or Intensity resolution refers to the smallest discernible change is gray level.

22. What is meant by illumination and reflectance? (R)

Illumination is the amount of source light incident on the scene. It is represented as i(x, y).

Reflectance is the amount of light reflected by the object in the scene. It is represented by r(x, y).

23. Define sampling and quantization. (R)

Sampling means digitizing the co-ordinate value (x,y) of the image. Sampling is the primary factor that determines the spatial resolution of the image.

Quantization means digitizing the amplitude value of the image. Quantization is the primary factor that determines the gray level resolution of the image.

24. Write the expression to find the number of bits to store a digital image? (R)

The number of bits required to store a digital image is b=M x N x k

Where M x N, refers to the size of the image and k refers to the number of bits per pixel. When M=N, this equation becomes $b=N^2k$

25. Find the number of bits required to store a 256 X 256 image with 32 gray levels? (A)

Given: 32 gray levels (i.e., L=32)

L= 2^k= 32, therefore k= 5 bits

256 * 256 * 5 = 3,27,680 bits.

26. What do you meant by Zooming and shrinking of digital images? (R)

Zooming may be viewed as over sampling. It involves the creation of new pixel locations and the assignment of gray levels to those new locations.

Shrinking may be viewed as under sampling. To shrink an image by one half, we delete every alternate row and column.

27. Define N_4(p) . (R)

A pixel p at coordinates (x,y) has four horizontal and vertical neighbors whose coordinates are given by (x +1,y),(x-1,y),(x,y+1),(x,y-1).This set of pixels are called 4-neighbors of p denoted by N_4(p).

	(x,y-1)	
(x-1,y)	p(x,y)	(x+1,y)
	(x,y+1)	

4 neighbors; the set of horizontal and vertical neighbors

28. Define N_D (P). (R)

The four diagonal neighbors of p have coordinates (x+1,y+1),(x+1,y-1),(x-1,y+1),(x-1,y-1) and are denoted by N_D(p).

(x-1,y-1)		(x+1,y-1)
	p(x,y)	
(x-1,y+1)		(x+1,y+1)

Diagonal neighbors; the set of 4 diagonal neighbors.

29. Define N_8(p). (R)

Diagonal neighbors together with the 4-neighbors are called 8-neighbors of p, denoted by N_8 (p). Some of the points in N_D (p) and N_8(p) fall outside the image if f(x,y) is on the border of the image if f (x,y) is on the border of the image. Eight neighbors is non-uniform distance from P. Effectively we have N_8(p)=N_4(p)+N_D(p).

(x-1,y-1)	(x,y-1)	(x+1,y-1)
(x-1,y)	p(x,y)	(x+1,y)
(x-1,y+1)	(x,y+1)	(x+1,y+1)

Eight neighbors

30. What are the types of adjacency and define them. (R)

Three types of adjacency:

- 4 -adjacency
- 8-adjacency
- m-adjacency

4-adjacency : Two pixels p and q are 4- adjacent if q is in the set $\mathbf{N_4(p)}$ **.**

8-adjacency: Two pixels p and q are 8- adjacent if q is in the set $\mathbf{N_8(p)}$

m-adjacency: Let V be the set of gray level values used to define adjacency. Two pixels p and q with values from V are said to m-adjacent if

i. q is in $N_4(p)$ (or)

ii. q is in N_D (P) and the set $N_4(p) \cap N_4(q)$ has no pixels whose values are from V.

31. Define connectivity and explain their types. (R)

Two pixels are said to be connected if

a. they are neighbors and

b. their gray levels satisfy a specified criterion of similarity

Types of connectivity:

1. 4 connectivity
2. 8 connectivity
3. m-connectivity (mixed connectivity)

32. Give the formula for calculating Euclidean distance, D_4 (city block distance), D_8 (chess board distance). (R)

Consider two pixels p,q with co-ordinates (x,y) and (s,t) respectively, three types of distances are defined as:

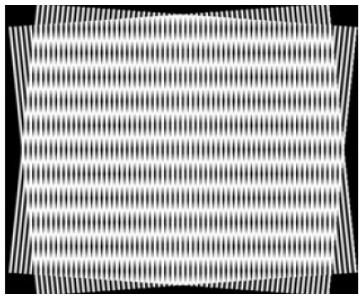
Euclidean Distance, $D_e(p,q) = \sqrt{(x-s)+(y-t)}$

City block distance, $D_4(p, q) = |x-s| + |y-t|$

Chess board distance, $D_8(p, q) = \max(|x-s|, |y-t|)$.

33. What is Moire pattern (or) How is aliasing defined with respect to images? (R)

If the two dimensional function (i.e., the image) is under sampled then a phenomenon called aliasing corrupts the sampled images. The corruption is in the form of additional frequency components being introduced into the sampling function. These are called aliasing frequencies. The effect of aliased frequencies can be seen in the form of 'Moire Patterns' as shown in figure.



34. What is false contouring? (R) (MAY-JUN 2013)

If the number of quantization levels is not sufficient a phenomenon called false contouring becomes visible. When groups of neighboring pixels are quantized to the same value, regions of constant gray levels are formed , whose boundaries are called contours.

35. How to overcome the effect of false contouring? (U)

False contouring can be held below the level of visibility by using the following two methods.

i) Contrast Quantization
ii) Pseudorandom Quantization (Dither).

36. What is dither (Pseudorandom Quantisation)? (R)

Dither is a method used to reduce the effect of false contouring. A small amount of uniformly distributed pseudorandom noise is added to the luminance samples before quantization. This pseudorandom noise is called dither.

37. Define checkerboard effect. (R) (MAY-JUN 2013), (NOV-DEC 2016)

Checkerboard pattern or effect is a degradation that results due to the reduction is spatial resolution. When lower resolution images are replicated to larger size, the pixel values are replicated to fill the display area leading to checkerboard effect.

PART B

1. Explain the steps involved in digital image processing. **(OR)** Explain various functional blocks of digital image processing. **(U)**
2. Describe the elements of visual perception and image formation in the eye. **(U) (NOV-DEC 2013)**
3. With necessary diagrams explain sampling and quantization. **(OR)** With necessary diagrams explain how an analog image is converted into digital image. **(R) (NOV-DEC 2016) (APR-MAY 2015) (MAY-JUN 2013)**
4. Describe the components of digital image processing system with neat diagram. (**OR)** What are the elements of an image processing system and describe its working? How this is used for weather forecasting applications? **(R) (MAY-JUN 2014)**
5. What is a color model? What are its types? Explain RGB and HSI color models with necessary diagrams. **(R) (NOV-DEC 2016)V (NOV-DEC 2015)**
6. Explain digital camera working principle. **(U) (NOV-DEC 2015)**
7. With necessary diagram explain the construction and principle of operation of a Vidicon Camera tube. **(R) (NOV-DEC 2013)**
8. Explain the various distance measures used for Image analysis. **(NOV-DEC 2016)**
9. What is a frame buffer ? Discuss the categories of digital storage for image processing applications. **(R)**
10. What is meant by the Image Sensing? Explain in detail the construction and operation of various Image sensing and Acquisition devices. **(R) (NOV-DEC 2016)**

UNIT II
IMAGE ENHANCEMENT

PART A

1. Specify the objective of image enhancement technique. (U)

The objective of enhancement technique is to process an image so that the result is more suitable than the original image for a particular application.

2. Explain the 2 categories of image enhancement. (R)

Image Enhancement methods are broadly classified into two types: i)Spatial domain methods and ii) Frequency domain methods.

i)Spatial domain refers to image plane itself & approaches in this category are based on direct manipulation of pixels in an image.

ii)Frequency domain methods are based on enhancing the image by modifying its fourier transform.

3. What are the types of spatial domain processing? (R)

Spatial domain processing methods are classified into three types:

i. Point Processing
ii. Mask Processing
iii. Global Operation

Point Processing is an image enhancement technique in which enhancement at any point in an image depends only on the gray level at that point

In mask processing each pixel is modified according to the values in a predefined neighborhood.

In global operation, all pixel values in the image are taken into consideration for the enhancement process.

4. What is meant by gray level transformation? What are its types? (R)

Gray level transformation is the simplest of all image enhancement techniques. It is a point processing method. In this method each pixel value in the original image is mapped on to a new pixel value to obtain the enhanced image. In its general form, a gray level transformation is represented as,

$$s = T(r)$$

Where 'r' denotes the pixel value before processing, 's' denotes the pixel value after processing and T represents the transformation that maps a pixel value 'r' to a pixel value 's'.

Types of Gray Level Transformation

1. Image Negative
2. Log Transformations
3. Power Law Transformations
4. Piece wise linear Transformations

5. What is Image Negatives? (U)

The negative of an image with gray levels in the range [0, L-1] is obtained by using the negative transformation, which is given by the expression.

$$s = (L-1)-r$$

Where s is output pixel, r is input pixel

6. What is contrast stretching/Adjustment? (R)) (NOV-DEC 2013)

Contrast stretching is an enhancement technique used to increase the dynamic range of the gray levels in an image.

7. What is thresholding? (R)

Thresholding is an image enhancement technique that create a binary image. All gray level values above a threshold 'T' is mapped to (L-1) and gray level values below the threshold is mapped to 0.

$$s = \begin{cases} 0, r < T \\ L-1, otherwise \end{cases}$$

8. What is grey level slicing? (R)

Highlighting a specific range of grey levels in an image often is desired. It displays a high value for all gray levels in the range of interest. Applications include enhancing features such as masses of water in satellite imagery and enhancing flaws in x-ray images.

9. Define image subtraction. (R)

The difference between 2 images f(x,y) and h(x,y) expressed as,

$$g(x,y)=f(x,y)-h(x,y)$$

The difference image g(x,y) is obtained by computing the difference between all pairs of corresponding pixels from f and h.

10.What is image averaging? Give its application. (R)

It is a process of adding a set of noisy images and then averaging. Image averaging is done to reduce the noise content in the image.

An important application of image averaging is in the field of astronomy, where imaging with very low light levels is routine, causing sensor noise frequently to render single images virtually useless for analysis.

11. What is meant by mask? (R)

Mask is the small 2-D array in which the values of mask co-efficient determines the nature of process. The enhancement technique based on this type of approach is referred to as mask processing.

12.What is meant by bit plane slicing? (R)) (NOV-DEC 2016)

Highlighting the contribution made to total image appearance by specific bits might be desired. Suppose that each pixel in an image is represented by 8 bits. Imagine that the image is composed of eight 1-bit planes, ranging from bit plane 0 for LSB to bit plane-7 for MSB. Highlighting the higher order bit planes to achieve enhancement is called bit plane slicing.

13.Define Histogram. (R)

The histogram of a digital image with gray-levels in the range [0, L-1] is a discrete function, $h(r_k) = n_k$, where r_k is the kth gray level and n_k is the no. of pixels in the image having gray level r_k. Histogram is a plot of r_k vs n_k.

14. What is meant by histogram equalization or histogram linearization? (R)

Histogram equalization is an image enhancement process that attempts to spread out the gray levels in an image so that they are evenly distributed across their range. Histogram equalization produces an output image that has a uniform histogram.

The transform is given by,

$$s_k = T(r_k) = \sum_{j=0}^{k} p_r(r_j)$$

$$= \sum_{j=0}^{k} \frac{n_j}{n} \qquad k = 0, 1, 2, \ldots, L-1$$

Thus a processed (output) image is obtained by mapping each pixel with level r_k in the input image to a corresponding pixel with level s_k in the output image.

15. What are the advantages of histogram equalization? (R)) (NOV-DEC 2015)

1. Histogram Equalization produces image with gray level values that cover the entire gray scale.
2. Histogram Equalization is fully automatic i.e. histogram equalization is only based on information that can be directly extracted from the given image.
3. Very simple computation.

16. What is meant by Histogram Matching (or) Histogram Specification) (R)

The method used to generate a processed image that has a specified histogram is called histogram matching or histogram specification. It allows the user to specify the shape of the histogram that the processed image is supposed to have.

17. What is a smoothing filter and what are its types? (R)

Smoothing filters are used for noise reduction and blurring. Smoothing filters remove the high frequency components hence it is also called as low pass filters. Smoothing filters are broadly classified into two types: i) Linear smoothing spatial filters and ii) Non linear smoothing spatial filters

18. Give some examples of linear smoothing spatial filters? (U)

i) Mean filters
   a)Box filter
   b)Weighted Average filter
ii) Geometric filters
iii) Harmonic filter
iv) Contra harmonic filter

19. What is a non linear smoothing spatial filters or order statistics filter? What are its types? (R)

These are spatial filters whose response is based on ordering the pixels contained in the image area encompassed by the filter.

Types of order statistics filters

Median filter
Max and Min filter
Midpoint filter
Alpha trimmed mean filter

20.What are the applications of smoothing filters?(U)

Smoothing filters are used for

i) removal of random noise
ii) Smoothing of false contours
iii) reduction of irrelevant details in an image.

21. Explain spatial filtering /Averaging ?(R) (MAY-JUN 2014)

Spatial filtering is the process of moving the filter mask from point to point in an image. For linear spatial filter, the response is given by a sum of products of the filter coefficients, and the corresponding image pixels in the area spanned by the filter mask.

22.What is a sharpening filter ?(R)

Sharpening filters are used to highlight fine details in an image or to enhance details that has been blurred. Sharpening filters are called as high pass filters. Derivative filters are used for image sharpening. First order derivative filter produces thicker edges in an image. Second order derivative filter produces thin edges in an image.

23. Name the different types of derivative filters?(R)

Derivative filters are of two types: First Order Derivative Filters and Second Order Derivative Filters.

First Order Derivative Filters (Gradient Operators)

Roberts cross gradient operators
Prewitt operators
Sobel operator

Second Order Derivative Filters

Laplacian Filters

24. Define first order derivative filter or Gradient filter ? (R)

For a function f(x, y), the gradient of *f* at coordinates (x, y) is defined as the two-dimensional column *vector*

$$\nabla \mathbf{f} = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix}$$

The magnitude of this vector is given by

$$\begin{aligned} \nabla f &= \text{mag}(\nabla \mathbf{f}) \\ &= [G_x^2 + G_y^2]^{1/2} \\ &= \left[\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2 \right]^{1/2} \end{aligned}$$

25. Define the second order derivative filter or Laplacian operators. (R)

Second order derivative filters are commonly referred to as Laplacian operators. Laplacian is a linear isotropic filters. A simple Laplacian operator for a function (image) f(x,y) is defined as,

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

Where,

$$\frac{\partial^2 f}{\partial^2 x^2} = f(x+1, y) + f(x-1, y) - 2f(x, y)$$

$$\frac{\partial^2 f}{\partial^2 y^2} = f(x, y+1) + f(x, y-1) - 2f(x, y)$$

The digital implementation of the two-dimensional Laplacian is obtained by summing these two components:

$$\nabla^2 f = [f(x+1, y) + f(x-1, y) + f(x, y+1) + f(x, y-1)] - 4f(x, y).$$

Simple laplacian masks are given by,

0	1	0
1	−4	1
0	1	0

1	1	1
1	−8	1
1	1	1

0	−1	0
−1	4	−1
0	−1	0

−1	−1	−1
−1	8	−1
−1	−1	−1

26.Define Robert's cross, Prewitt's and Sobel's Operators. (R)

Robert's Cross operator:

Robert's cross gradient operators is defined using a 2 x2 masks as,

$$\Delta f \simeq |G_x| + |G_y| = (Z_9 - Z_5) + (Z_8 - Z_6)$$

Roberts cross Gradient operators

-1	0
0	1

0	-1
1	0

Prewitt's Operator

Prewitt's operator is defined using a 3 x 3 mask and the digital approximation of the Prewitt's operator is defined as,

$$\nabla f \approx |(z_7 + z_8 + z_9) - (z_1 + z_2 + z_3)| + |(z_3 + z_6 + z_9) - (z_1 + z_4 + z_7)|$$

Prewitt's operators

-1	-1	-1
0	0	0
1	1	1

-1	0	1
-1	0	1
-1	0	1

Sobel's Operator

The Sobel's operators is defined as,

$$\nabla f \approx |(z_7 + 2z_8 + z_9) - (z_1 + 2z_2 + z_3)| + |(z_3 + 2z_6 + z_9) - (z_1 + 2z_4 + z_7)|.$$

Sobel operators

-1	-2	-1
0	0	0
1	2	1

-1	0	1
-2	0	2
-1	0	1

27. Write the application of sharpening filters? (U)

Important applications of sharpening filters are in the fields of

1. Electronic printing
2. Medical imaging
3. Industrial application
4. Autonomous target detection in smart weapons.

28.What is an isotropic filter? (R)

Isotropic filters are rotation invariant filters i.e., rotating the image and then applying the filter gives the same result as applying the filter to the image first and then rotating the result. Example: **Laplacian filter**

29.List the applications of spatial enhancement filters (or) Sharpening Filters? (R)

i) Printing industry
ii) Image based product inspection
iii) Forensics
iv) Microscopy
v) Surveillance etc.

30.What is unsharp masking? (R)) (NOV-DEC 2016)

Unsharp masking is the process of subtracting a blurred version of an image from the original image itself to sharpen it. Unsharp masking is defined as,

$$f_s(x,y) = f(x,y) - \bar{f}(x,y)$$

Where f(x,y) refers to the original image, $\bar{f}(x,y)$ refers to the blurred version of f(x,y) and $f_s(x,y)$ refers to the sharpened image obtained. Unsharp masking is used in the publishing industry to sharpen images.

