V.S.B ENGINEERING COLLEGE, KARUR.
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
RF AND MICROWAVE ENGINEERING
VII SEMESTER
UNIT 1
TWO PORT NETWORK THEORY

1) Define two-port network.

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

2) Which one is called junction?

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

3) Define scattering matrix.

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

4) What are scattering coefficients?

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

5) What is waveguide?

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

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

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

- Equipment is not readily available to measure total voltage and total current at the ports of the networks.
- Short circuit and open circuit are difficult to achieve over a wide range of frequencies.
- Presence of active devices makes the circuit unstable for short (or) open circuit. Therefore, microwave circuits are analyses using scattering (or) S parameters which linearly relate the reflected wave s amplitude with those of incident waves.

7) Write the properties of [S] matrix.

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

8) State the reciprocity theorem.

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 (branch m, v_m); that is

$V_k/i_m = v_m/i_k$

9) Define lossless network.

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.

10) What is the zero property of S-matrix?

It states that, f o r 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 .

11) Write the unitary property for a lossless junction.

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

12) Define non-reciprocal devices.

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

13) What is wire?

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

14) Mention the many forms of wire.

Wire in a circuit can takes on many forms,

- Wire wound resistors
- Wire wound inductors
- Leaded capacitors
- Elements-to- element interconnection applications

15) Write about the skin effect in a wire.

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.

$R=r\,l/A$

Where,

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

16) Give a short note on straight-wire Inductance in wire.

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.

17) Define a resistor.

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.

18) Mention the purpose of resistors.

Purpose of Resistors:

- In transistor bias networks, to establish an operating point.
- In attenuators, to control the flow of power.
- In signal combiners, to produce a higher output power.
- In transmission lines, to create matched conditions.

19) Name the types of resistors.

Types of resistors:

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

20) What do you meant by capacitors?

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.

21) Define Quality-factor (Q) of Capacitor.

It is defined as the measure of the ability of an element to store energy, equal to 2p times the average energy stored divided by the energy dissipated per cycle".

22) Write the applications of inductors.

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

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

16 mark Questions:

1. Explain in detail about low frequency parameters.
2. Discuss about high frequency parameters.
3. How microwave junction can be described by scattering matrix. Derive the scattering matrix relation between the input and output of an nxn junction?
4. Discuss about various losses available in microwave?
5. Explain the symmetry property in a reciprocal network.
6. Explain the unitary property in a lossless junction.
7. Explain the transmission matrix for 2-port networks.
8. State and explain the properties of S-parameters.
9. Discuss about behavior of wire at RF with neat diagrams.

10. Write in detail about resistors and its types.
11. Give a detailed note on Inductors.
12. Explain in detail about capacitors.

UNIT-2
RF AMPLIFIERS AND MATCHING NETWORKS

1) Write the function of matching networks?

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?

Input and output matching networks are needed to reduce undesired reflections and improve the power flow capabilities.

3) What are the parameters used to evaluate the performance of an amplifier?

Key parameters of amplifier, to evaluate the performance are

- Gain and gain flatness(in dB)
- Operating frequency and bandwidth (in Hz)
- Output power (in dB)
- Power supply requirements (in V and A)
- Input and output reflection coefficients (VSWR)
- Noise figure (in dB)

4) Define transducer power gain.

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.

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?

The available power gain for load side matching ($\Gamma_L = \Gamma^*_{out}$) 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.

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

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

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

- If $|\Gamma|>1$, then the magnitude of the return voltage wave increases called *positive feedback*, which causes instability (oscillator).

- If $|T|<1$, then the return voltage wave is totally avoided (amplifier). It s called as *negative feedback.*

9) Define unconditional stability.

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.

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

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

16 mark Questions:

1. Discuss various aspects of amplifier-power relations for RF transistor amplifier design.
2. Explain stability considerations for RF transistor amplifier design.
3. Explain various stabilization methods.
4. Discuss gain considerations for RF amplifier.
5. Explain in detail about unconditional stability.

UNIT-3
PASSIVE AND ACTIVE MICROWAVE DEVICES

1) Define microwave.

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

2) What are the major bands available in microwave frequencies?

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

- 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) Enumerate the basic advantage of microwaves.

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

4) Write the applications of microwaves.

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

6) Define a microwave junction.

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

7) Why is magic tee referred to as E-H tee?

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

8) Define scattering matrix.

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.

9) What are scattering coefficients?

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

10) What is waveguide?

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Therefore, microwave circuits are analyzed using scattering (or) S parameters which linearly relate the reflected wave s amplitude with those of incident waves.

12) Write the properties of [S] matrix.

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

13) Write the unitary property for a lossless junction.

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

14) What is H-plane Tee?

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.

15) What is E-plane Tee?

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.

16) Define tee junction.

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

17) Name some uses of waveguide tees.

It is used to connect a branch or section of the waveguide in series or parallel with the main waveguide transmission line for providing means of splitting and also of combining power in a waveguide system.

18) What are the types of waveguide tees?

The two types of waveguide are

- E-plane Tee(series)
- H-plane Tee(shunt)

19) Define difference arm.

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

20) What is sum arm?

In a H=plane tee, if two input waves are fed into port1 and port2 of the collinear arm, the output wave at port3 will be in phase and additive. Because of this, the third port is called as sum arm.

21) Write the applications of magic tee.

A magic tee has several applications,

- Measurement of impedance
- As duplexer
- As mixer
- As an isolator

22) What is hybrid ring?

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

23) What do you meant by hybrid junction?

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

24) Why bends are used?

- Bends are used to alter the direction of propagation in a waveguide system.
- The reflection due to the bend is a function of its radius.

25) Name some uses of waveguide twists.

- Waveguide twists are used to change the plane of polarization of a propagating wave.
- Waveguide twists are helpful in converting vertical to horizontal polarizations or vice versa.

26) Define gradual twists.

The gradual twists changes the plane of polarizations in a continuous fashion.

27) Give a note on directional couplers.

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

28) Define coupling factor(C).

The coupling factor of a directional coupler is defined as the ratio of the incident power p i to the forward power p i measured in Db

Coupling factor (dB) = 10log10Pi/Pf

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

24) Define directivity of directional coupler.

The directivity of a directional coupler is defined as the ratio of forward power p to the back power p expressed in Db.

$$D\ (dB) = 10\log 10 Pf/Pb$$

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

25) What do you meant by isolation?

Isolation is defined as the ratio of the incident power P_i to the back power P_b expressed in dB. Isolation (dB) = $10 \log_{10} P_i/P_b$

Isolation (dB) equals coupling plus directivity.

26) Define Isolator.

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

27) What is circulator?

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

28) Write the characteristics of a three port tee junction.

a) A short circuit may always be placed in one of the arms of a three port junction in such a way that no power can be transferred through the other two arms.

b) If the junction is symmetric about of its arms, a short circuit can always be placed in that arm so that no reflections occur in power transmission between the other two arms.

c) It is impossible for a general three port junction of arbitrary to present matched impedances at all three arms.

29) Mention the different types of directional couplers.

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

30) Define non-reciprocal devices?

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

31) Define Isolator.

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

32) What is circulator?

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

33) Write the properties of ferrites.

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.

34) Write the types of ferrite device.

Types of ferrite device:

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

- Gyrator
- Isolator
- Circulators

35) What is gyrator?

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

36) What do you meant by Faraday rotation?

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

37) Define 4-port circulator.

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

38) Write the applications of circulator.

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

39) Name some uses of isolators.

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

40) Define Faraday rotation isolator.