31.What is high boost filtering? (R)

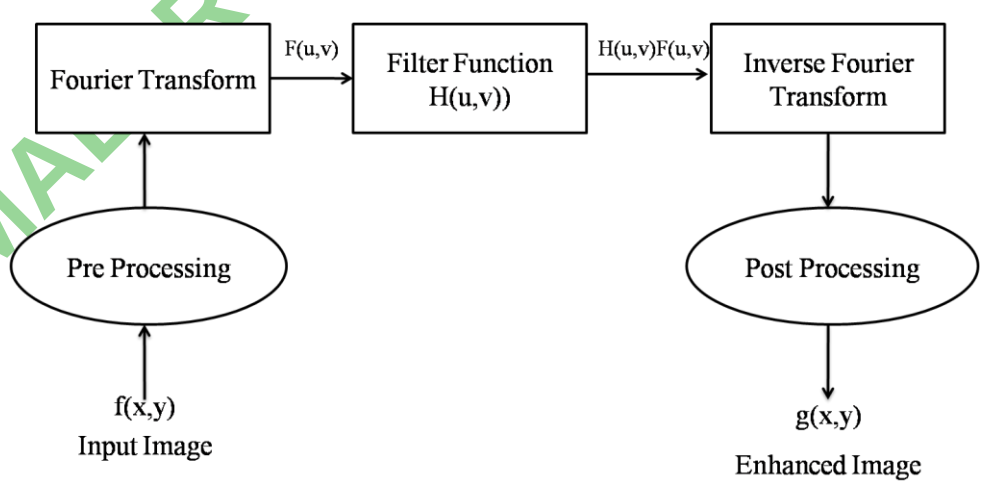
High boost filtering is a slight modification of unsharp masking. A high boost filtered image f_{hb} is defined as,

$$f_{hb}(x,y) = Af(x,y) - \bar{f}(x,y)$$

Where A ≥ 1, f(x,y) refers to the original image, $\bar{f}(x,y)$ refers to the blurred version of f(x,y) and $f_{hb}(x,y)$ *refers to the* sharpened image obtained.

32. Write the steps involved in frequency domain filtering. (A)

1. Multiply the input image by $(-1)^{x+y}$ to center the transform.
2. Compute F(u,v), the DFT of the image from (1).
3. Multiply F(u,v) by a filter function H(u,v).
4. Compute the inverse DFT of the result in (3).
5. Obtain the real part of the result in (4).
6. Multiply the result in (5) by $(-1)^{x+y}$



33.What are the types of frequency domain filters? (R)

Freqeuncy domain filters are classified into two types: i) Low Pass Filters ii) High Pass Filters

Type of Low Pass Filters(Smoothing Filters)

Ideal Low Pass Filters
Butterworth Low Pass Filters
Gaussian Low Pass Filters

Types of High Pass Filters (Sharpening Filters)

Ideal High Pass Filters
Butterworth High Pass Filters
Gaussian High Pass Filters

34.Give the filter function of ideal low pass filter and high pass filter ? (R)

The filter function of Ideal Low Pass Filter is given as,

$$H(U,V) = \begin{cases} 1 & if\ D(U,V) \leq D_0 \\ 0 & if\ D(U,V) > D_0 \end{cases}$$

The filter function of Ideal High Pass Filter is given as,

$$H(u,v) = \begin{cases} 0 & if\ D(U,V) \leq D_0 \\ 1 & if\ D(U,V) > D_0 \end{cases}$$

Where D_0 is the cutoff distance, D(u,v) is the distance from the point (U,V) in the image to the origin of the frequency rectangle.

35.Give the filter function of butterworth low pass filter and high pass filter ? (R)

A Butterworth Low Pass filter of order n is defined as,

$$\boldsymbol{H(U,V) = \frac{1}{1 + \left[\frac{D(U,V)}{D_0}\right]^{2n}}}$$

A Butterworth High Pass filter of order n is defined as,

$$\boldsymbol{H(U,V) = \frac{1}{1 + \left[\frac{D_0}{D(U,V)}\right]^{2n}}}$$

Where D_0 is the cutoff distance, D(u,v) is the distance from the point (U,V) in the image to the origin of the frequency rectangle.

36.Give the filter function of Gaussian low pass filter and high pass filter ? (R)

The filter function of Gaussian low pass filter is given by,

$$H(U,V) = e^{-D^2(U,V)/2\sigma^2} = e^{-D^2(U,V)/2{D_0}^2}$$

The filter function of Gaussian high pass filter is given by,

$$H(U,V) = 1 - e^{-D^2(U,V)/2\sigma^2} = 1 - e^{-D^2(U,V)/2{D_0}^2}$$

Where D_0 is the cutoff distance, D(u,v) is the distance from the point (U,V) in the image to the origin of the frequency rectangle.

37.What is homomorphic filtering? (R)

It is a frequency domain procedure for improving the appearance of an image by simultaneous gray level range compression and contrast enhancement using illumination-reflectance model.

PART B

1. Discuss the various of gray level transformation used for image enhancement. **(U)**
2. What is histogram equalization and explain with suitable example how it is used to enhance an image. **(R) (NOV-DEC 2016/2015) (APR-MAY 2015)**
3. What is histogram specification and explain with suitable example how it is used to enhance an image. **(R)**
4. Explain in detail linear spatial smoothing filters. **(R) (NOV-DEC 2013)**
5. Explain in detail non linear spatial smoothing filters **(R)**
6. Explain Homomorphic filtering in detail. **(R) (MAY-JUN 2013/14)(NOV-DEC 2014**
7. Explain the various spatial filters used for image sharpening. **(R)**
8. Explain the various image enhancement techniques in the frequency domain. **(R)) (NOV-DEC 2016)**
9. Explain gradient operators for Image Enhancement **(NOV-DEC 2016)**

UNIT III
IMAGE RESTORATION AND SEGMENTATION

PART A

1. What is meant by Image Restoration? (R)

Restoration attempts to reconstruct or recover an image that has been degraded, by using a clear knowledge of the degrading phenomenon.

2.What are the types of noise models? (R)

i. Gaussian noise
ii. Rayleigh noise
iii. Erlang noise
iv. Exponential noise
v. Uniform noise
vi. Impulse noise

3.What is salt and pepper noise? Suggest a filter to remove salt and pepper noise in images. (R)

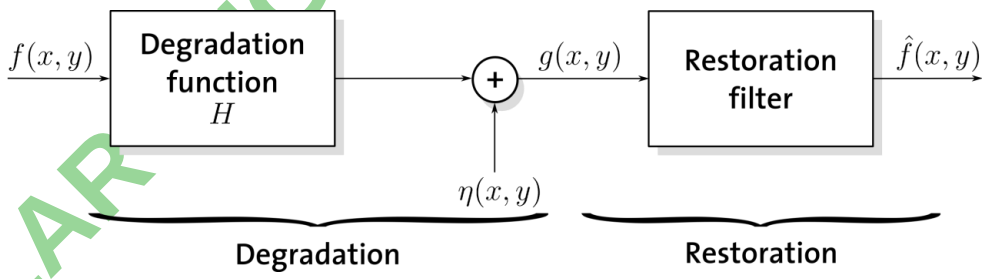
Bipolar impulse noise is called as Salt and Pepper Noise. Median filter is the most suitable filter to remove salt and pepper noise in images.

4.What is periodic noise ? (R)

Periodic noise arises typically from electrical or electromechanical interference during image acquisition**.**

5. How a degradation process is modeled? (U) (MAY-JUN 2013/2015)

The Image degradation/ restoration model is given as,



Degradation:

A system operator H (degradation function), together with an additive white noise term η(x,y) operates on an input image f(x,y) to produce a degraded image g(x,y).

Restoration

The restoration filter which is inverse of the degradation function is used to obtain an estimate of the original image from the degraded image.

6. What is fredholm integral of first kind? (R)

The equation,

$$g(x,y) = \iint_{-\infty}^{+\infty} f(\alpha,\beta)h(x,\alpha,y,\beta)d\alpha d\beta$$

which is called the superposition or convolution or fredholm integral of first kind. It states that if the response of H to an impulse is known, the response to any input f(α,β) can be calculated by means of fredholm integral.

7. What is a Median filter? What are its properties? (R)

The median filter replaces the value of a pixel by the median of the gray levels in the neighborhood of that pixel.

Median filter has the following properties:

i) A median filter smoothens additive white noise

ii) A median filter doesnot degrade edges

iii) A median filter is effective in removing impulses. (salt and pepper noise).

8. What is maximum filter and minimum filter? (R)

The 100th percentile is maximum filter, that is a **Max** filter replaces the value of a pixel by the maximum value of the gray levels in the neighborhood of that pixel. It is used in finding brightest points in an image and is effective in removing pepper noise.

The 0th percentile filter is minimum filter, that is a **Min** filter replaces the value of a pixel by the minimum value of the gray levels in the neighborhood of that pixel. It is used in finding darkest points in an image and is effective in removing salt noise.

9. What is goemtric mean filtering ? (R)

Geometric mean filter achieves smoothing better than the arithmetic mean filter. The amount of details lost in the geometric mean filtering is lesser. The filter is given by,

$$f(x,y) = \left[\prod_{(s,t)\in S_{xy}} g(s,t)\right]^{1/mn}$$

The product of the pixel values in the defined neighborhood raised to the power of 1/mn, gives the restore pixel value.

10.Write the need for adaptive median filter? (R)

Though median filter is effective in removing impulse noise, the fine details in the image are lost since the impulses are replaced with median values. Thus adaptive median filters are used to overcome this disadvantage of median filter.

11.What are the filters that can be used to remove periodic noise? (R)

Frequency domain filters are to be used to remove periodic noise in images. The commonly used frequency domain filters are,

Notch Filters

- Notch Reject filters
- Notch Pass filters

Optimum notch filters

12. Is 100% restoration possible. Justify. (E)

100% restoration is possible only if the true degradation function is known and the image is degraded only due to this degradation function. If the image is degraded by additive noise, 100% restoration is not possible.

13. Differentiate image enhancement and image restoration. (U) (NOV-DEC 2015)

Image Enhancement	**Image Restoration**
Image enhancement is a subjective process i.e., it is a heuristic procedure designed to manipulate an image in order to please the viewer. Modeling of degradation process is not required. Apriori knowledge of the degradation is not required. Ex: Contrast stretching	Restoration techniques are oriented towards modeling the degradation and applying the inverse process in order to recover the original image. Modeling of degradation is a must Apriori knowledge of the degradation function is required to model the degradation function. Ex: Removal of motion blur

14.What are the commonly used image restoration filters? (R)

Commonly used restoration filters are, i)Inverse Filter ii) Wiener Filter iii) Pseudo Inverse Filter.

15. What is inverse filtering? (R)

The simplest approach to restoration is direct inverse filtering, an estimate F^(U,V) of the transform of the original image simply by dividing the transform of the degraded image G(U,V) by the degradation function.

$$\hat{F}(U,V) = G(U,V)/H(U,V)$$

16. What is meant by blind image restoration? (R)

The process of restoring an image whose true degradation function is not known completely is call blind deconvolution or blind image restoration.

17.What are the disadvantage of wiener filter? (R)

i) Some knowledge of the degradation function is required

ii) Power spectra of the undegraded image and noise must be known.

18.What are the causes of degradation in an image? (R) (NOV-DEC 2016)

The degradations may be in the form of

- sensor noise
- blur due to camera misfocus
- relative object-camera motion(motion blur)
- random atmospheric turbulence and so on.

19. What is segmentation? (R)

Segmentation subdivides on image in to its constitute regions or objects. The level

to which the subdivision is carried depends on the problem being solved .That is segmentation should stop when the objects of interest in application have been isolated.

20. Write the applications of segmentation. (R)

Segmentation is the foremost step for all the detection and recognition applications. The applications of segmentation are,

i. Detection of cancerous cells from medical images

ii. Segmentation of roads from satellite images

iii. Vehicle Number Plate recognition

iv. Handwritten character recognition

21. How are edges detected in images? (U)

Derivatives are used to detect the edges in images.

- First order derivative filters are used to detect the presence of edge.

  Example:

  - Robert's Cross Gradient Operator
  - Prewitt's Operator
  - Sobel's Operator
- Second order derivative filters are used to detect the thin edges that is the fine details in the image. Example : Laplacian

22. Write about linking edge points. (R)

The approach for linking edge points is to analyze the characteristics of pixels in a small neighborhood (3x3 or 5x5) about every point (x,y)in an image that has undergone edge detection. All points that are similar are linked, forming a boundary of pixels that share some common properties.

23. What are the two properties used for establishing similarity of edge pixels? (R)

(i) The strength of the response of the gradient operator used to produce the edge pixel.

(ii) The direction of the gradient.

24. What is edge? What are its types? (R)

An edge is a set of connected pixels that lie on the boundary between two regions.

Types of Edges:

Ideal Edge
Ramp Edge
Line Edge
Roof Edge

25. Give the properties of the second order derivative around an edge? (R)

- The sign of the second order derivative can be used to determine whether an edge pixel lies on the dark or light side of an edge.
- It produces two values for every edge in an image.
- An imaginary straight line joining the extreme positive and negative values of the second derivative would cross zero near the midpoint of the edge.

26. What is meant by zero crossing property of second order derivative ? (R)

An imaginary line joining the extreme positive and negative values of the second derivative would cross zero near the midpoint of the edge. This property is called zero crossing property and is used for locating the centre of thick edges.

27. What are the disadvantages of Laplacian operator? (R)

- It is very sensitive to noise.
- Magnitude of Laplacian produces double edges, hence it complicates segmentation.
- Laplacian is unable to detect edge direction.

28. What is LoG (Laplacian of Gaussian) or Mexican hat function? (R) (NOV-DEC 2016)

To overcome the disadvantages of laplacian operator it is combined with smoothing as precursor to find edges via zero crossings. Due to its shape, LoG is sometimes called as Mexican hat function.

29. What are the various techniques that can be used for edge linking? (R)

The various techniques used for edge linking are

i. Local Processing
ii. Global Processing via Hough Transform
iii. Global Processing via Graph Theoretic Techniques.

30.What is object point and background point? (R)

For any image f(x,y), if we analyse the histogram of the image we find that object and background pixels have graylevels grouped into two dominant modes. To segment the objects from the background select a threshold T that separate these modes. Then any point (x,y) for which f(x,y)>T is called an object point. Otherwise the point is called background point.

31. What is thresholding ? What are its types ? (R) (NOV-DEC 2015)

Thresholding is the process of segmenting an image based on a threshold value that separates the object and background of the image. Certain images will contain mutilple objects, which can be segmented using multiple thresholds.

Types of Thresholding

- Global Thresholding
- Variable Thresholding
- Regional (or) Local Thresholding
- Dynamic or adaptive thresholding

32.What are the disadvantages of thresholding ? (R)

- Only two classes (object, background) are generated hence cannot be applied to multi channel images.
- More sensitive to noise.
- Requires the input image to have homogenous intensity.

33. Define region growing? (R)

Region growing is a procedure that groups pixels or subregions in to layer regions based on predefined criteria. The basic approach is to start with a set of seed points and from there grow regions by appending to each seed the neighbouring pixels that have properties similar to the seed.

34. Specify the steps involved in splitting and merging? (R)

i. Split any region R_i into 4 disjoint quadrants for which $P(R_i)$=FALSE.
ii. Merge any adjacent regions R_j and R_k for which $P(R_j U R_k)$=TRUE.
iii. Stop when no further merging or splitting is possible.

35.What is a quadtree? (R)

Quadtree is a tree in which each node have exactly four descendants.

PART B

1. Explain image degradation model /restoration process in detail. **(R)**
2. Explain in detail the filters used to restore an image degraded only by noise (OR) Explain in detail about Mean and Order statistics filters. **(R)**
3. Expalin in detail about adaptive filters. **(R)**
4. Explain in detail about frequency domain filters used for restoration of image degraded by periodic noise. **(R)**
5. What is the use of wiener filter in image restoration. Explain. **(R) (MAY-JUN 2014) (NOV-DEC 2016)(NOV-DEC 2013)**
6. What is meant by Inverse filtering? Explain. **(R) (MAY-JUN 2014/2015)**
7. Give the degradation model for a continuous function and show that degraded image is a convolution of original image and degradation function **(U)**
8. What is the source of noise in images ? Explain the important noise probability density functions used to model noise. State the applications of the noise models. **(R)**

9. Explain in detail the various segmentation techniques based on discontinuities.**(R)**
10. Explain Edge Detection techniques in detail. **(R)**
11. Discuss about region based image segmentation techniques. **(U) (NOV-DEC 2016)**
12. Explain how edges are linked using Hough Transform.**(R) (NOV-DEC 2015), (NOV-DEC 2016)**
13. Explain the various edge linking and boundary detection techniques. **(R)**
14. Explain global thresholding technique with an example. **(R)**
15. Define Thresholding and explain the various methods of thresholding in detail? **(R) (NOV-DEC 2013)**
16. Explain Morphological Processing with suitable examples. **(U)**

UNIT IV

WAVELET AND IMAGE COMPRESSION

PART A

1.What is the need for Wavelet Transform? (R)

Fourier Transform provides only frequency information, when the time localization of the spectral components are needed, a transform giving the TIMEFREQUENCY REPRESENTATION of the signal is needed. Thus a wavelet transform which provides the time-frequency representation is needed. Wavelet transform is based on small waves called wavelets, of varying frequency and limited duration.

2.What do you understand by the term Multi Resolution theory? (R)

Multi Resolution theory is concerned with the representation and analysis of images at more than one resolution. Features that may go undetected at one resolution may be easy to detect at another resolution.

3.What is Multi Resolution Analysis (MRA) ? (R)

MRA, as implied by its name, analyzes the signal at different frequencies with different resolutions. In MRA, a scaling function is used to create a series of approximations of an image, each differing by a factor of 2 in resolution from its nearest neighboring approximations. Wavelets are used to encode the difference in information between adjacent approximations.

4.What is an Image Pyramid? (R) (NOV-DEC 2016)

Image pyramid is a powerful structure for representing images at more than one resolution. In an image pyramid, a collection of decreasing resolution images are arranged in the shape of a pyramid.

The base of the pyramid contains a high resolution approximation and the apex contains a low resolution approximation.

5.What is subband coding? (R)

In subband coding, an image is decomposed into a set of bandlimited components called subbands. These subbands can be reassembled to construct the original image without error. Digital filters are used to perform decomposition and reconstruction.

6.What are the four fundamental requirements of MRA? (R)

MRA Requirement 1: The scaling function is orthogonal to its integer translates

MRA Requirement 2: The subspace spanned by the scaling function at low scales are nested within those spanned at higher scales.

MRA Requirement 3: The only function that is common to all Vj is f(x)= 0.

MRA Requirement 4: Any function can be represented with arbitrary precision.

7.What is image compression? (R)

Image compression refers to the process of reducing the size of an image for easy storage and transmission. It is achieved by removing the redundant data.

8.Compare Lossless and Lossy compression. (AZ)

Lossless Compression	Lossy Compression
Lossless compression can recover the exact original data after compression	Lossy compression will result loss of data in exchange for a substantial increase in compression
It is reversible	It is irreversible
Compression rate achieved is low	Higher compression rate can be achieved
It is used mainly for compressing database records, spreadsheets or word processing files, where exact replication of the original is essential	It is used to compress images, video and audio.

9. What is the need for Compression? (R) (MAY-JUN 2013/14/15)
Compression is the process of reducing the size of data. Compression is needed to reduce storage space and hence bandwidth requirements and cost.

10. What are the types of redundancy ? (R)
i) Coding Redundancy
ii) Interpixel Redundancy
iii) Psychovisual Redundancy

11. Define coding redundancy? (R)
The information is represented in the form of codes. If the codes fails to minimize the average number of bits required to represent each pixel it leads to coding redundancy.

12. Define interpixel redundancy? (R)
The value of any given pixel can be predicted from the values of its neighbors. Thus the information carried by individual pixel. This is known as interpixel redundancy.

- Interpixel redundancy in images is known as spatial redundancy.
- Interpixel redundancy in video is known as temporal redundancy.

13.Define Psychovisual redundancy. (R)
Certain information which has less relative importance than other information in normal visual processing are said to be psychovisually redundant information.

14. What is run length coding? (R) (NOV-DEC 2015)
Run-length Encoding, or RLE is a technique used to reduce the size of a repeating string of characters. This repeating string is called a ***run***; typically RLE encodes a run of symbols into two bytes, a symbol and count.

15. Define compression ratio. (R)

Compression Ratio $C_R = n_1/n_2$

where

n_1 - is the number of information carrying units in the first data set (original image)

n_2 - is the number of information carrying units in the second data set (compressed image)

16. Define source encoder(R)

Source encoder reduces the redundancy in the data to achieve compression. It performs three operations

1) Mapper -It reduces the interpixel redundancy.
2) Quantizer - It reduces the psycho visual redundancy,this step is omitted if the system is error free(Lossless).
3) Symbol encoder- This reduces the coding redundancy .This is the final stage of encoding process.

17. Define channel encoder(R)

The channel encoder reduces reduces the impact of the channel noise by inserting redundant bits into the source encoded data. Eg: **Hamming code**

18.What are the operations performed by error free compression? (R)

Error free compression or Lossless compression is achieved by

i) Reducing Interpixel redundancy and
ii) Reducing Coding Redundancy.

19. What is Variable Length Coding? (R)

Variable Length Coding is the simplest approach to error free compression. It reduces only the coding redundancy. It assigns the shortest possible codeword to the most probable gray levels. **Ex: Huffman Code**

20. Define Block code(R)

If each source symbol is mapped into fixed sequence of code symbols or code words the coding technique is called as block code.

21. Define instantaneous code(R)

If each codeword in a string of symbols can be decoded without the reference of succeeding symbols then the code is called is called instantaneous code.

22. Define prefix property or uniquely decodable code. (R)

A code is said to be uniquely decodable if the string of code symbols can be decoded in only one way. Prefix property states that a shorter codeword will never form the start of a larger codeword**.**

23. List the properties of Huffman code. (R)

i. It is a block code
ii. It is instantaneous code
iii. It is uniquely decodable code
iv. It is optimal code.

24. Define the procedure for Huffman shift(R)

List all the source symbols along with its probabilities in descending order. Divide the total number of symbols into block of equal size. Sum the probabilities of all the source symbols outside the reference block. Now apply the procedure for reference block, including the prefix source symbol. The code words for the remaining symbols can be constructed by means of one or more prefix code followed by the reference block as in the case of binary shift code.

25. Define arithmetic coding(R)

In arithmetic coding one to one corresponds between source symbols and codeword doesn't exist. An entire sequence of source symbol is assigned where as the single arithmetic code word assigned for a sequence of source symbols. A code word defines an interval of number between 0 and 1.

26.What is blocking artifacts? (R)

It is the block like appearance that results when the boundaries between subimages becomes visible after merging the decompressed subimages to get back the entire image.

27. What is bit allocation? (R)

The process of truncating, quantizing and encoding the coefficients of a transformed sub image is commonly called bit allocation

Two types

i) Zonal coding
ii) Threshold coding

28. What is JPEG? (R)

The acronym is expanded as "Joint Photographic Expert Group". It is an international image compression standard used to compress both monochrome and color images. It is based on lossy transform coding.

29. What are the coding systems in JPEG? (R)

1. A lossy baseline coding system, which is based on the DCT and is adequate for most compression application.
2. An extended coding system for greater compression, higher precision or progressive reconstruction applications.
3. A lossless independent coding system for reversible compression.

30. What are the basic steps in JPEG? (R)

The Major Steps in JPEG Coding involve:

Block Extractor
DCT (Discrete Cosine Transformation)
Quantization
Zigzag Scan
DPCM on DC component
RLE on AC Components
Entropy Coding

31. What is MPEG? (R)

The acronym is expanded as "Moving Pictures Expert Group". It is an international standard for video compression used for multimedia video compression.

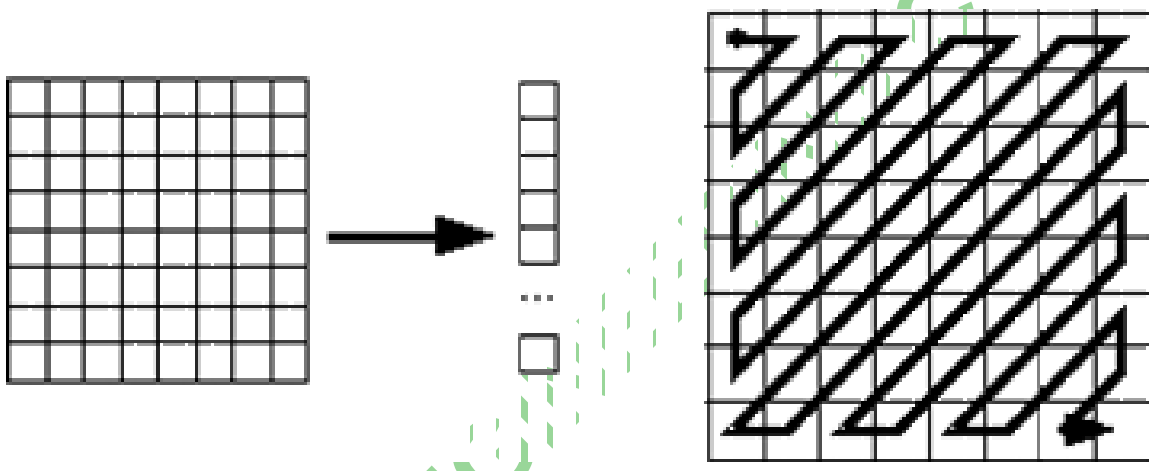
32. What are the types of MPEG standards? (R)

MPEG-1 –used for entertainment quality coding standard, CDROM Storage
MPEG-2 – cable TV distribution , narrow channel satellite broadcasting
MPEG-4 – Internet & Various multimedia applications
MPEG-7 – used for Search Engines

33. What is zig zag sequence? (R)

The purpose of the Zig-zag Scan:

- To group low frequency coefficients in top of vector.
- Maps 8 x 8 to a l x 64 vector



34. Define I-frame, P frame, B frame. (R)

I-frame is Intraframe or Independent frame. The first frame of the video is the I frame. It is compressed independently.

P-frame is called predictive frame. A P-frame is the compressed difference between the current frame and a prediction of it based on the previous I or P-frame

B-frame is the bidirectional frame. A B-frame is the compressed difference between the current frame and a prediction of it based on the previous I or P-frame or next P-frame. Accordingly the decoder must have access to both past and future reference frames.

35. What is Vector Quantisation ? (R)

Vector Quantisation is a block coding technique that quantizes blocks of data instead of single sample. The encoder and decoder consist of identical codebook. The code book consists of code vectors (group of image blocks) and corresponding address (index) of it .Thus instead of transmitting the code vector sonly the index of the code vector is transmitted, hence compression is achieved.

36. How compression is achieved with vector Quantisation ? (U)

The encoder and decoder consist of identical codebook. The code book consists of code vectors (group of image blocks) and corresponding address (index) of it .Thus instead of transmitting the code vectors only the index of the code vector is transmitted, hence compression is achieved

37.What are the types of Vector Quantisation? (R)

Tree Search Vector Quantisation
Multistage VQ
Mean Removed VQ
Gain Shape VQ
Classified VQ
Hierarchial VQ
Interpolative VQ
Lapped VQ
Lattice VQ

PART B

1. Explain in detail about Multi resolution Analysis**(R)**
2. Explain in detail about subband Coding. **(R)**
3. Explain the concept of Wavelets and Discrete Wavelet Transform. **(R) (NOV-DEC 2016)**
4. What is data redundancy? Explain three basic data redundancy? **(R)**
5. What is image compression? Explain any four variable length coding compression schemes. **(R)**
6. Explain Huffman coding principle and procedure. Discuss its properties and demerits. **(U)**
7. Encode using Huffman coding , and determine the average code word length (any problem). **(A)**
8. Encode using Arithmetic coding (any problem). **(A) (MAY-JUN 2014)**
9. Explain JPEG and JPEG 2000 compression standards (or) Explain about Image compression standards. **(R) (NOV-DEC 2013/2016) (APR-MAY 2015)**
10. Explain how compression is achieved in transform coding. **(U)**
11. Explain in detail the method of zonal and threshold coding. **(R)**
12. Explain Vector Quantization technique in detail. **(R) (NOV-DEC 2013)**
13. Discuss about MPEG standard and explain MPEG encoder in detail. **(U)**
14. Explain the principle and procedure of arithmetic coding. **(R) (MAY-JUN 2014)**
15. Write a detailed note on binary shift codes and Huffman shift, what is the advantage of shift codes. **(R)**
16. With suitable example explain how compression is achieved using Run Length Encoding **(U) MAY-JUN 2015)**

UNIT V

IMAGE REPRESENTATION AND RECOGNITION

PART-A

1. Define chain codes? (R)

Chain codes are used to represent a boundary by a connected sequence of straight line segment of specified length and direction. Typically this representation is based on 4 or 8 connectivity of the segments. The direction of each segment is coded by using a numbering scheme.

2. What are the demerits of chain code? (R)

The resulting chain code tends to be quite long. Any small disturbance along the boundary due to noise cause changes in the code that may not be related to the shape of the boundary.

3. What is thinning or skeletonizing algorithm? (R)

An important approach to represent the structural shape of a plane region is to reduce it to a graph. This reduction may be accomplished by obtaining the skeletonizing algorithm. It play a central role in a broad range of problems in image processing, ranging from automated inspection of printed circuit boards to counting of asbestos fibres in air filter.

4. Specify the various image representation approaches. (R)

- Chain codes
- Polygonal approximation
- Boundary segments

5. What is polygonal approximation method? (R)

Polygonal approximation is a image representation approach in which a digital boundary can be approximated with arbitrary accuracy by a polygon. For a closed curve the approximation is exact when the number of segments in polygon is equal to the number of points in the boundary so that each pair of adjacent points defines a segment in the polygon.

6. Specify the various polygonal approximation methods (R)

- Minimum perimeter polygons
- Merging techniques
- Splitting techniques

7. Name few boundary descriptors. (R)

- Simple descriptors
- Shape numbers
- Fourier descriptors

8. Give the formula for diameter of boundary (R)

The diameter of a boundary B is defined as Diam (B) $=\max_{i,j}[D(Pi, Pj)]$, D is the distance measure and Pi, Pj are the points on the boundary.

9. Define length of a boundary. (R)

The length of a boundary is the number of pixels along a boundary.Eg.for a chain coded curve with unit spacing in both directions the number of vertical and horizontal components plus _2 times the number of diagonal components gives its exact length.

10. Define eccentricity and curvature of boundary. (R)

Eccentricity of boundary is the ratio of the major axis to minor axis.

Curvature is the rate of change of slope.

11. Define shape numbers. (R)

Shape number is defined as the first difference of smallest magnitude. The order n of a shape number is the number of digits in its representation.

12. Specify the types of regional descriptors. (R)

- Simple descriptors
- Texture

13. Name few measures used as simple descriptors in region descriptors (R)

- Area
- Perimeter
- Compactness
- Mean and median of gray levels
- Minimum and maximum of gray levels
- Number of pixels with values above and below mean .

14. Define compactness. (R)

Compactness of a region is defined as (perimeter) ^2/Area. It is a dimensionless quantity and is insensitive to uniform scale changes.

15. Describe texture. (R) (NOV-DEC 2016)

Texture is one of the regional descriptors. It provides measures of properties such as smoothness, coarseness and regularity. There are 3 approaches used to describe texture of a region. They are:

- Statistical
- Structural and
- Spectral

16. Describe statistical approach. (R)

Statistical approaches describe smooth, coarse, grainy characteristics of texture. This is the simplest one compared to others. It describes texture using statistical moments of the gray-level histogram of an image or region.

17. Define gray-level co-occurrence matrix. (R)

A matrix C is formed by dividing every element of A by n(A is a k x k matrix and n is the total number of point pairs in the image satisfying P(position operator). The

matrix C is called gray-level co-occurrence matrix if C depends on P,the presence of given texture patterns may be detected by choosing an appropriate position operator.

18. Explain structural and spectral approach. (R)

Structural approach deals with the arrangement of image primitives such as description of texture based on regularly spaced parallel lines.

Spectral approaches are based on properties of the Fourier spectrum and are primarily to detect global periodicity in an image by identifying high energy, narrow peaks in spectrum.

19. What are the features of Fourier Spectrum? (R)

The features of Fourier spectrum are useful for texture description. They are:

- Prominent peaks in spectrum gives the principal direction of texture patterns.
- The location of peaks in frequency plane gives fundamental spatial period of patterns.
- Eliminating any periodic components by our filtering leave non- periodic image elements.

20. Define pattern. (R)

A pattern is a quantitative or structural description of an objective or some other entity of interest in an image.

21. Define pattern class. (R)

A pattern class is a family of patterns that share some common properties. Pattern classes are denoted w_1, w_2, ---w_M, where M is the number of classes.

22. Define training pattern and training set. (R)

The patterns used to estimate the parameters are called training patterns, and a set of such patterns from each class is called a training set.

23. Define training. (R)

The process by which a training set is used to obtain decision functions is called learning or training.

PART-B

1. Explain in detail any two boundary representation schemes with illustrative examples. **(U) (NOV-DEC 2016)**
2. How will you represent the region using run length code and tree approach? Explain with your own illustrative examples. **(U)**
3. What is co-occurrence matrix? Explain. **(R)**
4. Distinguish between regional and topological descriptors. **(U)**
5. Explain how the tree approach is used to describe different regions of an image. **(R)**
6. Explain Texture and Patterns. **(R)**
7. Explain Image Recognition based on matching. **(NOV-DEC 2016)**

ASSIGNMENTS

ASSIGNMENT 1 (UNIT I)

1.Analyze the various parameters of image processing i) Band number ii) Spectrum iii) wavelengths iv) applications.**(AZ)**

2. Let V= $\{0,1\}$ compute D_4,D_8 and D_e distance between p & q. **(A)**

$$\begin{bmatrix} 1(q) & 1 & 2 & 3 \\ 0 & 2 & 2 & 1 \\ 1 & 1 & 0 & 2 \\ 2 & 1 & 2 & 1(p) \end{bmatrix}$$

3.Consider the two image subsets S_1 and S_2 shown in the following figure for V={1}, determine whether these two subsets are **(AZ)**

a. 4-adjacent
b. 8-adjacent
c. m-adjacent

S_1 S_2

$$\begin{matrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 \\ 1 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 1 \\ 1 & 0 & 0 & 1 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 \end{matrix}$$

4. a)Calculate the storage space required to store an 8-bit image of size 256× 256 , 512 x 512,1024 x1024, 2048 x 2048 pixels.
b) Repeat the above problem in (a) for 9, 10, 11 & 12 bit images.
c) Repeat the problems (a) and (b) for color images. Tabulate the obtained results and analyse the storage requirements for gray scale and color images. **(AZ)**

ASSIGNMENT 2 (UNIT II)

1.Obtain Histogram equalization for the following image segment of size 5 x 5? . Draw the histogram for the image segment before and after histogram equalization. Write the inference on image segment before and after equalization. **(A)**

$$\begin{bmatrix} 20 & 20 & 20 & 18 & 16 \\ 15 & 15 & 18 & 16 & 15 \\ 15 & 15 & 19 & 17 & 15 \\ 19 & 16 & 17 & 18 & 16 \\ 18 & 20 & 17 & 15 & 20 \end{bmatrix}$$

2.Filter the following image using a 3×3 neighborhood averaging by assuming (a) zero padding and (b)pixel replication **(AZ)**

$$\begin{bmatrix} 1 & 2 & 3 & 2 \\ 4 & 2 & 5 & 1 \\ 1 & 2 & 6 & 3 \\ 2 & 6 & 4 & 7 \end{bmatrix}$$

3.Determine the average value of the given image

a) using 3 x 3 neighborhood b) using 5x 5 neighborhood. **(A)**

$$\begin{bmatrix} 1 & 1 & 2 & 3 & 2 & 2 \\ 1 & 1 & 2 & 3 & 2 & 2 \\ 4 & 2 & 2 & 5 & 1 & 1 \\ 1 & 1 & 2 & 6 & 3 & 3 \\ 2 & 2 & 6 & 4 & 7 & 7 \\ 2 & 2 & 6 & 4 & 7 & 7 \end{bmatrix}$$

ASSIGNMENT 3 (UNIT III)

1. Apply order statistics filter on the selected pixels on the image. **(A)**

$$\begin{pmatrix} [1] & 2 & 3 \\ 0 & [1] & [2] \\ 1 & 4 & 5 \end{pmatrix}$$

2. For the given image matrix, compute the new pixel value for the marked pixel using the following filters (i) Mean of filters, (ii) Max filter, (iii)Min Filter, (iv)Median filter of size 3×3, (v) Median filter of size 5×5. **(A)**

$$\begin{bmatrix} 1 & 4 & 5 & 3 & 3 \\ 2 & 1 & 1 & (3) & 5 \\ 5 & 6 & 3 & 1 & 8 \\ 4 & 1 & 2 & 5 & 6 \\ 5 & 4 & 2 & 4 & 7 \end{bmatrix}$$

3. A blur filter h(x,y) is given by,

$$h(x,y) = \begin{bmatrix} 0.1 & 0.1 & 0.1 & 0 \\ 0.1 & 0.1 & 0.1 & 0.1 \\ 0.05 & 0.1 & 0.1 & 0.05 \\ 0 & 0.05 & 0.05 & 0 \end{bmatrix}$$

Find the deblur filter using inverse filtering. **(A)**

ASSIGNMENT 4 (UNIT IV)

1.Obtain the tag for the sequence 1 3 2 1 for the probabilities P(1)=0.8, P(2)=0.02, P(3)=0.18 **(A)**

2. A 1024×1024 8-bit image with 4.2 bits/pixel entropy(computed from its histogram using Eq. H=-$\sum_{k-0}^{L-1} p_r(r_k)\log_2 p_r(r_k)$) is to be Huffman coded.