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

16 mark Questions:

1. Discuss about microwave frequency bands.
2. Write the advantage and applications of microwave.
3. Explain a basic microwave system with neat diagram.
4. How microwave junction can be described by scattering matrix. Derive the scattering matrix relation between the input and output of a n x n junction?
5. What are waveguide tees? What are its applications? State different types.
6. Explain the operation of H-plane tee and derive the scattering matrix for it.

7. Explain the operation of E-plane tee and derive the scattering matrix for it.
8. Explain the operation of magic tee and derive the scattering matrix for it.
9. Write about the relation between [S] [Z] and [Y] matrix.
10. Describe in detail the operation of a 2-hole directional coupler.
11. With a neat sketch explain the following:
    i. Corners ii. Bends iii. Twists

12. Explain about hybrid circuit. State its applications.
13. Explain directional coupler construction, principle of working and applications.
14. Drive the [S] matrix for directional coupler.
15. With neat diagrams explain different types of directional coupler.
16. What are performance parameters of directional coupler?
17. Explain S-matrix for 2-port networks.
18. State and explain the properties of S-parameters.
19. What are ferrite devices? What are its compositions and application?
20. Explain the construction and working of four port circulator with reference to Faraday rotation principle.
21. Explain the construction working and application of isolator based on Faraday rotation.
22. Explain the operation of gyrator with neat diagram.

UNIT-4
MICROWAVE GENERATION

1) What are the advantages of microwave transistors?

Microwave transistors are miniaturized designs to reduce device and package parasitic capacitances and inductances and to overcome the finite transit time of the charge carriers in the semiconductor materials.

2) What is bipolar transistor?

Bipolar is three-semiconductor (pnp or npn) region structure where charge carriers of both negative (electrons) and positive (holes) polarities are involved in transistor operation.

3) Name the advantages Si bipolar over GaAs.

Compared to GaAs devices Si bipolar transistors are inexpensive, durable have higher gain and moderate noise figure.

4) Name the surface geometries available in microwave power transistors.

Three geometries are available

- Interdigitated
- Overlay
- Matrix

5) Write the applications of bipolar transistors.

Bipolar transistors are suitable for oscillator and power amplifier applications in addition to small-signal amplifiers.

6) What are the configurations available in bipolar transistors?

A transistor can be connected as three different configurations

1. Common Base (CB)
2. Common Emitter (CE)
3. Common Collector (CC)

It is depending on the polarities of the bias voltages connected to its terminals.

7) What are the different modes of bipolar transistor?

A bipolar transistor can operate in four different modes depending on the voltage polarities across the two junctions,

1. Normal (active) mode
2. Saturation mode
3. Cutoff mode
4. Inverse (inverted)

8) Define saturated drift velocity.

Maximum velocity of charge carriers in a semiconductor is called saturated drift velocity (v_S).

9) What is referred as unipolar transistor?

In a field-effect transistors, the current flow is carried by majority carriers either electrons or holes, this type is referred to as a unipolar transistor.

10) Write the advantages of unipolar transistor?

- It may have voltage gain in addition to current gain.
- Efficiency is higher.
- Noise Figure is low.
- Its operating frequency is up to X band.
- Its input resistance is very high, up to several mega ohms.

11) Define homo junction transistor.

When the transistor junction is joined by two similar materials such as silicon-to-silicon or germanium-to-germanium, it is a homo junction transistor.

12) What do you meant by hetero junction transistor?

The transistor junction formed by two different materials, such as GE to GaAs, is called a hetero junction transistor.

13) What are MESFET?

Field Effect Transistors (FETs) at microwave frequencies are mostly fabricated in GaAs and use a Metal semiconductor (MES) schottky junction for gate contact. This device is referred to as MESFET or Metal- semiconductor Field Effect Transistors.

14) Define n-channel JFET.

The n-type material is sandwiched between two highly doped layers of p-type material that is designated p^+. This type of device is called as n-channel JFET.

15) What is called as p-channel JFET?

The p-type material is sandwiched between two highly doped layers of n-type material that is designated n^+. This type of device is called as p-channel JFET.

16) What is called as pinch off?

When drain voltage V_d is increased, in JFET the space charge regions expand and join together, so that all free electron carriers are completely depleted in the joined region. This condition is called pinch off.

17) Write the expression for pinch off voltage in JFET.

As the drain voltage V_d is further increased, the space charge regions expand and join together, so that all free electron carriers are completely depleted in the joined region. This condition is called pinch off.

Pinch off voltage, $V_p = q N_d a^2/2 e$

18) Define ON JFET.

The JFET has a conducting channel between the source and the drain electrodes when the gate bias voltage is zero. This is the ON state and the transistor is called a normally ON JFET.

19) Which one is called depletion mode JFET?

A gate voltage must be applied to deplete all carriers in the channel. This device is referred to as depletion mode JFET or D-JFET.

20) What is the amplification factor for JFET?

The amplification factor for a JFET is,

$$m = r_d \, g_m$$

21) What is break down voltage in JFET?

As the drain voltage V_d increases for a constant gate voltage V_g, the bias voltage causes avalanche breakdown across the gate junction and the drain current I_d increases sharply

$V_b = V_d + |V_g|$

22) Write the applications of GaAs MESFET.

- The GaAs MESFETs the substrate is doped with chromium (Cr), which has an energy level near the center of the GaAs band gap. This is a very high resistivity substrate and it is commonly called the semi-insulator GaAs structure.
- Used in broad band amplifier applications.

23) Write the applications of GaAs MESFET.

- The GaAs MESFETs are very commonly used in microwave integrated circuits for high power, low noise applications.
- Used in broad band amplifier applications.

24) Which one is called semi-insulator GaAs structure?

In GaAs MESFETs the substrate is doped with chromium (Cr), which has an energy level near the center of the GaAs band gap. This is a very high resistivity substrate and it is commonly called the semi-insulator GaAs structure.

25) Define pinch off voltage.

The pinch off voltage is the gate reverse voltage that removes all the free charge from the channel.

26) What is called high electron mobility transistor?

The field effect transistor which is made using a hetero junction is called high electron mobility transistor.

27) Define threshold voltage V_{th}.

A minimum gate voltage is required to induce the channel, and it is called the threshold voltage V_{th}.

28) Name the modes of operation for n-channel and p-channel.

There are basically four modes of operation for n-channel and p-channel MOSFETs,

a) n-channel enhancement mode (normally OFF)
b) n-channel depletion mode (normally ON)
c) p-channel enhancement mode (normally OFF)
d) p-channel depletion mode (normally ON)

29) Write the advantages of MOSFETs over MESFETs, and JFETs.

- In the active region of an enhancement-mode MOSFET, the input capacitance and the transconductance are almost independent of gate voltage, and output capacitance is independence of the drain voltage. This leads to very linear (Class A) power amplification.
- The active gate-voltage range can be larger because n-channel depletion-type MOSFETs can be operated from the depletion - mode region ($-V_g$) to the enhancement - mode region ($+V_g$).

Due to these two advantages, MOSFETs are often used as power amplifiers.

30) Describe tunneling phenomenon.

When the doping level is increased the depletion region reduces. Due to thin depletion region, even for very small forward bias many carriers penetrate through the junction and appear at the other side. This phenomenon of penetration of carriers through the depletion region is known as tunneling.

31) What are the key characteristics of a tunnel diode?

The key characteristics of a tunnel diode are its negative resistance region.

32) What are the applications of tunnel diode?

- Relaxation oscillator
- Microwave oscillator
- Storage device
- Pulse generator
- High speed switching networks

33) Draw the symbol of tunnel diode.

34) What are the advantages and disadvantages of tunnel diode?