(a)What is the maximum compression that can be expected?
(b) Will it be obtained ? **(A)**

3. Given a four-symbol source $\{a,b,c,d\}$ with source probabilities $\{0.1,0.4,0.3,0.2\}$, arithmetically encode the sequence 'abcda'. **(A)**

4. Consider the simple 4×8, 8 –bit image:

21	21	95	95	169	169	243	243
21	21	95	95	169	169	243	243
21	21	95	95	169	169	243	243
21	21	95	95	169	169	243	243

(a) Compute the entropy of the image
(b) Compress the image using Huffman code
(c) Find the average length of the code and its redundancy. **(A)**

5.The arithmetic decoding process is the reverse of the encoding procedure. Decode the message 0.32256 given the coding model. **(A)**

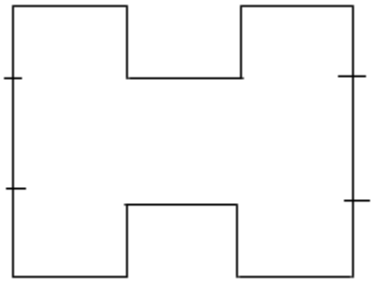
Symbol	**Probability**
a	0.2
e	0.3
i	0.1
o	0.2
u	0.1
!	0.1

6. Perform Hufffman Algorithm for the following intensity distribution, for a 32 x 32 image. Obtain the coding efficiency and compare with that of uniform length code.

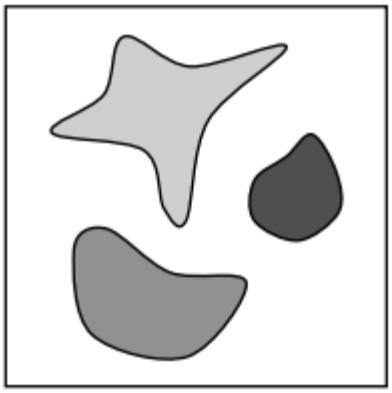
Symbol	**Intensity Distribution**
S_0	252
S_1	80
S_2	114
S_3	172
S_4	200
S_5	26
S_6	104
S_7	76

ASSIGNMENT 5 (UNIT V)

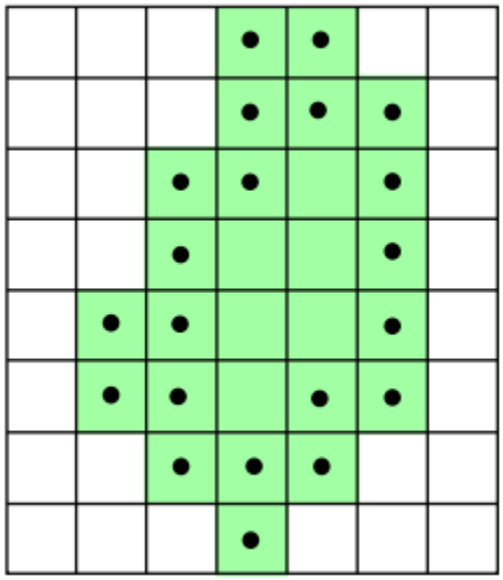
1. (a) What is the order of shape number for the figure shown
   (b) Obtain the shape number



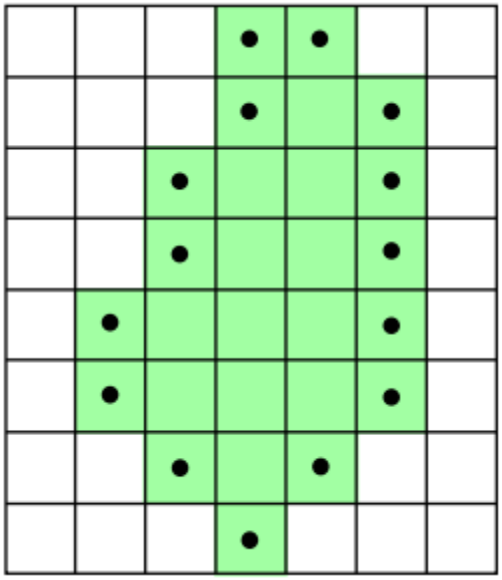
2. Determine the Euler number of the given image.



3.Determine the 4- direction chain code and first difference for the boundary of the given image.



4. Determine the 8- direction chain code and first difference for the boundary of the given image.



5.Compute the first difference of the given chain code 0110233210332322111.

EC6011

ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY

EC6011 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY

UNIT-I

BASIC CONCEPTS

PART-A

1. Define EMI/EMC (Nov. / Dec. 2012) (Nov. / Dec. 2014) (R)

EMI: Electromagnetic interference is the degradation in the performance of a device or equipment or a system caused by an electromagnetic disturbance.
EMC: Electromagnetic interference is the degradation in the performance of a device or equipment or a system caused by an electromagnetic disturbance.

2. Give some examples of EMI.(U)

TRANSMISSION LINES- high intensity electric and magnetic fields near transmission lines cause unintentional activation or explosion of electro explosive devices apart from presenting radiation hazards to humans.
MAINS POWER SUPPLY- easily picks up EM noises from lightning and thunderstorm; transients from circuit breakers, switches etc, and impair the operation of computers and many IT products.

3. What is the purpose of TEMPEST? (E)

TEMPEST (**Total Electrical and Mechanical Protection against Emission Spurious Transmission**) is used to denote a whole set of highly sensitive specifications and special measurement procedures for ensuring compliance with these specifications.

4. What is the difficulty in using TEMPEST? (C)

Difficulty in TEMPEST specifications:
- Cost effective.
- Testing involves specially designed equipment which is sensitive and precision calibrated more frequently.
- Receivers often have a cursor controlled integrated sweep capability, which allows the test engineer to stop and perform interactive analysis of the signal.

5. What are the classifications of EMIC? (Nov. / Dec. 2012) (May / June 2014) (AZ)

i. Radiated Emission (RE)
ii. Radiated Susceptibility (RS)
iii. Conducted Emission (CE)
iv. Conducted Susceptibility (CS)

6. Define Electromagnetic disturbance. (R)

Electromagnetic disturbance is any electromagnetic phenomenon which may degrade the performance of a device, or equipment or a system.

7. Define Radio Frequency Interference. (R)

Radio frequency interference is the degradation in the reception of a wanted signal caused by radio frequency disturbance, which is an electromagnetic disturbance having components in the radio frequency range.

8. What is radiated emission? (R)

Direct radiation from source to receptor.

9. What is conducted emission? (R)

Direct radiation picked up by the electrical power cables or the signal/control cables connected to the receptor via conduction.

10. Mention few units of parameters (R)

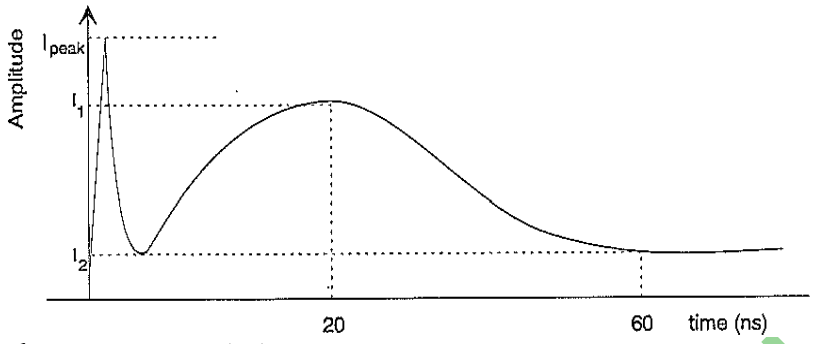
RE/RS - field strength (V/m or Tesla)
CE/CS - voltage & current(V or A)
VOLTAGE- V, dBV, dBmV, dBμV
CURRENT- A, dBA,dBmA,dBμA
POWER- W,mW,μW,pW, dBW,dBmW,dBμW
ELECTRIC FIELD- V/m,dBV/m
MAGNETIC FIELD- tesla-W/m
SOURCE STRENGTH OR WEAK CELESTIAL SOURCES-flux unit (FU) = 260 dBW/m^2 /HZ

11. What are the types of natural noise? (R)

TERRESTRIAL NOISE includes
1. atmosphere
2. lightning
3. electrostatic discharge

CELESTIAL NOISE includes
1. cosmic/galactic noise
2. solar noise

12. Draw the waveform of an ESD: (A)

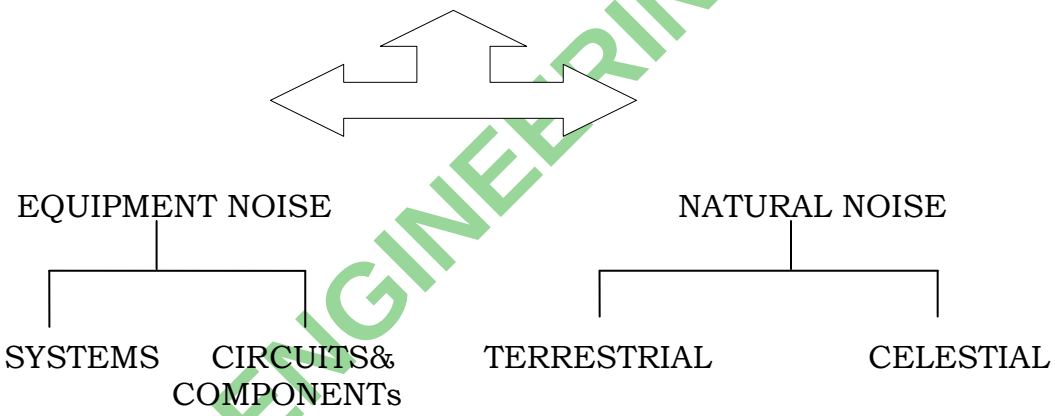


13. Define ESD Phenomenon (R)

Electrostatic discharge is a natural phenomenon in which accumulated static electric charges are discharged. This discharge produces EMI.

14. What are the different sources of EMI:(Nov/ Dec 2011) (Nov/Dec 2014) (E)

EM NOISE



15. What are the different types of transients? (R)

TYPES OF TRANSIENTS:

The transients carried by the electrical power lines can be identified and divided into the following distinct categories;

- Transient over voltages-probably as a result of terrestrial phenomena such as lightning or strong radar/radio/communication transmissions from such equipment located near power transmission lines.
- Sudden decrease or increase in the mains voltage- caused by the switching off of a low impedance load

16. What are the effects of cloud to cloud discharge? (Nov. / Dec. 2014) (AZ)

The term cloud to cloud discharge refers to all discharges that does not contact the ground. Static charges acquired by a cloud produce a static electric field. The value of this electric field intensity can be established from a knowledge of the charge distribution and discharges from the ground. In calculating the electric

field intensity the effect of ground in taken ino acount while considering the presence of image charges.

PART-B

1. Explain EMI with examples(10) and Explain the classifications of EMI/EMC(6): **(AZ)**
2. What is EMI? Explain the EMI problem with example. (8) **(R)**
3. What is the basic differences are between conducted and radiated emission (8)? **(AZ)**
4. Explain the sources of EMI: **(AZ)**
5. Explain natural EM noise: **(AZ)**
6. Explain Equipment noise: **(AZ)**
7. Explain EMI coupling modes: **(AZ)**
8. Explain ESD phenomena and effects: **(AZ)**
9. Explain transient phenomena and suppression: **(AZ)**
10. Explain transient and surge suppression devices: **(AZ)**
11. Explain the different lighting discharges, EM fields produced by lighting and its effect on transmission lines**(Nov. / Dec. 2011) (AZ)**
12. Explain the concept of ESD with waveform& equivalent circuits **(Nov/Dec 2011) (AZ)**
13. What the basic differences are between conducted and radiated emission? **(Nov/ Dec. 2012) (AZ)**
14. Briefly explain about the various coupling modes of EMI. **(Nov. / Dec. 2012) (AZ)**
15. Briefly explain about the various sources of EMI**. (Nov. / Dec. 2012) (AZ)**
16. Explain the concept of transient phenomena suppression. **(Nov. / Dec. 2011) (AZ)**
17. Compare the features of radiated DM coupling and radiated CM coupling. **(May / June 2013) (E)**
18. Classify the transient suppression devices and explain their working. **(May/June 2013) (E)**
19. i)Discuss in detail about the various EMI coupling modes with CM and DM current measurement**. (Nov. / Dec. 2013) (U)**
    ii) Brief explain about the various sources of EMI. (**Nov. / Dec. 2013) (AZ)**
20. Discuss in detail about the ESD phenomena and transient phenomena and its suppression techniques in EMI .(**Nov. / Dec. 2013) (U)**
21. i)Briefly explain the various sources of EMI (May / June 2014) (AZ)
    ii)Explain the concept of ESD phenomena and its effects. **(AZ)**
22. i)What are the basic differences between conducted and radiated emissions? **(May / June 2014) (AZ)**
    ii)Describe in detail about the CM and DM based EMI coupling modes. **(U)**
23. i) Explain how passive components are chosen for EMC in details (**Nov/Dec 2014) (AZ)**
    ii) Explain the coupling modes of EMI **(AZ)**
24. Explain about various sources of EMI, and the different phenomena of EMI (**Nov. / Dec. 2014) (AZ)**

UNIT-II
EMI MEASUREMENTS
PART-A

1. **What is TEM cell? (Nov. / Dec. 2012) (May / June 2014) (R)**

   A TEM cell is a rectangular coaxial transmission line, resembling strip line, with outer conductors closed and joined together. The rectangular section is tapered at both ends and matched to a 50 ohms coaxial transmission line.

2. **What are the components of OATS? (AZ)**
   i. EUT
   ii. Transmit and receive antenna.
   iii. Site.

3. **What is LISN? (R)**

   LISN: Line Impedance Stabilization network. Objectives are,
   - To present constant impedance to the product's power cord outlet over the frequency range of the conducted emission test.
   - To block conducted emissions that is not due to the product being tested so that only the conducted emissions of the product are measured.

4. **What are the measurement precautions to be carried out in OATS? (AZ)**

   EM ENVIRONMENT:
   It should be quiet and free from the presence of such strong signals as those from broadcast radio or TV receivers and manmade EM radiations.

   EM SCATTERS:
   Test site should be free from EM scatters.
   Sources are buildings and other similar structures, electric transmission lines, open telephone and telegraph lines, fences and vegetation such as trees, underground cables and pipelines not buried deep enough.
   To avoid underground scatters, metallic ground plane can be used.

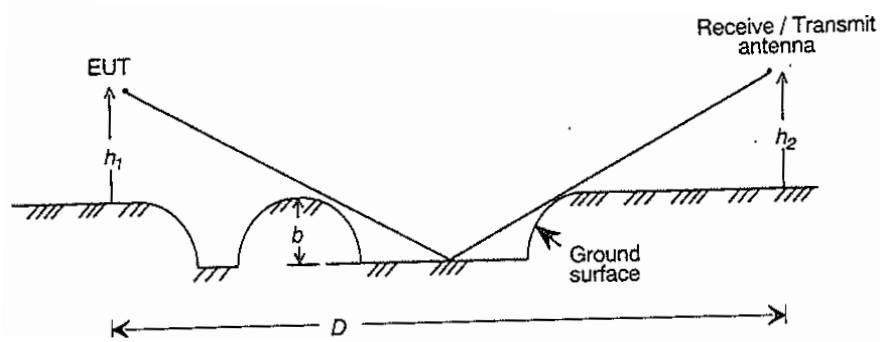
   POWER AND CABLE CONNECTIONS:
   The electrical power connections to the EUT and he cables between the transmit and receive antenna located in the test site and the transmitter and receiver equipment located nearby are placed in underground trenches.
   The power leads pass through filters to eliminate the CE carried by the power lines.

5. **What is a current probe? (R)**

   Current probe is constructed from a core of ferrite material that is separated into two halves, which are joined by a hinge and closed with a clip. The ferrite core is used to concentrate the magnetic flux.

6. **Brief about terrain roughness: (E)**

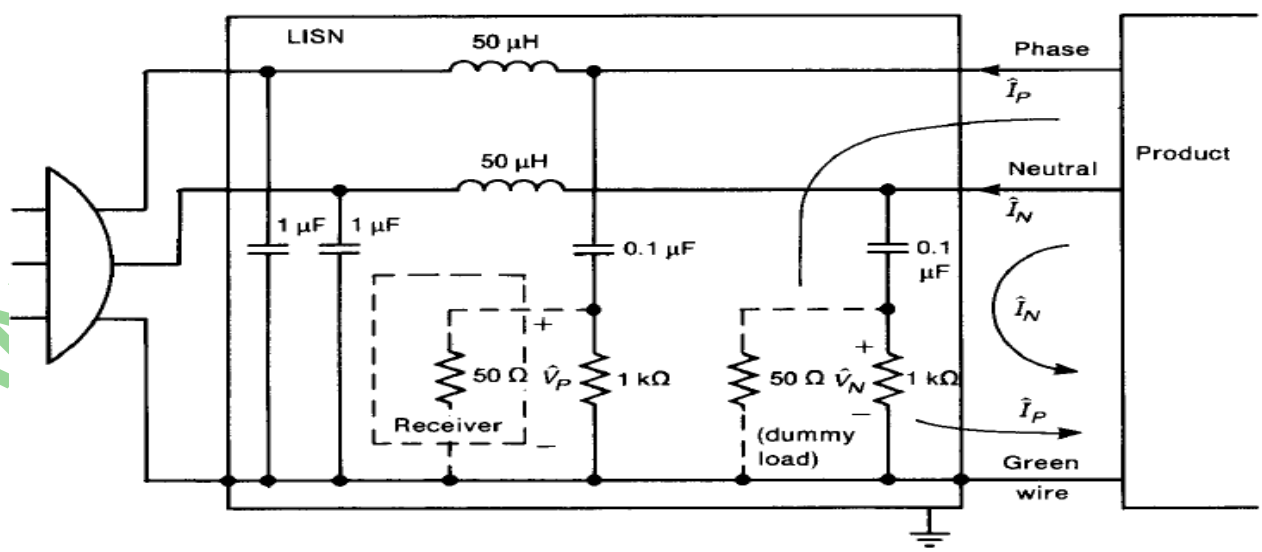
To avoid significant scattering from terrains within test area, some restrictions are imposed on the roughness of the terrain.



7. **What is the purpose of feed through capacitor? (Nov. / Dec. 2014) (R)**

Feed through capacitors are intended for the use with power lines they must operate up to 600V dc and can be designed to handle mains currents of more than 100A without significant loss. Feed through capacitors are originally designed for DC power line in RF module or system. It passed through the DC (and low frequency signals) but blocks the RF energy. In practical use the: feed through capacitors are fitted to the metal case of the RF module on holes where the wires enter the system. They let the signal pass through but will stop the RF from escaping from the device through that hole to the outside wiring.

8. **Draw the schematic of LISN: (A)**



9. **What is spectrum analyzer? (R)**

Spectrum analyzers are devices that display the magnitude spectrum for periodic signals. These devices are basically radio receivers having a band pass filter that is swept in time. A band pass filter whose center frequency is swept in time from the start frequency to the end frequency (chosen by the operator) selects and displays the spectral components of the input signal that are present within the bandwidth of the instrument at the point in the time of the sweep.

10. **What is the purpose of baluns? (AZ)**

Balancing is a critical factor in the accurate measurement of radiated emissions. If the antenna–feed line combination is not balanced, the measured data may appear to comply with the regulatory limits when in fact they may not because of the pattern distortion caused by the unbalance.

11. **What are EMI measuring instruments? (Nov. / Dec. 2014) (A)**

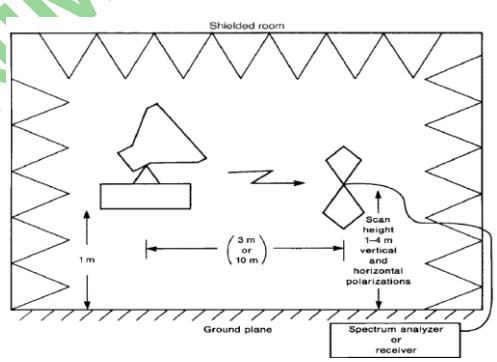
i. LISN
ii. Anechoic chamber
iii. OATS
iv. EMC analyzer.
v. TEM cells

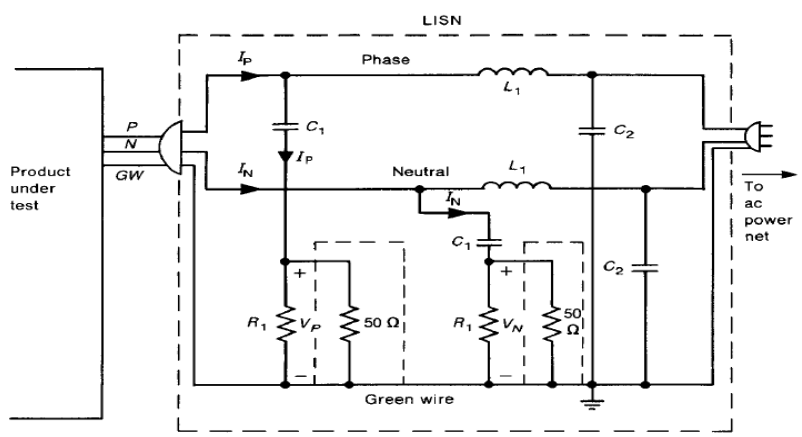
12. **What is feed through capacitor? (Nov. / Dec. 2011) (A)**

Feed through capacitors are intended for the use with power lines they must operate up to 600V dc and can be designed to handle mains currents of more than 100A without significant loss.

13. **How is radiated emission and conducted mission measured? (Nov. / Dec. 2011) (E)**

Radiated emission measurement: **conducted emission measurement:**





PART-B

1. Explain the principles of RE/RS measurements: **(AZ)**
2. Explain the test instrumentation for emission and susceptibility testing. **(AZ)**
3. Explain the principles of CE/CS measurements: **(AZ)**
4. Explain LISN: **(AZ)**
5. Explain EMC analyzer and detection technique: **(AZ)**
6. Explain the spectrum analyzer, LISN and Antennas TEM cell. (5+5+6) **(AZ)**
7. Explain TEM cell measurement: **(AZ)**
8. Explain OATS: **(AZ)**
9. Explain anechoic chamber measurement: **(AZ)**
10. Explain feed through capacitor(8) and current probe(8) (E)
11. Explain with diagram measurement of RE and RS(8)**(Nov. / Dec. 2011) (AZ)**
12. Explain antenna factor measurement.(8) **(Nov. / Dec. 2011) (AZ)**
13. Explain the procedure for measurement of radiation susceptibility and radiated Emission using TEM cell.(16) **(Nov. / Dec. 2011) (AZ)**
14. Describe the EMI analysis. **(Nov. / Dec. 2012) (AZ)**
15. Explain the voltage probes and current probes. **(Nov. / Dec. 2012) (AZ)**
16. Explain the EMC analyzer, LISN and antenna of EMI measuring instruments. **(Nov. / Dec. 2012) (AZ)**
17. i)Explain the basic principles of RE and RS measurements. **(May / June 2013**) **(AZ)**
    ii)Derive the equation for NSA **(May / June 2013) (AZ)**
18. Describe the steps of RE and RS measurements using TEM cell. **(May / June 2013) (AZ)**
19. i) Explain in detail the operating principle and measurements that can be carried out in a microwave anechoic chamber. How is the chamber quality assessed? **(Nov. / Dec. 2013) (AZ)**
    ii) Discuss in detail about the EMC analyzer and detection technique. **(Nov/Dec 2013) (A)**
20. i) Describe with diagrams the operating principles of TEM & GTEM cells for RE & RS measurement. **(Nov. / Dec. 2013) (AZ)**
    ii) Explain fully with diagram the operation of Artificial main network (LISN) and its role in CE evaluation. Sketch the equivalent circuit of LISN.**(Nov/Dec 2013) (AZ)**
21. i) Explain in detail about the RS and CSA measurement system. **(May / June 2014) (AZ)**
    ii) Write a short note on feed through capacitor (E)
22. i) Describe the EMI analysis. **(May / June 2014) (AZ)**
    ii) Explain the voltage probes and current probes. **(AZ)**
23. Explain the EMC analyzer and the various detection techniques associated with that. **(Nov. / Dec. 2014) (AZ)**
24. Explain the basic principle associated with RE, CE, RS, CS measurements. **(Nov/ Dec 2014) (AZ)**

UNIT-III
EMC STANDARDS AND REGULATIONS
PART-A

1. **Define standard (R)**

   Standards are nothing but which provides enhanced compatibility, reliability and maintainability over the appliances.

2. **List five national and international standards used for CE and RE: (E)**

   ANSI, FCC, DOD, IEC, CNELEC

3. **What is MIL-STD-461/462? (R)**

   MIL-STD 461 Requirements of the control of EMI emissions and susceptibility
   MIL-STD 462 EMI characteristics, measurements.

4. **What is the abbreviation of CE? (R)**

   Conformity European

5. **What is frequency assignment? (May / June 2014) (R)**

   The term frequency assignment is used for easier functioning of radio–based services to function harmoniously without causing electro-magnetic interference.

6. **What are the objectives of EMC standards? (Nov. / Dec. 2011) (A)**

   - Enhanced compatibility, reliability and maintainability
   - Competitiveness of product in multi vendor market
   - Inbuilt quality improvements to meet intended performance

7. **What are the approaches for efficient spectrum utilization?(Nov/ Dec 2011) (E)**

   - Reduction of bandwidth per channel
   - Increase in information transmitted.

8. **Differentiate the near and far fields (Nov. / Dec. 2014) (AZ)**

   In an radiating system or an antenna the region or the fields near the antenna is called as near field and the fields at some other distance is called as the far fields.

9. **Name four CE standards adapted in India : (A)**

TABLE 3.7 INDIAN EMI/EMC STANDARDS

	INDIAN STANDARD IS 6873	CISPR PUBLICATION	EC STANDARD
Part I	From ignition system of motor Vehicles and other similar devices	12	EN 55012
Part II	From house hold electrical appliances	14	EN 55014
Part III	From sound and TV receiver	13	EN 55013
Part IV	From industrial, scientific and medical (SM) RF equipment and microwave equipment for heating and therapeutic apparatus	11	EN 55011
Part V	From luminaries for fluorescent lamps	15	EN 55015
Part VI	From high voltage transmission system	16	EN 55016
Part VII	From information technology equipment	22	EN 55022

10. **Why are EMC regulations needed? (Nov. / Dec. 2012) (E)**

Compliance to EMC regulation is mandatory now for importing and exporting of products in respective countries. EMC regulations cover entire spectrum of electrical products, from computing devices to microwave oven to aircraft.

11. **What is spectrum conservation? (Nov/Dec 2012) (May/June 2014)(R)**

An important objective of frequency assignment is to make it easier for various radio-based services to function harmoniously without causing electromagnetic interference among one another. The term *radio-based* denotes services that use radio waves or electromagnetic waves of frequencies arbitrarily lower than 3000GHz, propagated in space without artificial guide. The *Radio-based* services include a wide range of terrestrial and space communications, surveillance, position determination, direction finding, and navigation. Radio astronomy is based on the reception of weak electromagnetic signals, which is also requires proper frequency co-ordination if electromagnetic interference is to be avoided.

Frequency allocation and frequency assignment are technical administrative functions that ensure that permitted radio services operate without interfacing with each other. Increasing demands on a limited frequency spectrum necessite the development of new techniques and technologies of transmission more and more information on a given frequency bandwidth. Such techniques of improving spectrum efficiency are called spectrum conservation techniques. There are two approaches for efficient spectrum utilization. These are the reduction of bandwidth per channel for a particular service, or an increase in information transmitted using a given frequency bandwidth

PART-B

1. Explain FCC CE and RE standard: **(AZ)**
2. Explain CISPR CE and RE standard: **(AZ)**
3. Explain IEC/EN CS standard: **(AZ)**
4. Explain EMC standards and specifications: **(AZ)**
5. Explain frequency assignment and spectrum conservation: **(AZ)**
6. Explain the types of modulation used for spectrum conservation: **(AZ)**
7. Compare the different performance standards for EMC **(Nov. / Dec. 2011) (AZ)**
8. Explain any two spectrum conservation methods by frequency planning? **(Nov. / Dec. 2011) (AZ)**
9. Explain in detail about the following international standardizing organizations. FCC, CISPR, ANSI, DOD. **(Nov. / Dec. 2012) (AZ)**
10. Explain in detail about the following international standardizing organizations, FCC CE and RE Standards IEC / EN and CS Standards. **(Nov/Dec. 2012) (AZ)**
11. List the approaches available for efficient frequency planning and explain in detail. **(May / June 2013**) **(A)**
12. Tabulate the limits for CE and RE under MIL-STD-461 D. **(May / June 2013**) **(A)**
13. Explain in detail about the following international standardizing organizations. **(Nov/Dec 2013) (AZ)**
    i) FCC CE and RE standards
    ii) DOD
    iii)CENEEC
14. Describe in detail about the CISPR international standardizing organization and its CE and RE standards. **(Nov/ Dec 2013) (AZ)**
15. Explain in detail about the following international standardizing Organizations **(May/June 2014**) **(AZ)**
    i) FCC CE and RE standards
    ii) IEC/EN and CS standards
16. Explain in detail about the following international standardizing Organizations **(May/June 2014**) **(AZ)**
    i)CISPR CE and RE standards
    ii)ANSI
    iii)DOD
17. Explain the EMC standards and regulations in detail. **(Nov. / Dec. 2014) (AZ)**
18. Discuss about the frequency assignment and spectrum conservation with respect to EMC. **(Nov/ Dec 2014) (U)**

UNIT-IV
EMI CONTROL METHODS AND FIXES
PART-A

1. **What is grounding? (May / June 2014) (Nov. / Dec. 2014) (R)**

   Grounding is a technique that provides a low resistance path between electrical or electronic equipment and the earth or common reference low impedance plane to bypass fault current or EMI signal.

2. **What are the precautions used in earthing for EMC? (R)**
   i. Moisturization
   ii. Chemical salting
   iii. Cathode protection
   iv. Material, size, coatings and method of bonding.

3. **What is single point grounding? (R)**

   In this each subsystem is grounded to separate planes (structural grounds, signal grounds shield grounds, AC primary and secondary power grounds

4. **What is multi point grounding? (R)**
   In this scheme, every equipment is heavily bonded to a solid ground conducting plane which is then earthed for safety purpose.

5. **What is hybrid grounding? (R)**

   In this scheme, the ground appears as a single point ground at low frequencies and a multi point ground at high frequencies.

6. **What is floating ground? (R)**

   This system is electrically isolated from the equipment cables, building, ground and other conductive objects to avoid a coupling loop for noise. Currents present in the ground systems and their flow in signal circuits.

7. **What is cable shield grounding? (R)**

   When shielded cable is used for interconnection of two subsystems or system, the shield must be single ground reference at both ends.

8. **What is single shield? (R)**

   For a conductor used below optical frequencies, the conduction current is normally much greater than the displacement current.

9. **What is multimedia laminated shield? (R)**

In this shielding, where there are n-number os shields of impedances z1, z2,.. zm including both metals and air gaps. The total reflection loss can be expressed as the sum of the reflection losses at earth interface.

10. **What is isolated double shield? (R)**

In a big shielding enclosure, a very high shielding is normally provided with double isolated conducting metal sheets separated by an inner core made up of dry plywood.

11. **What is shielding? (R)**

It's a technique that reduces or prevents coupling of undesired radiated electromagnetic energy into equipment to enable it to operator compatibly in its electromagnetic environment.

12. **What is bonding? (R)**

Electrical bonding is a process in which components or modules of an assembly, equipment or subsystems are electrically connected by means of a low impedance conductor.

13. **What is filtering? (R)**

Filtering is an important mitigation for suppressing undesired conducted electromagnetic interference (EMI). When a system incorporates shielding, undesired coupling caused by radiated EMI is reduced.

14. **What is EMC gasket? (R)**

EMC gaskets are shielding arrangements used to reduce the leakage of electromagnetic energy at metal-to-metal joints. Conductive gaskets, when properly compressed, provide electrical continuity between seam-mating surfaces.

15. **What is the purpose of isolation transformer? (R)**

To suppress the common and differential mode interference the isolation transformed is used.

16. **What is the purpose of opto-isolator? (Nov/Dec2012)(May/June2014)(AZ)**

Electromagnetic interference problems are greatly reduced in signal transmission lines when optical isolators are used for coupling signals in both digital and analog forms.

17. **What are the factors that influence the EMI performance of bonding? (Nov. / Dec. 2011) (AZ)**

i. Generation of intermediation products because of nonlinear effects at contacts between similar and dissimilar metals.
ii. Development of potential differences caused by DC and AC resistances and inductance of a given length of the bond strap.
iii. Adverse impedance response because of resonance of inductance and the residual capacitance of the bond strap.

18. **Write in brief how opto-isolator is used to control EMI. (Nov /Dec 2011) (E)**

Electromagnetic interference problems are greatly reduced in signal transmission lines when optical isolators are used for coupling signals in both digital and analog forms. The guided wave propagation of modulated optical signals through optical fibers does not involve radiation, and interference signal cannot enter fiber-optic transmission lines.