Advantage:

- Low cost
- Low noise
- High speed
- Low power consumption

Disadvantages:

- Low output voltage swing
- No isolation between input and output.

35) Explain how a reverse biased pn junction exhibits a capacitor?

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.

16 mark Questions:

1. Explain the constructional details and principle of operation of GaAs MESFET with neat diagrams and characteristic curves.
2. Give the physical structure and equivalent diagram of microwave field effect transistors.
3. Explain the operation of microwave bipolar transistor with neat diagrams.
4. Explain the operation of HEMT with neat diagrams and characteristic curves.
5. Explain the operation of MOSFET with neat diagrams and characteristic curves.
6. Explain the construction and working of tunnel diode.
7. Write advantages and applications of tunnel diode.
8. Explain the construction and working of varactor diode with neat diagram.
9. What are the applications of varactor diode?
10. Explain the field equations of circular waveguide resonator.
11. Explain in detail about Gunn diode with neat diagram?
12. Explain Ridley Watkins Hilsun (RHW) theory with the help of two valley modal.
13. Explain in detail about high field domain.
14. Describe the operating principles of LSA diode?
15. Describe the modes of operation for Gunn diode?
16. Explain the construction and operation of Read diode.
17. What are avalanche transit time device? Explain the operation, construction and applications of the following devices.
    (1) IMPATT
    (2) TRAPATT
18. Explain the theory of a resistance amplifier?
19. What are parametric devices? Explain the working of a parametric up converter and a down converter?
20. Derive the Manley Rowe power relations. What are the conditions for parametric up converter and down converter?
21. Describe the applications of the parametric amplifiers
22. Explain (1) Degenerate paramp(2) Non degenerate paramp.
23. Explain the fabrication techniques of a monolithic microwave integrated circuit.
24. List out the basic materials required for the manufactured of MMIC.
25. Discuss the discrete, integrated and monolithic microwave integrated circuits?
26. List the basic characteristics required for an ideal substrate material.
27. List the basic properties provided by ideal conductor, dielectric and resistive materials used in MMICs.
28. Describe the MMIC techniques.

UNIT-5
MICROWAVE MEASUREMENTS

1) What is transit time?

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

2) Write the classification of microwave tubes.

They are classified into two types

- type microwave tube or linear beam
- M type microwave tube

3) Name the two configuration of klystron

There are two basic configurations of Klystron tubes

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

4) What is drift space?

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

5) Define velocity modulation.

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

6) Define bunching.

The electrons passing the first cavity gap at zeros of the gap voltage pass through with unchanged velocity, those passing through the +ive half cycles of gap voltage undergo an increase in velocity, those passing through the ive half cycles of gap voltage undergo an decrease in velocity, As a result of these, electron bunch together in drift space. This is called bunching.

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

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

8) Why the output cavity is called as catcher cavity?

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

9) Mention the application of two c a v i t i e s .

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

10) Define electronic efficiency.

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

$$\text{Efficiency} = P_{out} / P_{IN}$$
$$= b_0 I_2 V_2 / 2I_0 V_0$$

11) Define reflex klystron.

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

12) What do you meant by applegate diagram?

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

13) Mention the same characteristics of reflex klystrons.

- Frequency range: 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.

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

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.

The electronic efficiency of a reflex klystron oscillator is defined as $h = P_{ac} / P_{dc}$

17) What is meant by microwave resonators?

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

18) Define resonant frequency.

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?

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

16 Mark questions:

1. What is velocity modulation? Explain how velocity modulation is utilized in klystron.
2. Derive an expression for the efficiency of a two cavity klystron amplifier.
3. What are the characteristics and applications of klystron amplifier?
4. What is klystron? Describe its operation and obtain an expression for its power output.
5. Derive the power output for two cavity klystron amplifier.
6. Derive the expression for optimum distance of klystron in bunching process.
7. Draw and explain the operation of klystron oscillator.
8. Derive the expression for velocity modulation in klystron oscillator.
9. What are the assumptions made when analysis a two-cavity klystron.
10. Explain the working of a TWT amplifier with neat sketch.
11. Write the advantages and applications of TWT.
12. Derive Hull cutoff condition with respect to magnetron.
13. Explain the working of a magnetron with p - mode oscillation.
14. Explain the construction and working of cylindrical magnetron.
15. Derive the expression for cyclotron angular frequency of cylindrical magnetron.
16. Derive the expression for power output and efficiency of cylindrical magnetron.
17. Write short notes on
    a. Low VSWR b. High VSWR
18. Explain the attenuation loss measurement with neat diagram?
19. Explain about power meter using double bridge?
20. Explain high power measurements by calorimetric method?
21. Explain the method of measuring impedance of a given load, with suitable diagram?
22. Explain frequency and wavelength measurements with neat diagrams?
23. Write short notes on
    a. Average power
    b. Bolometer sensor
    c. Schottky Barrier Diode sensor
    d. Thermocouple sensor

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TWO MARKS QUESTIONS WITH ANSWERS

UNIT I INTRODUCTION TO OPTICAL FIBERS 9

Evolution of fiber optic system- Element of an Optical Fiber Transmission link-- Total internal reflection-Acceptance angle –Numerical aperture – Skew rays Ray Optics-Optical Fiber Modes and Configurations -Mode theory of Circular Wave guides- Overview of Modes-Key Modal concepts- Linearly Polarized Modes -Single Mode Fibers-Graded Index fiber structure.

1. **What are the limitations of optical fiber communication systems?**
   - Not suitable for short distance and low bandwidth applications.
   - Fiber splicing is expensive
   - Susceptivity to physical damage.
2. **What is the necessity of cladding for an optical fiber?**
   The necessity of cladding for an optical fiber is
   - To avoid leakage of light from the fiber
   - To avoid mechanical strength for the fiber
   - To protect core from scratches and other mechanical damages.
3. **List the advantages of mono-mode fiber.**
   The advantages of mono-mode fiber are
   - No internal dispersion
   - Information capacity of single mode fiber is large.
4. **Define - Acceptance Angle**
   The maximum angle Φ_{max} with which a ray of light can enter rough the entrance end of the fibre and still be totally internally reflected is called acceptance angle of the fiber.
5. **List the uses of optical fiber.**
   The uses of optical fibers are as follows
   - To act as light source at the inaccessible places
   - To transmit the optical images. (example: endoscopy)To act as sensors to do mechanical, electrical and magnetic measurements
   - To transmit the information which are in the form of coded signals of the telephone communications, computer data etc.
6. **List the disadvantages of mono-mode fiber.**
   The disadvantages of mono-mode fiber are
   - Launching of light into single mode and joining of two fibers are very difficult.
   - Fabrication is very difficult and so that fiber is so costly.

7. **What is the principle used in the working of fibers as light guides?**

The phenomenon of total internal reflection is used to guide the light in the optical fiber. To get total reflection, the ray should travel from denser region rarer region i.e. from core to clad region. Of the fiber and the angle of incidence in the denser medium should be greater than the critical angle of that medium.

8. **Define- Refraction**

When light travels from air medium to glass medium, bending of light may occur. This is called refraction.

9. **What is critical angle?**

When we increase the incident angle with respect to normal, at some incident angle, the dielectric of surface and φ_2 becomes 90 and such incident angle is called critical angle.

10. **What is Snell's law?**

The relationship at the interface is called Snell's Law. It is given by the equation $n_1 \sin\varphi_1 = n_2 \sin\varphi_2$.

11. **What is meant by mode coupling?**

The effect of coupling energy from one mode to another mode is known as mode coupling. The cause of mode coupling is due to waveguide perturbations such as deviations Of the fiber axis from straightness variations in the core diameter, irregularities at the Core- cladding interface and refractive index variations.

12. **What is V number of a fiber?**

Normalized frequency or V number is a dimensionless parameter and represents the relationship among three design parameters variables of the fiber, core radius and relative refractive index and the operating wavelength λ.

It is expressed as $V = (2*\pi*$ Numerical aperture $) / \lambda$

13. **Compare Ray optics and wave optics.**

Ray optics	**Wave optics**
It is used to represent the light propagation	It is used to analyze mode theory
It is used to study reflection and refraction of light	It is used to analyze diffraction and interference of light waves

14. Differentiate between mono-mode fiber and multi-mode fiber.

Mono-mode fiber or single more fiber	Multi-mode fiber
Only one ray passes through the fiber	More than one ray passes through fiber at a time
Coupling efficiency is less.	Coupling efficiency is large.
LED is not suitable for single mode fiber	LED is suitable for multi mode fiber
Intermodal dispersion is not present	Intermodal dispersion is present
Fabricating single mode fiber is difficult.	Fabricating multi mode fiber is easy.

15. What is meant by linearly polarized mode?

The field components HE, EH, TE, TM forms linearly polarized modes. Linearly polarized Modes are labeled LP_{jm} where j and m are integers designation mode solutions.

16. What are the three windows of optical communications?

The three wavelengths 850nm, 1300nm, and 1500nm are three optical windows of optical communication system.

17. Define – Fiber Optic system

Fiber optic system is nothing but a fiber-optic cable is essentially light pipe that is used to carry a light beam from one place to another.

18. What are the advantages of graded index fiber?

The advantages of graded index fiber are

- It provides higher bandwidth.
- It exhibits less intermodal dispersion because the different group velocities of the mode tend to be normalized by the index grading.

19. What is step index fiber?

Step index fiber is a cylindrical waveguide that has the central core with uniform refractive index n_1 surrounded by outer cladding with refractive index of n_2. The refractive index of the core is constant and is larger than the refractive index of the cladding. It makes a step change at the core cladding interface.

20. Why step index single mode fiber preferred for long distance communication?

The step index single mode fiber is preferred for long distance communication because

- They exhibit higher transmission bandwidth because of low fiber losses.
- They have superior transmission quality because of the absence of the model noise.
- The installation of single mode fiber is easy and will not require any fiber replacement over twenty plus years.

21. Define- Birefringence

Manufactured optical fibers have imperfections such as asymmetrical lateral stresses, non - circular cores and variations in refractive index profiles. These imperfections break the circular symmetry of the ideal fiber and lift the degeneracy of the two modes. These modes propagate with different phase velocity and it is called as fiber birefringence.

22. What types of fibers are used commonly?

Based on refractive index profile, step index fiber and graded index fibers are used. Based on propagation, Single or Mono mode and multimode fibers are used.

23. Define – Wave-front

For plane waves, some constant phase points from a surface which is referred to as wave-front.

24. What is an index profile?

The index profile of an optical fiber is a graphical representation of the magnitude of the refractive index across the fiber.

25. What are leaky modes in optical fibers?

In leaky modes, the fields are confined partially in the fiber core and attenuated as they propagate along the fiber length, due to radiation and tunnel effect.

26. What is the purpose of cladding?

Cladding provides mechanical strength, reduces scattering loss resulting from dielectric discontinuities at the core surface and protects the core from absorbing surface contaminants with which it could come into contact.

27. What are leaky rays?

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.

28. What are the conditions for total internal reflection?

The conditions for total internal reflections are:

- The ray should travel from denser to rarer medium. i.e. from core to clad region of the optical fiber.
- The angle of incidence in the denser should greater than the critical angle of that medium.

29. What are guided modes?

Guided modes are a pattern of electric and magnetic field distributions that is repeated along the fiber at equal intervals.

30. Define- Mode

Mode is the pattern of distribution of electric and magnetic fields.

- Transverse- Electric mode (TE)
- Transverse Magnetic mode (TM)

31. Define - Mode-Field Diameter

The fundamental parameter of a single mode fibre is said to be the mode field diameter. It is possible to determine the mode-field diameter with the help of the fundamental LPo1 mode.

32. What are meridional rays?

Meridional rays are the rays which follows zig -zag path when they travel through fiber and for every reflection it will cross the fiber axis.

33. When do you have phase shift during total internal reflection of light?

When the light ray travels from denser medium to rarer medium, if the angle of incidence is greater than the critical angle of Core medium, then there is a phase shift for both TE and TM waves.

34. State Goes- Haenchen effect.

Goes- Haenchen effect states that, there is a lateral shift of the reflected ray at the point of incidence and at the core-cladding interface. This lateral shift is called the **Goes- Haenchen** effect.

35. Differentiate between meridional rays and skew rays.

- A **meridional ray** is a ray that passes through the axis of an optical fiber.
- A **skew ray** is a ray that travels in a non-planar zig-zag path and never crosses the axis of an optical fiber.

36. What do you mean by RAY?

In optics a **ray** is an idealized model of light, obtained by choosing a line that is perpendicular to the wave-fronts of the actual light, and that point in the direction of energy flow. Rays are used to model the propagation of light through an optical system, by dividing the real light field up into discrete rays that can be computationally propagated through the system by the techniques of ray tracing.

37. What are skew rays?

A **skew ray** is a ray that travels in a non-planar zig-zag path and never crosses the axis of an optical fiber.

38. What are the advantages of optical network?

The advantages of optical network are as follows:

- Low signal attenuation (as low as 0.2 dB/km),
- Immunity to electromagnetic interference
- High security of signal because of no electromagnetic radiation,
- Huge bandwidth
- Low signal distortion, suitable for carrying digital information,
- Low power requirement
- No crosstalk and interferences between fibers in the same cable,
- Low material usage, small space requirement, light weight, non-flammable, cost-effective and high electrical resistance

39. What is an optical network?

An optical network is not necessarily optical transmission, but the switching could be optical, or electrical, or hybrid and also an optical are not necessarily packet-switched.

40. What are the advantages of optical communication?

The advantages of optical communication are

- Low transmission losses
- Electrical isolation
- Small size and weight
- No electromagnetic interference

41. Define – Longitudinal modes

Longitudinal modes are associated with the length of the cavity and determine the typical spectrum of the emitted radiation.

42. Define – Transverse Modes

Transverse modes are associated with the electromagnetic field and beam profile in the direction perpendicular to the plane of PN junction. They determine the Laser characteristics as the radiation pattern and the threshold current density.

PART B

1. Evolution of fiber optic system (or) Explain the three operating windows.
2. Elements of an optical fiber transmission link (or) explain the basic block diagram of OFC.
3. Explain the Basic laws of optics. (or) Explain Numerical aperture, Total internal reflection, Acceptance angle.
4. Explain the different types (modes) of fiber. (SM, MM, SI and GI fiber diagrams, advantages and drawbacks)

5. Detail explanation of SM and GI fiber with suitable expression.
6. Give elaborate explanation about optical fiber communication link.
7. What is mode? Give explanation about linearly polarized mode.
8. A step index multimode fiber with a numerical aperture of 0.2 support approximately 1000 modes at an 850nm wavelength. What is the diameter of its core? How many does the fiber supports at 850nm and 1550nm?
9. Derive the wave equation for a cylindrical fiber.
10. Find the core radius necessary for single mode operation at 1320nm of a step index fiber with n1 = 1.48 and n2 = 1.478. Determine the numerical aperture and acceptance angle of this fiber.