PART-B

1. Explain grounding: **(AZ)**
2. Explain the precautions in earthing and system grounding for EMC: **(AZ)**
3. Explain the types of shielding discontinuities that exist in shielding walls: **(AZ)**
4. Explain EMC gaskets: **(AZ)**
5. What is shielding? Explain shielding theory and effectiveness: (R)
6. Explain cable shielding : **(AZ)**
7. Explain power line filter design: **(AZ)**
8. Explain the characteristics of filters. **(AZ)**
9. Explain the principles and practice of earthing. **(Nov. / Dec. 2011) (AZ)**
10. Explain shielding theory & shielding effectiveness based on the types of shield **(Nov/ Dec 2011) (AZ)**
11. Write shorts notes on the following topics: **(E)**
    i. Electrostatic discharge
    ii. Errors in EMI testing. **(Nov. / Dec. 2012)**
12. Write short notes on the following topics **(E)**
    i. Isolation transformer
    ii. Opto isolator. **(Nov. / Dec. 2012)**
13. With suitable diagrams explain the properties of EMC gaskets. **(May / June 2013**) **(A)**
14. With suitable circuit diagrams explain the performance of isolation transformer and opto-isolator. **(May / June 2013**) **(A)**
15. i) Explain with diagram the principle of operation and application of single point, multi point and hybrid grounding. **(Nov. / Dec. 2013) (AZ)**
    ii) Write a short note on EMI gasket. **(Nov. / Dec. 2013) (C)**

16. i) Explain with diagram the shielding effectiveness (SE) of a metal barrier with relation to Absorption loss, reflection loss and multiple internal reflection loss. **(Nov. / Dec. 2013) (AZ)**
    ii) Write a short note on opto-isolator **(Nov. / Dec. 2013) (C)**
17. i) Explain with diagram the shielding effectiveness (SE) of a metal barrier with relation to absorption loss, Reflection loss and multiple internal reflection losses. **(May / June 2014**) (AZ)
    ii) Write short notes on EMI gasket. (C)
18. Write short notes on**(May / June 2014**) (E)
    i) Electrostatic discharge
    ii) Errors in EMI testing
19. i) Explain the working principle of an Opto-isolator **(Nov. / Dec. 2014) (AZ)**
    ii) Explain how EMI is controlled by the filtering technique and EMI gasket. **(AZ)**
20. Explain how grounding and bonding helps in controlling EMI. **(Nov. / Dec. 2014) (AZ)**

UNIT-V
EMC DESIGN AND INTERCONNECTION TECHNIQUES
PART-A

1. **What are the types of EMI suppression cables? (R)**

   - Twisted Pair Cable
   - Coaxial Cable
   - Shielded wire bundles
   - Absorptive Cable
   - Ribbon Cable

2. **What is PCB Board? (R)**

   Printed Circuit Boards are primarily an insulating material used as base, into which conductive strips are printed. The base material is generally fiber glass and the conductive connections are generally copper and are made through etching process.

$$SE(\text{dB}) = \alpha_R(\text{dB}) + \alpha_A(\text{dB}) + \alpha_{IR}(\text{dB})$$

3. **What are pads in PCB? (R)**

   Pads come in all sorts of shapes and sizes .They can be through hole or SMD but they all follow the same general guidelines.

4. **What is vias in PCB? (R)**

   Vias are special pads which connect electrical signals from one side of board to another. Vias are made of conducting material which are called plated through hole.

5. **What is Trace Routing? (R)**

   A PCB design tool represents the necessary connections between parts with a wire. These wires are called nets. Nets acts as design guide.

6. **Define decoupling. (May / June 2014) Nov. / Dec. 2014) (R)**

   It is important to remember that noise signals should be confined to their known and desired location and not be allowed to propagate to other parts of the system where they may radiate more efficiently or cause functional problems. These noise signals can couple either by radiation from PCB to PCB or via conducting paths such as in reconnect cables or backplanes. Eliminating this coupling is referred to as decoupling the sub systems.

7. **What is system Zoning?(Nov. / Dec. 2011) (May / June 2014) (R)**

   Handling every EMC problem at once is a very complex task. It is therefore a good idea to split the systems into smaller subsystems or zones and handle these individually. The zones may in some casesa only be different areas of the same PCB. The important part is to have control of what happens in side one zone and how the zones interact.

8. **What is internal cable routing?(Nov. / Dec. 2011) (R)**
   The connection between the sub systems through internal cables is known as internal cable routing.

9. **What is the purpose of grounding in PCB?(R)**
   The main purpose of grounding pattern is to minimize the ground impedance and the size of any potential ground loops from a circuit back to the power supply.

10. **What is the use of the Bypass Capacitor? (R)**
    The main function of the bypass capacitor is to create an AC shunt to remove the undesirable energy from entering susceptible areas .It is acting as a high frequency bypass source to reduce the transient circuit demand on the power supply unit.

PART-B

1. Explain the types of EMI suppression cables and considerations carried out in connectors for improving EMC(8 +8): **(AZ)**
2. Explain about component selection and mounting: **(AZ)**
3. Explain trace routing and impedance control: **(AZ)**
4. Explain decoupling in PCB design: **(AZ)**
5. Explain zoning and grounding in PCB: **(AZ)**
6. Explain the suppression techniques used in PCB design: **(AZ)**
7. Explain the signal integrity problems in IC packages and PCBs: explain about the SI issues in PCB design: **(AZ)**
8. Explain the different methods of component relation and mounting in EMC design. **(Nov. / Dec. 2011) (AZ)**
9. Explain PCB design and trace routing with necessary diagrams. **(Nov. / Dec. 2011) (AZ)**
10. Explain the case studies of some EMI problems in PCBs and high frequency ICs. **(Nov. / Dec. 2012) (AZ)**
11. Discuss how passive components are chosen for EMC in detail. **(Nov. / Dec. 2012) (U)**
12. Explain how various components and modules of an assembly are bonded together. **(Nov. / Dec. 2012) (AZ)**
13. i)What are the EMC considerations in PCB design? **(May / June 2013**) **(R)**
    ii)Explain the PCB grounding systems. **(May / June 2013**) **(AZ)**
14. Discuss about EMI reduction techniques at the PCB level and explain the decoupling principle. **(May / June 2013**) (U)
15. Describe the various features that govern a PCB layer stack up with reference to a multi-layer board. Discuss the various PCB power supply decoupling aspects to minimize EMI. **(Nov. / Dec. 2013) (U)**
16. Write short notes on the following topics: **(Nov. / Dec. 2013) (E)**
    i)Interconnection techniques in EMC design.
    ii)Zoning and grounding in PCB design.
17. i) Discuss how the passive components are chosen for EMC in detail. **(May / June 2014**) **(U)**

ii)Explain how the various components and modules of an assembly are bonded together. **(AZ)**

18. Explain the trace routing and impedance control problems in PCBs and high frequency ICs design**(May / June 2014**) **(AZ)**
19. Explain about PCB design trace routing. **(Nov. / Dec. 2014) (AZ)**
20. i)Explain in detail about zoning and grounding interconnection techniques related to EMC design. **(Nov. / Dec. 2014) (AZ)**
    ii)Explain about decoupling and impedance control in EMC design techniques. **(AZ)**

ASSIGNMENTS

UNIT -I (Assignment -1)

1. How do you calculate the induced voltages appearing as transients on power lines for known terminal impedances from a knowledge of terminal currents?
2. Describe an antenna effect of a conductor. Explain the relation between length and wavelength of the radiated signal
3. What are the types of Electro Magnetic interference? With neat diagram explain the sources and consequences of EMI.
4. Explain the cloud-to-ground discharge and cloud-to-cloud discharge.
5. Explain the various mechanisms in which electromagnetic interference can travel from its source to the receptor
6. Define the term transient. Mention the characteristics of standardized transients.

UNIT -II (Assignment -2)

1. With diagrams explain the design considerations of FCC open area RE measurement sites with DUT kept stationary and also with DUT rotatable 3600 in azimuthal plane. How is such site evaluated experimentally to comply FCC regulation for RE measurements?
2. Discuss the impact of radiated common mode and differential mode coupling. Also explain how the surges on main power supply affect appliances and how it can be avoided with appropriate design.
3. Explain Common mode, Differential mode and ground loop coupling.
4. Describe the construction of Anechoic chamber and discuss how low and high frequency tests are performed
5. Illustration of the use of a line impedance stabilization network (USN) in the measurement of conducted emissions, and also Explain in detail about LISN circuit.

UNIT -III (Assignment -3)

1. What is the need for standards? Explain the civilian standards FCC, CISPR and IEC.
2. Explain the need for EMI standards. Discuss briefly on EN standards.
3. Discuss on the grounding strategies for (i) large systems (ii) mixed signal systems.
4. Explain about the various types of shielding techniques
5. (i)Explain about American National Standards Institute (ANSI) standard for measurements.
   (ii)Briefly describe FCC CE and RE standards.

UNIT –IV (Assignment -4)

1. List the factors that influence the EMI performance of bonding. What are the general guidelines for a good bond ? Discuss the various bonding techniques
2. Discuss the various methods of grounding to combat EMI
3. Discuss in detail the specifications for emission d susceptibility given in MIL461E standard
4. What is isolation transformer? Briefly describe the function of isolation transformer.
5. (i) Describe the requirement of shielding. And also explain in detail about various types of solid and non- solid shielding techniques.

UNIT –V (Assignment -5)

1. How is propagation path loss computed? What do you mean by susceptibility level? Describe the relationship between PCB traces and susceptibility level.
2. Discuss briefly on control devices in EMC design. Draw the block diagram for propagation loss routine and explain.
3. Give a detailed account on anechoic chamber used for EMI measurement and explain the procedure for RE and RS measurement.
4. Give a detailed account on EMI test receivers and EMI test wave simulators.
5. (i). Discuss how Electromagnetic compatibility is achieved in PCB design.
   (ii) Describe how component selection and mounting is performed in PCB.

EC 6014

COGNITIVE RADIO

UNIT-I

INTRODUCTION TO SDR

PART-A

1) Define Software-Defined Radio. (NOV / DEC 2016) (R)

Software-defined radio (SDR) is a radio communication system where components that have been typically implemented in hardware (e.g. mixers, filters, amplifiers, modulators/demodulators, detectors, etc.) are instead implemented by means of software on a personal computer or embedded system.

2) What is the evolution of Software-Defined Radio? (U)

Cognitive Radio is an evolution of SDR. A cognitive radio (CR) is an SDR that additionally senses its environment, tracks changes, and reacts upon its findings.

3) What are the key applications of SDR? (AZ)

Military, Public safety networks, Wireless medical networks and Space Communication which are some of the applications of SDR.

4) What are the tradeoffs required in SDR?

The tradeoffs includes Radio node, Source set, channel set, Joint control ,Channel coding and decoding modules, Software object.

5) Mention the design tradeoffs in usage scenarios. (C)

Field Programmable Gate Array (FPGA), Digital Signal Processor(DSP) and General Purpose Processor(GPP),RF Front end, ADC, DAC.

6) Compare Software architecture with radio architecture. (E)

A radio is one where at least some part of the signal processing is done digitally. The digital signal processing could be done with any combination of fixed hardware or reconfigurable hardware. Also if any error occurred in hardware part, it could be resolved only with the help of a person. A software defined radio is a digital radio that has some part

of the signal processing chain implemented as software and if any fault occurs, it is easy to change the specifications in software.

7) Mention the types of antenna's used in SDR. (AZ)

Directional antennas, Reconfigurable antennas and UWB antennas

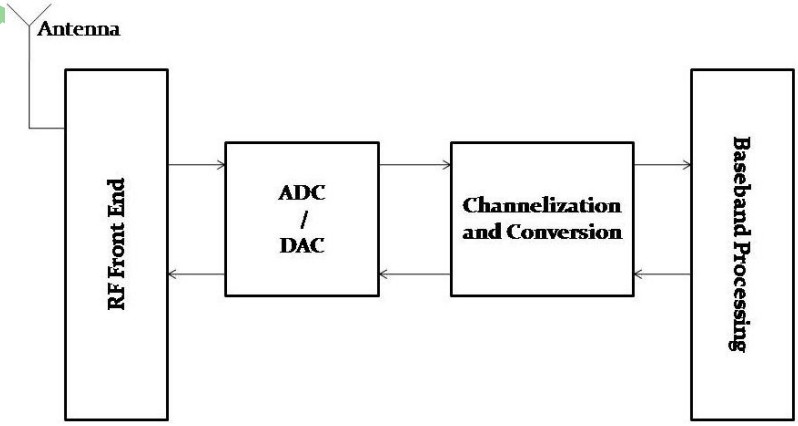
8) What are the requirements of SDR? (U)

Unintentional disturber, high power and efficiency, best sensitivity, wide frequency range, etc,.

9) List out the potential benefits of SDR. (R)

- Reduce costs in providing end-users with access to ubiquitous wireless communications – enabling them to communicate with whomever they need, whenever they need to and in whatever manner is appropriate.
- New features and capabilities to be added to existing infrastructure without requiring major new capital expenditures, allowing service providers to quasi-future proof their networks.
- The use of a common radio platform for multiple markets, significantly reducing logistical support and operating expenditures.
- Remote software downloads, through which capacity can be increased, capability upgrades can be activated and new revenue generating features can be inserted.

10) Draw the block diagram of SDR. (R)



11) Define Software flexibility and affordability. (NOV / DEC 2016) (R)

- ✓ If new software is implemented, it should be adaptive and supportive to existing system is called software flexibility.
- ✓ When new software is introduced, it should be cost effective to support the existing system is called software affordability.

PART-B

1. Discuss the evolution of architecture of Software -Defined radio (SDR) in detail. (C) **(NOV / DEC 2016)**
2. Discuss about the architecture implications of software defined radio. (C)
3. Write the potential benefits of SDR. **(NOV / DEC 2016)** (U)
4. Discuss in detail about the technology tradeoffs in SDR with neat diagram. (AZ) **(NOV / DEC 2016)**
5. Illustrate the Software Radio functions. (U)
6. Discuss in detail about the design for a SDR implementation mentioning the Software Radio reference platform parameters. (A)
7. Explain the Spectrum Implications in SDR. (U)
8. Describe about the tiers in SDR in detail. (U)
9. Enumerate the different applications of SDR. (A)
10. Examine the top down object oriented design analysis of SDR. (AZ)
11. How software architecture is implemented? (AZ)
12. Distinguish software architecture from radio architecture. (AZ)

UNIT-II

SDR ARCHITECTURE

PART-A

1) Mention some essential functions of the software radio. (AZ)

A function of software radio includes spreading/de-spreading, frequency-hop-and chip-rate recoveries, code/decode functions, modulation/demodulation, carrier and symbol rate recovery, and channel interleaving/de-interleaving.

2) What is SCA? (R)

The Software Communications Architecture (SCA) is an open architecture framework that tells designers how elements of hardware and software are to operate in harmony within a software defined radio.

3) What are the characteristics and properties of joint control in SDR? (AZ)

Autonomous selection of band, mode and data format. Singleton (Single band versus multiple bands) and null functions. Joint Control integrates all fault modes, multiple Personalities and support functions on a limited resource of applications-specific integrated circuits (ASIC's), Fields programmable gate arrays (FPGA's), Digital Signal Processors(DSP's) and General-Purpose Computers to provide a reliable telecommunications object.

4) How does the hardware architecture support the SDR? (A)

The modem in the hardware part of SDR is used to support the functions of SDR. Also the modem works in both receive and transmit mode.

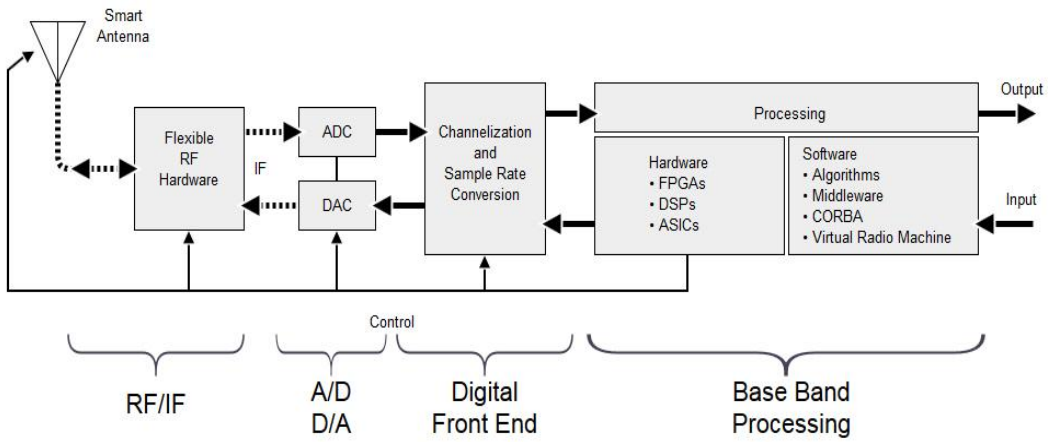
5) Discuss the role of software architecture in SDR. (U)

The software architecture of SDR is mainly used to place waveforms and applications onto a software based radio platform in a standardized way.

6) What are the architecture goals of SDR? (U)

- Implement all transceiver functions in software.
- Replace as many analog components and hardwired digital VLSI devices of the transmitter-receiver as possible with programmable devices.

7) Draw the topology of SDR. (R)



8) List out some properties of SDR. **(U)**

Carrier frequency, signal bandwidth, modulation and network access.