UNIT II SIGNAL DEGRADATION OPTICAL FIBERS 9

Attenuation - Absorption losses, scattering losses, Bending Losses, Core and Cladding losses, Signal Distortion in Optical Wave guides-Information Capacity determination -Group Delay-Material Dispersion, Wave guide Dispersion, Signal distortion in SM fibers-Polarization Mode dispersion, Intermodal dispersion, Pulse Broadening in GI fibers-Mode Coupling-Design Optimization of SM fibers-RI profile and cut-off wavelength.

1. **Differentiate linear scattering from non-linear scattering.**

   Linear scattering mechanisms cause the transfer of some or all of the optical power contained within one propagating mode to be transferred linearly into a different mode. Non-linear scattering causes the optical power from one mode to be transferred in either the forward or backward direction to the same or other modes at different frequencies.

2. **What is meant by Fresnel reflection? (N/ D 2011)**

   When the two joined fiber ends are smooth and perpendicular to the axes, and the two fiber axes are perfectly aligned, the small proportion of the light may be reflected back into the transmitting fiber causing attenuation at joint. This is known as Fresnel reflection.

3. **What are the types of material absorption losses in silica glass fibers?**

   The types of material absorption losses in the glass composition are
   - Absorption by impurity atoms in the glass material.
   - Intrinsic absorption by the basic constituent atoms in the glass material.

4. **How do we minimize optical losses at the interface?**

   Optical losses at the interface can be minimized if
   - Jointed fiber ends are smooth
   - Perpendicular to fiber axis
   - Two fiber axes are perfectly aligned

5. **What is meant by attenuation coefficient of a fiber? (N / D 2011)**

   If P(0) is the optical power in a fiber at the origin (at Z = 0), then the power P(Z) at a distance z further down the fiber is $P(z) = P(0)\, e^{-\alpha_p z}$. The above equation can be rewritten as $\alpha_p(1 / z) \{ P(0) / P(z)\}$. Where α_p is the fiber attenuation coefficient given in units of km^{-1}

6. **What is intrinsic absorption in optical fibers?**

The absorption caused by the interaction with one or more of the major components of the glass is known as intrinsic absorption.

7. **What are the factors that cause Rayleigh scattering in optical fibers? (M / J 2012)**

The in-homogeneity's of a random nature occurring on a small scale compared with the wavelength of the light in optical fiber causes Rayleigh scattering.

8. **What is meant by dispersion in optical fiber? (A/ M 2008)**

Dispersion of the transmitted optical signal causes distortion in both analog and digital signals along optical fibers. Dispersion mechanisms within the fiber cause broadening of the transmitted light pulses as they travel along the channel.

9. **What are the ways to reduce macro bending losses? (N / D 09), (N/ D 10)**

Ways to reduce macro bending losses are

- Designing fibers with large relative refractive index differences.
- Operating at the shortest wavelength possible.

10. **What are the factors that cause Mie scattering in optical fibers?**

The non-perfect cylindrical structure of the waveguide by the fiber imperfections causes Mie scattering in optical fibers.

11. **Define – Group Velocity Dispersion (GVD) (A/ M 2011), (N/D 2010)**

Intra-modal dispersion is pulse spreading that occurs within a single mode. The spreading arises from the finite spectral emission width of an optical source. This phenomenon is known as Group Velocity Dispersion.

12. **What is meant by linear scattering?**

Linear scattering mechanisms cause the transfer of some or all of the optical power contained within one propagating mode to be transferred linearly into a different mode.

13. **Define- Beat Length**

Beat Length is defined as the period of interference effects in a birefringent medium. When two waves with different linear polarization states propagate in a birefringent medium, their phases will evolve differently.

14. **What is intra Modal dispersion?**

Intra Modal Dispersion is pulse spreading that occurs within a single mode. The spreading arises from finite spectral emission width of an optical source. This phenomenon is also called as group velocity dispersion.

15. **Why intra modal dispersion occurs?**

Intra modal dispersion occurs because colours of light travel through different materials and different waveguide structures at different speeds.

16. **What are the causes of intra modal dispersion?**

There are two main causes of intra modal dispersion.

- Material Dispersion
- Waveguide Dispersion.

17. What is wave guide dispersion?

Wave guide dispersion occurs because of a single mode fiber confines only about 80% of optical power to the core. Dispersion arises since 20% of light propagates in cladding travels faster than the light confined to the core.

Amount of wave-guide dispersion depends on fiber design. Other factor for pulse spreading is inter-modal delay.

18. Compare splices and connectors.

Splices	Connectors
Permanent or Semi-permanent joints	Temporary joints
Splice loss is low	Connector loss is high

19. Define - Cross Talk in couplers

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

20. Define- Polarization Maintaining Fiber? (PMF)

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 polarizations modes. Such fiber is used in special application where processing the polarization is essential.

21. What is material dispersion?

Material dispersion arises from the variation of the refractive index of the core material as a function of wavelength. Material dispersion is also referred to as chromatic dispersion. This causes a wavelength dependence of group velocity of given mode. So it occurs because the index of refraction varies as a function of optical wavelength. Material dispersion is an intra modal dispersion effect and is for particular importance for single mode wave guide.

22. What is group velocity?

As light is not perfectly monochromatic then the combination of two waves of slightly different frequencies propagating together moves with a group velocity given by

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

23. What is polarization?

Polarization is a fundamental property of an optical signal. It refers to the electric field orientation of a light signal which can vary significantly along the length of a fiber.

24. What is pulse broadening?

Dispersion induced signal distortion is that, a light pulse will broaden as it travels along the fiber. This pulse broadening causes a pulse to overlap with neighboring pulses. After a time‘t’, the adjacent pulses can no longer be individually distinguished at the receiver and error will occur.

25. What is profile dispersion?

A fiber with a given index profile (alpha) will exhibit different pulse spreading according to the source wavelength used. This is called profile dispersion.

26. What is polarization mode dispersion (PMD)?

The difference in propagation times between the two orthogonal polarization modes will result pulse spreading. This is called as polarization mode dispersion. (PMD)

27. Define – Dispersion Flattening

Dispersion-flattened single-mode fiber 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 wavelengths simultaneously.

28. What is fiber birefringence?

The modes propagate with different phase velocities and the difference between their effective refractive indices is called the fiber birefringence.

29. What is mode coupling?

In an electromagnetic waveguide, the exchange of power occurs among modes. Mode is the path for light rays through an optical fiber. The electric field distribution of various modes yields similar distributions of light intensity within the fiber core. Individual modes do not normally propagate throughout the length of the fiber. It gives mode conversion which is known as mode coupling.

Mode coupling leads to intramodal dispersion like material dispersion and waveguide dispersion and also intermodal dispersion

30. Define- Dispersion Shifted Fiber

By creating a fiber with large negative waveguide dispersion & assuming the same values for material Dispersion as in a standard single mode fiber, the addition of waveguide and material dispersion can then be shifted to zero dispersion point to long wavelength. The resulting optical fiber is called as dispersion Shifted Fiber.

31. What is M-C fiber?

Fibers that have a uniform refractive index throughout the cladding are called as M-C fiber or Matched cladding fiber.

32. Define - Cut-off Wavelength of the fiber

The cut-off wavelength is defined as the minimum value of wavelength that can be transmitted through the fiber. The cut-off wavelength can be transmitted as $\lambda_c = \frac{2\pi a}{V}\ (NA)$.

33. Write a note on scattering losses.

Scattering losses in glass arise from microscopic variation in the material density from compositional fluctuation and from structural in-homogeneities or defects occurring during fiber manufacture.

34. What is intramodal delay?

The factor which gives rise to pulse spreading is called as intra-modal delay. It is a result of each mode having a different value of group velocity at a single frequency.

35. Mention the losses responsible for attenuation in optical fibers.

The losses which are responsible for attenuation in optical fibers are as follows

- Absorption losses
- Scattering losses
- Bending losses

36. What is the function of coupler? What are the different types of optical couplers?

A coupler is a device which is used to combine and split signals in an optical network.

Different types of couplers are

- Directional coupler
- Star coupler
- Fused fiber coupler
- 2 x 2 coupler

37. What are the requirements of good couplers?

The requirements of good couplers are

- Good optical couplers should have low insertion losses.
- Insensitive to temperature
- Good optical couplers should have low polarization-dependent loss.
- Reliability

38. What is intermodal dispersion?

Intermodal dispersion is a pulse spreading that occurs within a single mode. The spreading arises from finite spectral emission width of an optical source. It is called as group velocity dispersion or intermodal dispersion.

39. Write the light ray guiding condition.

Light ray that satisfies total internal reflection at the interface of the higher refractive index core and the lower refractive index cladding can be guided along an optical fiber.

40. What do you mean by extrinsic absorption?

Absorption phenomena due to impurity atoms present in the fiber is called as extrinsic absorption.

41. What is the measure of information capacity in optical waveguide?

It is usually specified by bandwidth distance product in Hz. For a step index fiber the various distortion effects tend to limit the bandwidth distance product to 20MHz.

42. Define - Microscopic Bending

Fiber losses occur due to small bending arise while the fiber is inserted into a cable is known as Microscopic Bending.

43. Write Short notes on scattering losses.

Scattering losses caused by the interaction of light with density fluctuations within a fiber. During manufacturing, regions of higher and lower molecular density areas, relative to the average density of the fiber, are created. Light traveling through the fiber interacts with the density areas light is partially scattered in all directions.

44. What is Rayleigh scattering?

The index variation causes a Rayleigh type of scattering of light. Rayleigh scattering in glass in the same phenomenon that scatters light from sun in the atmosphere, giving rise to blue sky.

45. Write the expression for Rayleigh scattering Loss.

The expression for Rayleigh scattering loss is given by

$\alpha_{scat} = (8\pi^3/3\lambda^2)(n^2 - 1)^2 k_B T_f \beta_T$

Where n= refractive index k_B= Boltzmann constant T_f = fictive temperature

β_T = isothermal compressibility λ = operative wavelength

46. When will Rayleigh scattering occurs?

Rayleigh scattering is the main loss mechanism between the ultraviolet and infrared regions. Rayleigh scattering occurs when the size of the density fluctuation (fiber defect) is less than one-tenth of the operating wavelength of light.

47. What do you mean by fiber optic coupler?

A fiber optic coupler is a device used in optical fiber systems with one or more input fibers and one or several output fibers. Light entering an input fiber can appear at one or more outputs and its power distribution potentially depending on the wavelength and polarization.

48. What do you mean by fiber optic connectors?

An optical fiber connector terminates the end of an optical fiber and enables quicker connection and disconnection than splicing. The connectors mechanically couple and align the cores of fibers so light can pass.

49. List the features of optical connectors.

The features of good connector are:

- Low insertion loss, Low cost and low environmental sensitivity
- Reliability Ease of use, Ease of installation
- Compatibility

50. What is the need for fiber alignment?

Fiber optic sensors constitute the core of telecommunication markets as well as being important part of automotive and industrial applications. With the recent renewed growth and technology advances in fiber optics, there is an increasing need for automating photonics alignment.

51. What do you mean by micro-bend Losses?

Micro-bends are small microscopic bends of the fiber axis that occur mainly when a fiber is cabled. Micro bend losses are caused by small discontinuities or imperfections in the fiber. Uneven coating applications and improper cabling procedures increase micro-bend loss. External forces are also a source of micro-

52. What do you mean by macro-bend losses?

Macro-bend losses are observed when a fiber bend's radius of curvature is large compared to the fiber diameter. Light propagating at the inner side of the bend travels a shorter distance than that on the outer side.

53. What are connectors? What are the types of connectors?

The connectors are used to join the optical sources as well as detectors to the optical fiber temporarily. They are also used to join two optical fibers. The two major types of connectors are

- Expanded beam connector
- Ferrule type connector.

54. What are the requirements of splices?

- Should be easy to install
- Should have minimum power loss
- Should be strong and light in weight
- Should cause low attenuation.

55. What are the methods of fiber splicing?

There are three methods of fiber splicing. They are

- Electric arc fusion splicing or fusion splicing
- Mechanical splicing, V-groove splicing or loose tube splicing.

PART B

1. Explain the various losses associated with fiber. (or) Explain absorption, scattering and bending losses.
2. Derive the expression of intra modal dispersion (or) derive the expression of material and waveguide dispersion.
3. Discuss about polarization mode dispersion.
4. Explain about mode coupling.
5. Explain the design optimization of single mode fiber.
6. Discus in detail about fiber splicing.
7. What are the primary requirements of a good fiber connector design?
8. What are the loss or signal attenuation mechanisms in a fiber? Explain.
9. Describe the various types of connectors and couplers in fiber.
10. Explain fiber alignment and joint losses.

UNIT III FIBER OPTICAL SOURCES AND COUPLING 9

Direct and indirect Band gap materials - LED structures -Light source materials - Quantum efficiency and LED power, Modulation of a LED, lasers Diodes- Modes and Threshold condition - Rate equations-External Quantum efficiency - Resonant frequencies - Laser Diodes, Temperature effects, Introduction to Quantum laser, Fiber amplifiers - Power Launching and coupling, Lencing schemes, Fiber -to- Fiber joints, Fiber splicing-Signal to Noise ratio , Detector response time.

1. **What are the advantages of LED?**
   The advantages of LEDs are
   - They have long life
   - LEDs are less complex circuits than Laser diodes
   - Fabrication is easier
   - Less expensive
   - Used for short distance communication
2. **What are the two types of confinement used in LEDs?**
   The two types of confinements used in LEDs are
   - Carrier confinement
   - Optical confinement
3. **What are the basic methods of current confinement?**
   The basic methods of current confinement are
   - Inner strip confinement
   - Proton confinement
   - Preferential dopant diffusion
   - RE growth of back biased PN junction.
4. **What are the two types of LED configurations?**
   The two types of LED configurations are
   - Homo junction
   - Single and Double hetero junction
5. **What are the three requirements of Laser action?**
   The three requirements of Laser action are
   - Absorption
   - Spontaneous emission
   - Stimulated emission
6. **What are the fundamental structures of Index guided lasers?**
   The fundamental structures of index guided lasers are
   - Bent layer configuration
   - Selectively diffused construction
   - Buried hetero structure
   - Varying thickness structure

7. **Define External Quantum Efficiency.**

The external quantum efficiency is defined as the number of photons emitted per radiative electron-hole pair recombination above threshold.

8. **Define Internal Quantum Efficiency.**

The internal quantum efficiency is the fraction of the electron-hole pairs that recombine radiatively. If the radiative recombination rate is R and the nonradiative recombination ratio is R_{nr}, then the internal quantum efficiency is the ratio of the radiative recombination rate to the total recombination rate.

9. **Define Quantum Efficiency of a photo detector.**

Quantum efficiency is defined as the number of the electron-hole carrier pairs generated per incident photon of energy hυ, is given by η = (number of electron- hole pairs generated) / (number of incident photons). $\eta = \frac{I_p/q}{p_0/h\nu}$

Where I_p = photon current; q = charge of the electron; p_0 = optical output power;

υ = frequency of the optical signal.