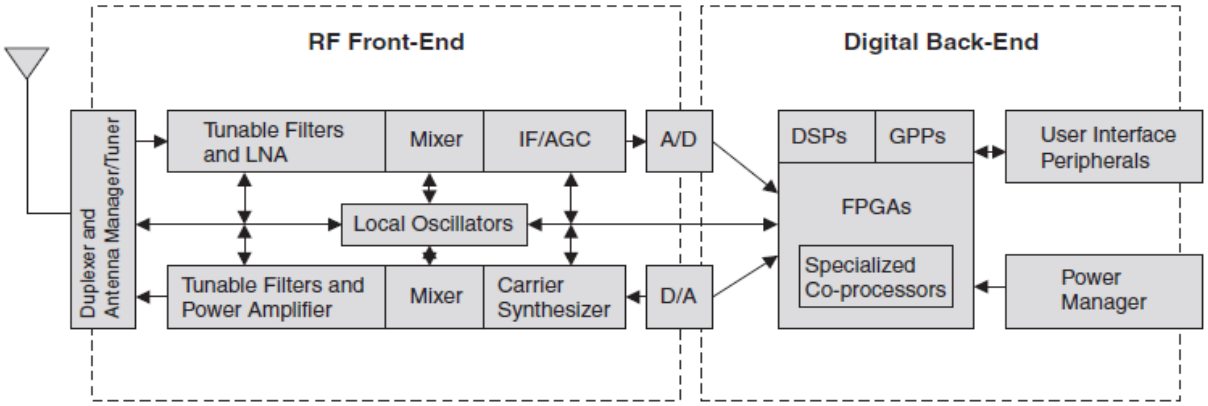
9) Mention the applications of SDR **(A)**

1. Vehicular Communication networks
2. Cognitive radio and Intelligent wireless adaptation
3. Satellite communication networks

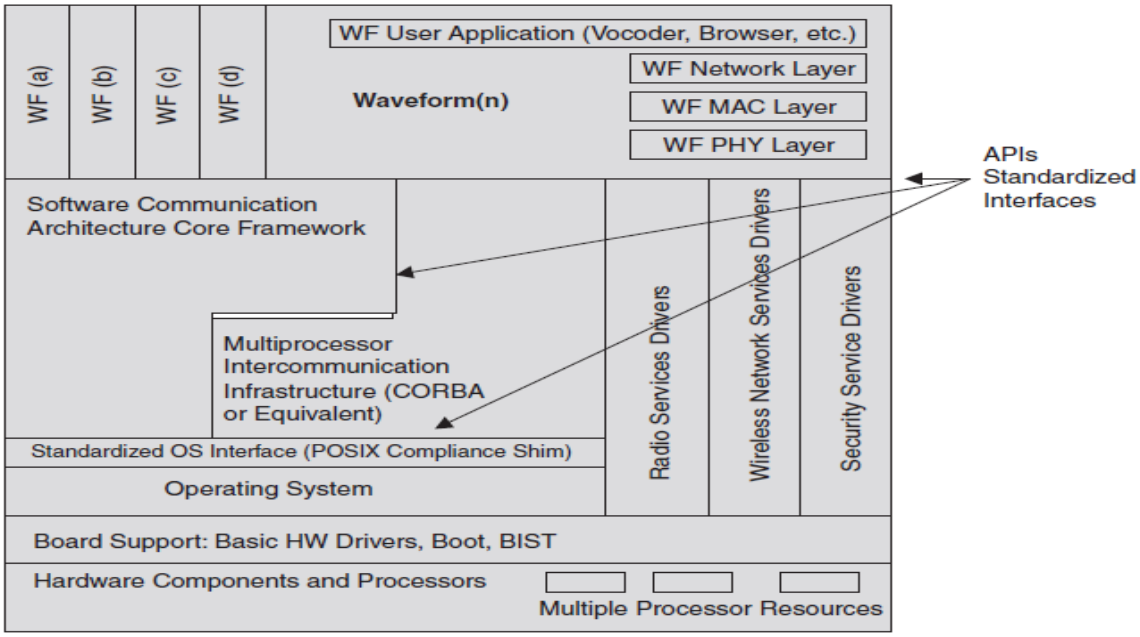
10) What are the functional components in SDR? **(R)**

GPP(General purpose processor), DSP, FPGA, ADC, DAC, Mixer, Local Oscillator

11) Draw the SDR transceiver. **(U)**



12) What is the protocol stack of SDR? **(U)**



13) What is the software design process? (R)

Software design is the process of implementing software solutions to one or more set of problems. One of the important parts of software design is the software requirements analysis (SRA). It is a part of the software development process.

14) Define software objects. (R)

Software objects are modeled after real-world objects in that they, too, have state and behavior. A software object maintains its state in *variables* and implements its behavior with methods.

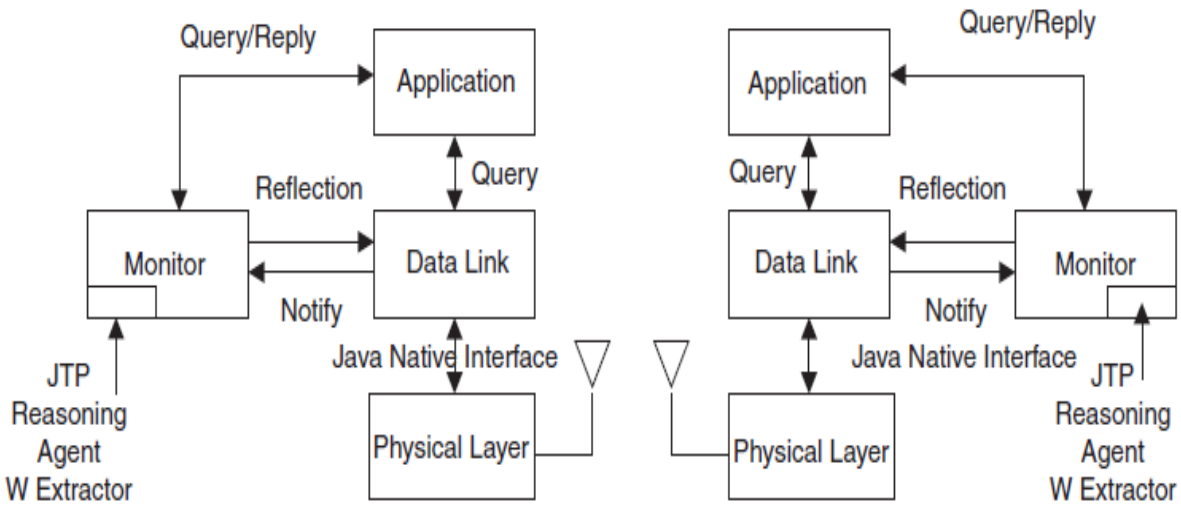
15) What is the software radio design tradeoffs required? (U)

Boot Loader, Operating system, Board Support package(BSP), Hardware abstraction layer(HAL).

16) Define Programmable Digital Radio (PDR). (R)

A digital radio performs part of the signal processing or transmission digitally, and also programmable in the field is called as PDR.

17) Draw the SDR forum architecture framework. (U)



18) What do you mean by Virtual machine and Middleware? (NOV / DEC 2016) (R)

Virtual machine is a software computer like a physical computer which runs an operating system and software application. Middleware is software that acts as a bridge between operating system and software application.

19) What is Plug and Play module? (NOV / DEC 2016) (R)

A new technology introduced can be interfaced or removed according to the application and it should be compatible to the existing system. This is called Plug and Play module.

PART-B

1) Define and explain each essential functions of the software radio. (R)

2) What are the architectural goals of SDR? Explain with neat diagrams. (R)

3) Explain the RF front-end architecture of SDR. (R)

4) Discuss about the use of MEMS in RF for SDR. (U)

5) Briefly describe in detail on top level component topology of SDR. **(NOV / DEC 2016)** (U)

6) With neat diagrams, explain the functional components and properties of SDR architecture.(R)

7) Explain the various interface topologies available for SDR. (U)

8) Discuss briefly about architecture partitions of SDR with diagrams. (A)

9) Discuss in detail about the hardware architecture of SDR. **(NOV / DEC 2016)** (AZ)

10) Explain the interfaces used in plug and play modules. (A)

11) Explain the computational processing resources in SDR. **(NOV / DEC 2016)** (U)

12) Illustrate and explain the software architecture of SDR with suitable diagram. (A)

13) Justify how the software defined radio acts as a platform for cognitive radio. (AZ)

UNIT III

INTRODUCTION TO COGNITIVE RADIOS

PART-A

1) Define self-aware cognitive radio. **(R)**

It states that the humans are self aware and instead, it refers to the radio's ability to keep track of its performance and available resources and ir alter its behavior to account for needs and changes required. Also the radio will use the knowledge of itself in the optimization problem.

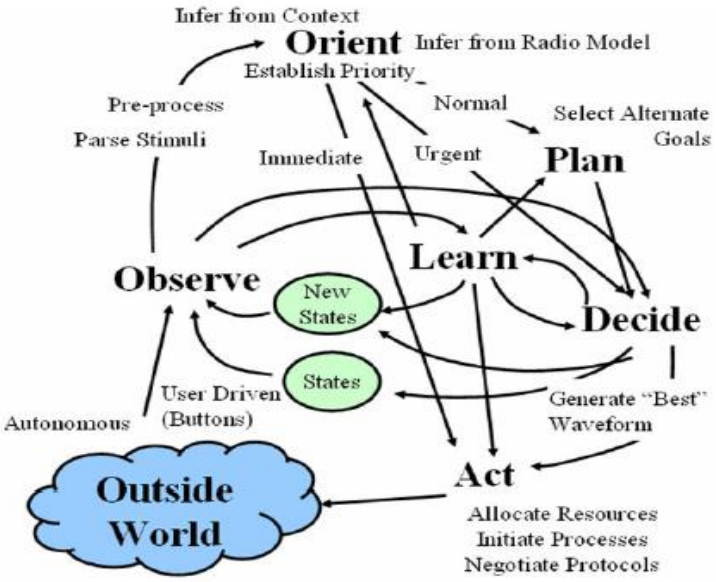
2) Differentiate iCR and DSA. **(U)**

Ideal Cognitive Radio (iCR) differs form Dynamic Spectrum Architecture (DSA) in its degree of integration of self-awareness, user awareness and machine learning.

3) What is cognition cycle? **(R)**

The cognitive radio network follows the cognitive cycle for best resource management and network performance. It starts by sensing the environment, analyzing the outdoor parameters, and then making decisions for dynamic resource allocation and management to improve the utilization of the radio electromagnetic spectrum.

4) Draw the cognition cycle. **(U)**



5) List some characteristics of Radio Cognition Task. (R)

1. Spectrum Sensing 2. Spectrum Analysis 3.Spectrum Access Decisions

6) What are the potential impact areas of cognitive radio? (U)

1. Human Machine Interface (HMI)
2. Radio Centric Operations
3. Network Centric Operations

7) What are the challenges in CR? (A)

Policy Challenges:
1. Allowance of Self learning Mechanism
2. Allowance of Software Challenges
3. Allowance of Frequency and waveform agility

Security Challenges:
1. Equipment Authorization
2. Software Certification
3. Monitoring Mechanisms

8) What is location awareness in cognitive radio? (R)

The cognitive radio knows where it is, in the form of latitude, longtitude and altitude or relative location to some reference nodes

9) Define environment awareness in CR. (R)

The cognitive radio knows the terrain and geographical information related to the radio propagation and channel characteristics. This awareness is critically important for a cognitive radio to choose the appropriate spectrum, channel model, antenna configuration and networking techniques.

10) Define spectrum pooling. (R)

It is a novel approach to radio resource management enabled by cognitive radio. Pooling is the rental of public and government spectrum by the present owners to cellular service providers.

11) What is Policy Language ? **(R)**

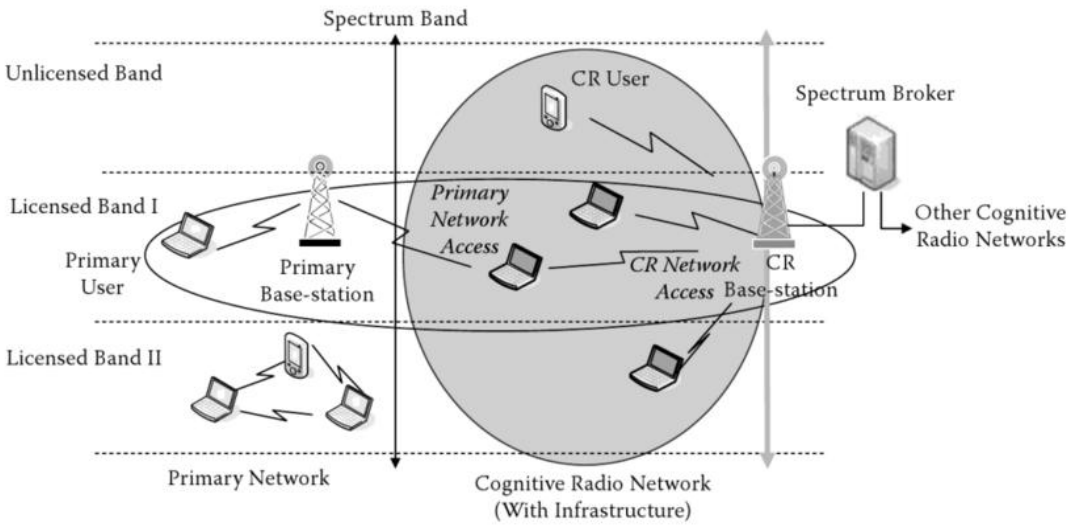
It serves as an interface between two regulators and radio engineers.

Web Ontology Language (OWL), and DARPA Agent Markup Language (DAML)

12) What are the design tradeoffs in usage scenarios? **(U)**

It includes the hardware and system requirements and constraints, particularly its complexity and cost. These systems are used to measure the interference that a cognitive transmitter causes to a primary receiver.

13) Draw the architecture of cognitive radio network **(U)**



14) How environment awareness acquire in cognitive radio? (NOV / DEC 2016) **(U)**

The environment awareness in cognitive radio have a complete knowledge of the surrounding environment by acquiring the information on topography, objects, propagation channel and meteorology of the target location.

15) What is optimization of radio resources? (NOV / DEC 2016) **(C)**

A radio is optimized, when it achieves a level of performance and satisfies the user needs by minimizing the consumption of resources such as occupied bandwidth and battery power.

16) Classify Sensing mechanism. **(R)**

a. Radio Sensing
b. Radio Vision
c. Radio Hearing

17) Mention the radio sensing sensors. **(U)**

The most widely used radio sensing sensor in wireless system is antenna. Antenna is a transducer that converts electromagnetic signal into electrical signals and viceversa.

18) State the principal of Radio vision sensors. **(U)**

Radio vision sensor such as image sensor is a device that captures optic signals from the environment and converts them to electric signals in order to construct the corresponding image.

19) Name the subsystems of location awareness engine. **(R)**

a. Location Sensing
b. Location Awareness Core
c. Location Adaptation

PART-B

1) Draw the cognitive radio framework and explain each block. (R)

2) With a neat diagram, explain the simplified cognition cycle. (U)

3) List and explain the characteristics of radio cognition task. (R)

4) Explain the structuring knowledge for cognition tasks. (E)

5) What are the primary concepts of location aware cognitive radio? Explain with neat architecture. (U)

6) Explain environment aware cognitive radio in detail. (R)

7) Discuss about ideal CRA and dynamic spectrum access architectures. (U)

9) Write short notes on (i) Spectrum awareness (ii) Challenges and opportunities in CR. (R)

10) Define and describe the design considerations for cognitive radio. (AZ)

11) What are the primary concepts of Position awareness cognitive radio? Explain with neat architecture. **(NOV / DEC 2016)** (U)

12) Discuss any two Artificial Intelligent Techniques suitable for cognitive radio and its working principle with neat diagram. **(NOV / DEC 2016)** (E)

UNIT IV

COGNITIVE RADIO ARCHITECTURE

PART-A

1) What are the primary functions of Cognition? (R)

The primary functions of cognitive radios are dynamic spectrum allocation using spectrum sensing to detect and negotiate usage of incumbent spectrum.

2) What is the objective of cognitive radio architecture? (R)

The objective of cognitive radio architecture is to identify the components and interfaces for cognitive radios with sensory and perception capabilities in the user as well as radio domain.

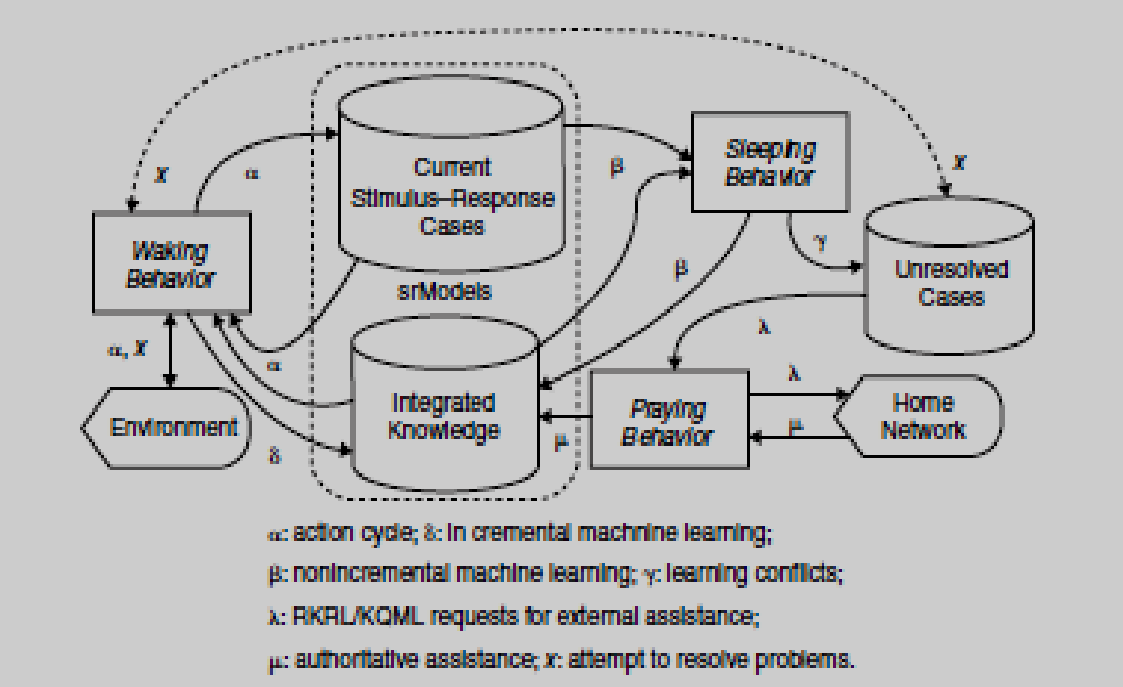
3) Mention the parameters of cognition function. (U)

The parameters of Cognition Function are channel occupancy, free channels, the type of data to be transmitted, the modulation types that may be used.