10. **In a 100ns pulse, 6 *10^6 photons at wavelength of 1300nm fall on an InGaAs photo-detector on the average, 5.4 *10^6 electron-hole pairs are generated. Find the quantum efficiency.**

$$\eta = \frac{No.of\ electron - hole\ paris\ generated}{No.of\ photons\ incident}$$

$$\eta = \frac{5.4 \times 10^6}{6 \times 10^6} = 0.9 = 90\%$$

11. **What do you mean by Laser diode?**

A laser diode, or LD, is an electrically pumped semiconductor laser in which active medium is formed by a p-n junction of a semiconductor diode similar to that found in a light-emitting diode.

12. **Differentiate LEDs and Laser diodes**.

Sl. No.	LED	Laser diodes
1	The output obtained is incoherent.	The output obtained is coherent.
2	Less expensive and less complex.	More expensive and more complex.
3	Long life time.	Less life time.
4	Their response is fast	Their response is faster than LED
5	Bandwidth of LED is moderate	Bandwidth of Laser diode is higher
6	Wide range of wavelengths are available	A small range of wavelength is available

13. **What do you mean by Avalanche Photo Diode?**

An avalanche photodiode (APD) is a highly sensitive semiconductor electronic device that exploits the photoelectric effect to convert light to electricity. APDs can be thought of as photo-detectors that provide a built-in first stage of gain through avalanche multiplication.

14. **What do you mean by direct band gap Materials?**

In some materials a direct transition is possible from valance band to conduction band. Such type of materials is called as direct band gap materials. Ex. GaAs, InP, InGaAs.

15. What do you mean by in direct band gap Materials?

In some materials a direct transition is not possible from valance band to conduction band. Such type of materials is called as indirect band gap materials.

Ex. Silicon, Germanium.

16. What is meant by hetero-junction? List the advantages of heterojunctions.

A hetero-junction is an interface between two adjoining single crystal semiconductors with different band-gap energies. Devices are fabricated with heterojunctions are said to have heterostructure.

Advantages of Hetero-junction are

- Carrier and optical confinement
- High output power and High coherence and stability

17. What is the principle of operation of LASER?

The principle of operation of LASER is population inversion. The population of the upper energy level is greater than lower energy level i.e. N_2 is > N_1.this condition is known as population inversion.

18. What are the three modes of the cavity of LASER Diode?

The three modes of the cavity of LASER are

- **Longitudinal modes**, related to the length L of the cavity
- **Lateral modes** lie in the plane of the P-N junction. These modes depend upon the side wall preparation and width of the cavity.
- **Transverse modes** are associated with the Electro Magnetic field and beam profile in the direction perpendicular to the plane of the P-N junction. These modes determine the radiation pattern of the LASER.

19. What is population inversion?

Under thermal equilibrium, the lower energy level E_1 of the two level atomic systems contains more atoms than upper energy level E_2. To achieve optical amplification, it is must to create non-equilibrium distributions of atoms such that population of the upper energy level is greater than lower energy level i.e. N_2 is > N_1.this condition is known as population inversion.

20. What is a DFB LASER? Differentiate DFB LASER from other types of LASERs?

In Distributed Feedback LASER, the lasing action is obtained by periodic variations of refractive index, which are incorporated into multilayer structure along the length of the diode. DFB LASER does not require optical feedback unlike the other LASERs.

21. When an LED has 2V applied to its terminals, it draws 100mA and produce 2mW of optical power. Determine conversion efficiency of the LED from electrical to optical power. (N / D 2008)

Given data $V_{in} = 2V;\ I_{in} = 100 \times 10^{-3}A;\ P_{out} = 2 \times 10^{-3}W$

LED conversion efficiency = $\frac{P_{out}}{P_{in}}$ $P_{in} = V_{in} \times I_{in} = 2 \times 100 \times 10^{-3}$

Conversion efficiency = $\frac{P_{out}}{P_{in}} = \frac{2\times10^{-3}}{2 \times 100\times10^{-3}} = 0.01$

22. Distinguish between direct and indirect band-gap materials.

Direct band-gap materials	Indirect band-gap materials
The electron and hole have the same momentum value.	The conduction band minimum and the valence band maximum energy level occur at different values of momentum value.

23. Why is silicon not used to fabricate LED or LASER diode?

- Silicon is not used to fabricate LED or LASER diode because
- It is an indirect band-gap semiconductor. Its energy level is 1.1eV; radiated emission corresponds to infrared but not the visible light.

24. Distinguish between direct and external modulation of LASER diodes.

Direct Modulation	External Modulation
Easy to demonstrate and has low cost.	Complex and expensive
Low gain	High gain

25. Compare surface and edge emitting LEDs.

Surface emitting LED	Edge emitting LED
Wider spectral width (typically 125 nm)	Narrow spectral width (typically 75 nm)
Emission pattern is less directional	Emission pattern is less directional

26. Compare the performance of APD with PIN diode. (N / D 2008)

APD	PIN
Excellent Linearity	Linearity is less compared to APD
High sensitivity	Less sensitive compared to APD (15 dB less)
High signal to Noise Ratio	Low signal to Noise Ratio

27. What are the necessary features of a photo detector? (N / D 2007)

The designed features of a photo detector are

- High quantum efficiency
- Low rise time or faster response
- Low dark current.

28. Define – Responsivity of a photo detector (N/ D 2008), (N / D 2010)

Responsivity is defined as the ratio of output photo current to the incident optical power.

29. Define- Threshold Current

The threshold current is conventionally defined by extrapolation of the lasing region of the Power Vs Current curve. At high power outputs, the slope of the curve decreases because of junction heating.

30. Give some types of Photo-detectors.

The types of Photo-Detectors are

- Photodiodes
- Phototransistors and Photomultipliers
- Semiconductor based detectors
- Pyroelectric detectors.

31. What are the types of photodiodes?

The types of photodiodes are

- Avalanche photodiode (APD)
- PIN photo-detector.

32. Define – Photocurrent

The high electric field present in the depletion region causes the carriers to separate and be collected across the reverse- biased junction. This gives to a current flow in the external circuit, with one electron flowing for every carrier pair generated. This current flow is known as photocurrent.

33. Define – Impact Ionization

In order for carrier multiplication to take place, the photo-generated carriers must traverse a region where a very high electric field is present. In this high field region, a photo generated electron or hole can gain energy so that it ionizes bound electrons in the valence band upon colliding with them. This current multiplication mechanism is known as impact ionization.

34. Define – Avalanche Effect

The newly created carriers are accelerated by the high electric field, thus gaining enough energy to cause further impact ionization. This phenomenon is called avalanche effect.

35. Define – Long Wavelength cut off related to photodiode

The upper wavelength cutoff (λ_c)is determined by the band-gap energy E_g of the material. If E_g is expressed in units of electron volts (eV), then λ_c is given in units of micrometers (μm)

36. Define – Multiplication M

The multiplication M for all carriers generated in the photodiode is defined by

$$M = I_M / I_P$$

I_M = average value of the total multiplied output current

I_P = primary un-multiplied output current

37. Give the advantages of Pin Photodiodes.

The advantages of Pin photodiodes are

- Low noise level
- High quantum efficiency
- Large bandwidth
- Very low reverse bias is necessary

38. What are the advantages of Quantum Well LASERs?

The advantages of Quantum Well LASERs are

- High threshold current density
- High modulation speed
- High line width of the device.