4) Define behavior epoch. Mention the modes of behavior. (R)

Behavior that lasts for a specific time interval is called behavior epoch. Modes of behavior : Waking, Sleeping and Praying

5) Draw the cognitive behavior model. **(R)**



6) What is waking behavior? (NOV / DEC 2016) **(R)**

Waking behavior is optimized for real-time interaction with the user, isochronous control of SWR assists and real time sensing of the environment. The conduct of the waking behavior is informally referred to as the awake-state.

7) Define sleeping behavior. **(R)**

If the cognitive PDAs predicts or become aware of long epoch of low utilization, then the CPDA initiate sleeping behavior

8) What is a conflict? **(R)**

A Conflict is a context in which the user overrode a CPDA decision about which the CPDA had a little or no certainity.

9) Define prayer behavior. **(A)**

The attempts to resolve unresolved conflicts via the mediation of the PDAs home network may be called as Prayer Behavior

10) What are the components of CR? (R)

Hardware Components : ADC, DAC and processor suite.

Software Components : User Interface, Networking software, information security. RF media access software and ant antenna related software

11) Define world model. (U)

The world model consists primarily of bindings between a priori data structures (dialog states, action requests, plans and actions) and the current scene (Scene bindings, dialog bindings, phrase and word bindings)

13) What are the components of observe-phase data structures? (U)

Functional Components :

User SP and environment (Rf and physical) sensor subsystems

14) Define decide-phase components (R)

The decide phase selects among the candidate plans. The radio might have the choice to alert the user to an incoming message or to defer the interruption.

15) Describe any two design rules of cognitive radio. (AZ)

1. The cognition function should maintain a topological model of space-time of the user, the physical environment, the radio networks and the internal states of the radio.
2. The CRA requires each CR to predict, in advance, an upper bound on the amount of computational resources required for each cognition cycle.

16) Compare cognitive radio and software radio. (NOV / DEC 2016) (AZ)

A software defined radio incorporated with the intelligence system that has the capability of sensing the environment, optimizing the radio resources and learning the system performance is called cognitive radio.

PART-B

1) Discuss about the primary functions of cognitive radio with diagram. (U)

2) What is behavior? Explain the various modes of behavior. (A)

3) With neat architecture, explain the cognitive radio components. (U)

4) Write short notes on a) A-Priori Knowledge Taxonomy b) Observe-phase data structure. (A)

5) Explain natural language encapsulation and Radio Procedure Knowledge Encapsulation. (AZ)

6) Explain the various components of cognitive radio architecture. (E)

7) Describe the design rules in detail for cognitive radio. (AZ)

8) Explain the reinforced hierarchical sequences and NLE. (A)

9) Discuss the components of orient, plan and decide phases in detail. (U)

10) Discuss the primary functions, components and design rules of Cognitive Radio. (A) **(NOV / DEC 2016)**

11) What is cognition cycle? Discuss the various phases involved in cognition cycle with neat diagram. **(NOV / DEC 2016)** (U)

12) Draw and explain the "Architecture maps' of Cognitive radio with neat diagram. (U) **(NOV / DEC 2016)**

UNIT V

NEXT GENERATION WIRELESS NETWORKS

PART-A

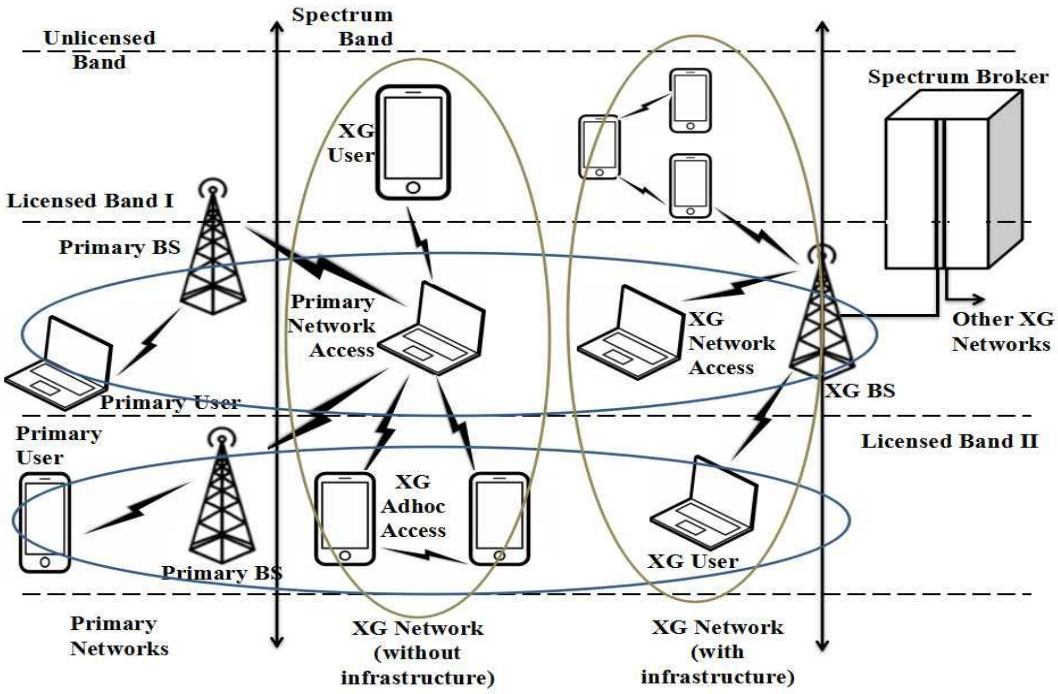
1) Define XG? What is the need of it? (R)

XG represents NeXt Generation communication network and it is also called as Dynamic Spectrum Access (DSA) Network.

Need for XG :

- To provide high bandwidth to mobile users
- To use the spectrum in dynamic manner

2) Draw the xG network architecture. (R)



3) What is re-configurability? Give its parameters. (R)

Re-configurability is the capability of adjusting operating parameters for the transmission on the fly without any modifications on the hardware components.

Its parameters are :

a) Operating frequency b) Modulation c) Transmission power

d) Communication technology

4) Mention the functions of cognitive radios in xG network. (U)

The main functions for cognitive radios in xG networks:

a) Spectrum sensing

b) Spectrum management

c) Spectrum mobility

d) Spectrum sharing

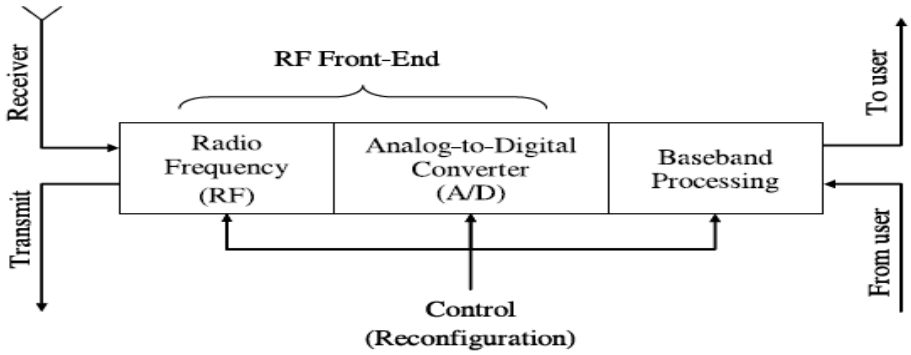
5) What is Spectrum sensing and Spectrum mobility? (NOV / DEC 2016) (R)

- *Spectrum sensing* : Detecting unused spectrum and sharing the spectrum without harmful interference with other users.
- *Spectrum mobility* : Maintaining seamless communication requirements during the transition to better spectrum.

6) Define cognitive capability. (U)

Cognitive capability refers to the ability of the radio technology to capture or sense the information from its radio environment and also to identify the portions of the spectrum that are unused at a specific time or location

7) Draw the physical architecture of cognitive radio. (R)



8) List out some main components of wideband RF front-end architecture. (U)

a) RF Filter
b) Low Noise Amplifier (LNA)
c) Mixer
d) Voltage Controlled Oscillator (VCO)
e) Phase Locked Loop (PLL)
f) Channel Selection Filter
g) Automatic Gain Control (AGC)

9) What are the steps involved in cognitive cycle? (U)

a) Spectrum Sensing
b) Spectrum Analysis

c) Spectrum Decision

10) Mention the applications of xG network. (A)

a) Leased Network b) Cognitive Mesh Network

c) Emergency Network d) Military Network

11) List out the challenges of spectrum sensing. (AZ)

a) Interference Temperature Measurement

b) Spectrum sensing in multi-user networks

c) Detection capability

12) What are the parameters of spectrum management? (A)

The parameters of spectrum management which represents the quality of a particular spectrum band are as follows :

a) Interference level b) Channel error rate c) Path-loss

d) Link layer delay e) Holding time

13) What do you meant by decision model? (R)

A decision model is a framework used for OFDM based XG networks to transmit multiple spectrum bands simultaneously. It is used to combine many spectrum characterization parameters so as to maintain the quality of the XG network.

14) Define spectrum handoff. (R)

If primary users appear in the spectrum band occupied by xG users, xG users should vacate the current spectrum band and move to the new available spectrum immediately. This process is known as Spectrum Handoff.

15) What is spectrum sharing? Mention the steps involved in it. (U)

Spectrum sharing can be regarded to be similar to generic medium access control (MAC) problems in existing systems.

Steps involved:

a. Spectrum sensing b. Spectrum allocation c. Spectrum access

d. Transmitter-receiver handshake e. Spectrum mobility

16) What is CCC? (R)

Common Control Channel (CCC) facilitates many spectrum sharing functionalities:

- Transmitter receiver handshake
- Communication with a central entity
- Sensing information exchange

17) Differentiate Centralized and Distributed inter-network spectrum sharing. (U)

Centralized Inter-network Spectrum Sharing	Distributed Inter-network Spectrum Sharing
A centralized entity controls the spectrum allocation and access procedures	Each node is responsible for the spectrum allocation and access.
Based on a distributed sensing procedure	Based on a local (or possibly global) policies.

18) What are the upper layer issues in xG network? (U)

The upper layer issues in xG network are :

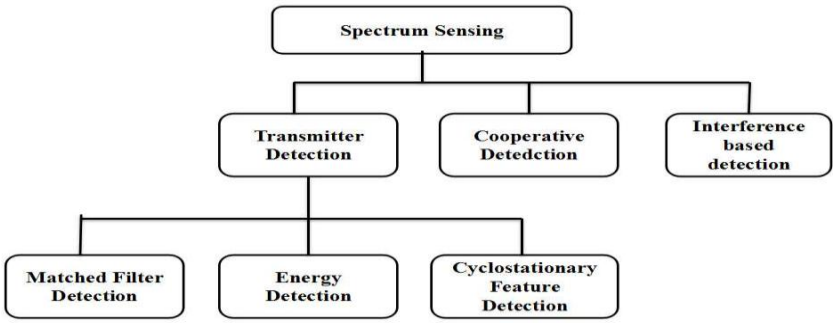
a. Routing Challenges

b. Transport Layer Challenges

19) Justify what is the need of cross layer design in xG network? (U)

The performance of xG networking functionalities directly depends on the properties of the spectrum band in use. This direct relationship necessitates a cross-layer design in the entire xG networking protocol stack.

20) Mention the Spectrum Sensing techniques (R)



21) What is a primary network? (R)

Primary network is an existing network infrastructure, which has an exclusive right to a certain spectrum band. Ex: Common cellular and TV broadcast networks. The components of primary network are primary user and primary base station.

22) List the components of an XG network. (R)

The following are the components of an XG network:

a) XG User b) XG BS c) Spectrum Broker

23) Name the Access types in XG network. (R)

a) XG Network Access b) XG Adhoc Access c) Primary Network Access

24) What are the issues in Spectrum Mobility? (U)

a) *Spectrum mobility in the time domain:* CR networks adapt to the wireless spectrum based on the available bands. Because these available channels change over time, enabling QoS in this environment is challenging.

b) *Spectrum mobility in space:* The available bands also change as a user moves from one place to another. Hence, continuous allocation of spectrum is a major challenge.

25) Mention the applications of XG networks. (A)

a) Leased Network b) Cognitive Network c) Emergency Network

d) Military Network e) Public Safety Network

26) Give the Spectrum Management challenges. (C)

a) Decision Model

b) Multiple Spectrum band decision

c) Cooperation with reconfiguration

d) Spectrum decision over heterogeneous spectrum bands

27) Define Spectrum Handoff Latency. (R)

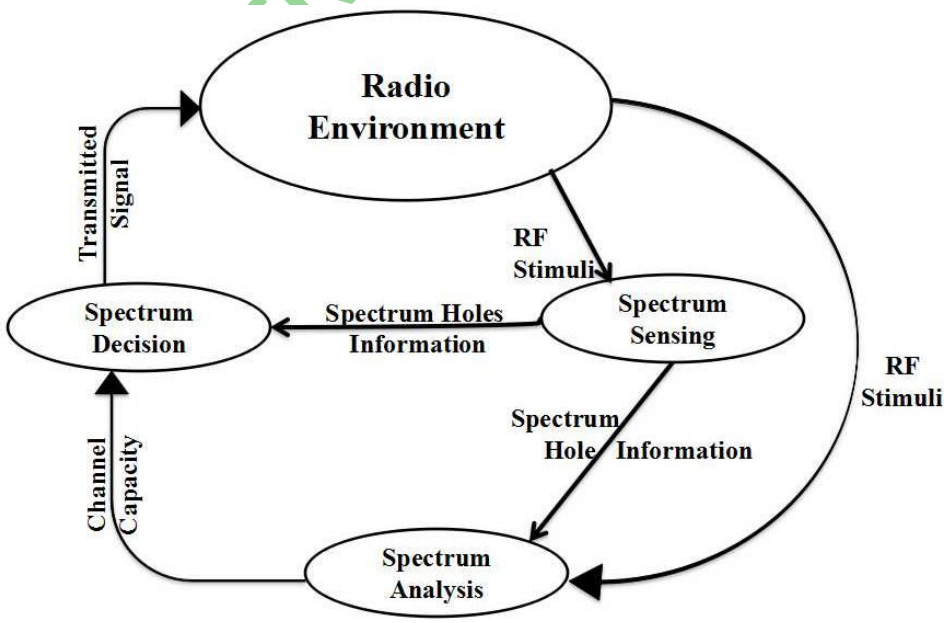
Spectrum Handoff latency affects the performance of communication and transport protocols. During spectrum handoff, the channel parameters such as path loss, interference, wireless link error and link layer delay are influenced by the dynamic use of the spectrum and also the changes in the PHY and MAC channel parameters can initiate spectrum handoff. In order to estimate the effect of the spectrum handoff latency, information about the link layer and sensing delays are required.

28) Mention the open research issues for routing in XG networks. (E)

The open research issues for routing in XG networks are:

a) Common Control Channel (CCC)
b) Intermittent Connectivity
c) Rerouting
d) Queue Management

29) Draw cognitive cycle.



30) List the parameters that affect the quality of the user application in cross layer spectrum management. (E)

A. Round Trip Time (RTT)

B. Error Probability

C. Behavior of communication protocols (MAC).

31) Comment on the term "spectrum hole" and justify the concept with diagram. (U)
(NOV / DEC 2016)

The Cognitive Radio enables the usage of temporally unused spectrum, which is referred to as spectrum hole or white space.

PART-B

1) Explain each components and its functionality of XG network architecture with neat diagram. **(NOV / DEC 2016)** (U)

2) With physical architecture, discuss about the uses, characteristics and objectives of cognitive radio in xG network. (U)

4) What are challenges and requirements of spectrum sensing? Explain. (A)

5) Discuss about spectrum management and its challenges (C)

6) Define spectrum mobility. Explain its challenges and parameters in xG networks. (C)

7) Explain in detail about spectrum sharing process with steps. (AZ)

8) Write short notes on a. Inter-network spectrum sharing b. Intra-network spectrum sharing. (U)
(NOV / DEC 2016)

9) Explain the upper layer issues in xG networks. **(NOV / DEC 2016)** (AZ)

10) Describe in detail about the cross layer design issues in xG networks. (AZ)

ASSIGNMENT QUESTIONS

S.No	QUESTIONS	BTL
	UNIT I	
1	Discuss how the MIMO Antennas for Software Defined radio.	A
2	Analyze various modulation techniques of SDR.	AZ
3	Discuss the Simulation tools, test beds, software and hardware prototypes.	E
	UNIT II	
1	What are the Quantifying degrees of programmability and briefly explain it.	C
2	Enumerate the Computational properties of functional components.	AZ
3	Explain the Architecture partitions of SDR.	A
	UNIT III	
1	Illustrate the Spectrum mobility and handoff in Cognitive Radio for real time applications.	A
2	Interpret machine learning, self configuration, distributive adaptation and co-existence in cognitive radio.	E
3	Categorize the applications and services in cognitive radio for different phases.	AZ
	UNIT IV	
1	Examine the multi hop transmission, routing and cross layer optimization	U
2	Elaborate the measurement and statistical modeling of spectrum usage.	A
3	Evaluate modulation and waveform design, propagation modeling and spectrum sensing.	E
	UNIT V	
1	Exhibit information theoretic analysis and fundamental performance limit of dynamic spectrum access.	C
2	Describe spectrum sharing, resource allocation, multiple access and power control in XG networks.	U
3	Observe and summarize the standardization of Cognitive Radio.	A