39. An LED has radiative and nonradiative recombination times of 30 and 100ns respectively. Determine the internal quantum efficiency. (N / D 2007)

Given data:

$\tau_r = 30 * 10^{-9}$ sec

$\tau_{nr} = 100 * 10^{-9}$ sec

formula:

$\eta_{int} = R_r / (R_r + R_{nr})$

R_r is the radiative recombination rate

R_{nr} is the non- radiative recombination rate.

$R_r = 1 / \tau_r$, $R_{nr} = 1 / \tau_{nr}$

$\eta_{int} = R_r / (R_r + R_{nr})$ = 77%

$$\frac{1/30 * 10^{-9}}{\frac{1}{30 * 10^{-9}} + \frac{1}{100 * 10^{-9}}} = 77\%$$

PART B

1. Explain the different types of LED structures. (or) Explain hetero junction structure, surface emitting and edge emitting LED.
2. Explain the LED light source materials.
3. Derive the expression of quantum efficiency and LED power.
4. Explain different types of LASERs and modes and threshold condition.
5. Different types of lensing schemes with suitable diagram.
6. Derive the expression of signal to Noise ratio. (or) Discuss the various noise sources associated with receiver.
7. Discuss about detector response time.
8. With neat sketch, explain the working of LED with double hetero junction structure.
9. Why is the double hetero structure preferred for optical fiber communication? Justify your answer. Derive with relevant mathematical expression of optical power emitted from LED.
10. Discuss various noise sources available in APD and also derive the expression for the optimum gain at maximum signal to noise ratio.

UNIT IV FIBER OPTIC RECEIVER AND MEASUREMENTS 9

Fundamental receiver operation, Pre amplifiers, Error sources – Receiver Configuration– Probability of Error – Quantum limit.Fiber Attenuation measurements- Dispersion measurements – Fiber Refractive index profile measurements – Fiber cut- off Wave length Measurements – Fiber Numerical Aperture Measurements – Fiber diameter measurements.

1. **What is bit rate?**

   The transmitted signal is two level binary data stream consisting of either 0 or 1 in a time slot of duration T. this time slot is referred to a bit period.

2. **List out different methods for measuring refractive index profile.**

   The different methods for measuring refractive index profile are
   - Inter- ferometric method
   - Near field scanning method
   - End field scanning method.

3. **Define – Quantum Limit (M / J 2013)**

   To find the minimum received optical power required for a specific bit error rate performance in a digital system. This minimum received power level is known as the Quantum Limit.

4. **What are the error sources of receiver? (M / J 2013)**

   The error sources of receiver are
   - Thermal noise
   - Dark current noise
   - Quantum noise

5. **A digital fiber optic link operating at 1310 nm, requires a maximum BER of 10^{-8}. Calculate the required average photons per pulse.**

   The probability error $P_r(o) = e^{-N} = 10^{-8}$

   Solving for $N = 8 \log_e 10 = 18.42$

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

6. **What is Inter Symbol Interference (ISI)?**

   Each pulse broadens and overlaps with its neighbors, eventually indistinguishable at the receiver output. This effect is known as Inter Symbol Interference.

7. **Why silicon is preferred to make fiber optical receivers?**

   Silicon phonic devices can be made using existing semiconductor fabrication technique. Also silicon has been already used as substrate for most integrated circuit; it is possible to create hybrid devices in which the optical and electronic components are integrated onto a single micro-chip.

8. **How does dark current arise?**

   When there is no optical power incident on the photo detector a small reverse leakage current flows from the device terminals known as dark current. Dark current contributes to the total system noise and gives random fluctuations about the average particle flow of the photocurrent.

9. Define – Modal Noise and Mode Partition Noise. (A / M 2011), (M / J 2013)

Disturbances along the fiber such as vibrations, discontinuities, connectors, splices and source / detector coupling may cause fluctuations in the speckle patterns. It is known as modal noise. Phenomenon which occurs in multimode semiconductor LASERs when the modes are not well stabilized is known as mode partition noise.

10. What is meant by (1/f)noise corner frequency? (N / D 2009)

The (1 / f) noise corner frequency is defined as the frequency at which (1/f) noise, which dominates the FET noise at low frequencies and has (1/f) power spectrum.

11. What is $P^+ \pi P_n^+$ reach through structure?

In the P^+ (heavily doped p- type) substrate, high resistivity p- type material is deposited followed by the construction of an n^+ (heavily doped n-type) layer. The π layer is an intrinsic layer.

12. List the advantages of preamplifiers.

The advantages of preamplifiers are

- Low noise level
- High bandwidth
- High dynamic range
- High gain
- High sensitivity.

13. What are the types of preamplifiers?

The types of preamplifiers are

- Low- impedance preamplifier
- High impedance preamplifier
- Trans impedance front end preamplifier

14. What are the standard fiber measurement techniques?

The standard fiber measurement techniques are

- Fiber attenuation measurement
- Fiber dispersion measurement
- Fiber refractive index profile measurement
- Fiber cutoff wavelength measurement
- Fiber numerical aperture measurement
- Fiber diameter measurement.

15. Define – Bend Attenuation

Attenuation occurring as a result of either a bend in an optical fiber that exceeds the minimum bends radius or an abrupt discontinuity in the core/cladding interface. The incident light rays strike the boundary between the core and the cladding at an angle less than the critical angle and enter the cladding..

16. What is the technique used for measuring the total fiber attenuation?

The cutback method is often used for measuring the total attenuation of an optical fiber. The cutback method involves comparing the optical power transmitted through a long piece of fiber to the power transmitted through a very short piece of the fiber.

17. What are the factors that produce dispersion in optical fibers?

The factors that produce dispersion in optical fibers are

- Propagation delay difference between the different spectral components of the transmitted signal
- Variation in group velocity with wavelength.

18. What are the methods used to measure fiber dispersion?

The methods used to measure fiber dispersion are

- Time domain measurement
- Frequency domain measurement

19. What are the methods used to measure fiber refractive index profile?

The methods used to measure fiber refractive index profile are

- Inter-ferro-metric method
- Near infra scanning method
- Refracted near field method.

20. Define – Minimum Detectable Optical Power

It is defined as the optical power necessary to produce a photocurrent of the same magnitude as the root mean square of the total current.

21. What are the noise effects on system performance?

The main penalties are modal noise, wavelength chirp, spectral broadening, and mode-partition noise.

22. Why the attenuation limit curve slopes towards to the right?

As the minimum optical power required at the receiver for a given BER becomes higher for increasing data rates, the attenuation limit curve slopes downward to the right.

23. What do you mean thermal noise?

Thermal noise is due to the random motion of electrons in a conductor. Thermal noise arising from the detector load resistor and from the amplifier electronics tend to dominate in applications with low signal to noise ratio.

24. What is meant by excess noise factor?

The ratio of the actual noise generated in an avalanche photodiode to the noise that would exist if all carrier pairs were multiplied by exactly m is called the excess noise factor. (F).

25. What are the system requirements?

The key system requirements are as follows

- The desired or possible transmission distance
- The data rate or channel bandwidth
- Bit error rate (BER)

26. Give the two analyses that are used to ensure system performance.

The two analyses that are used to ensure system performance are

- Link power budget analysis
- Rise time budget analysis.

27. Define – Extinction Ratio

The extinction ratio ε is usually defined as the ratio of the optical energy emitted in the 0 bit period to that emitted during 1 bit period.

28. Define – Modal Noise

It arises when the light from a coherent LASER is coupled into a multimode fiber operating at 400Mbps and higher. It mainly occurs due to mechanical vibrations and fluctuations in the frequency of the optical source.

29. What are the measures to avoid modal noise?

The measures to avoid modal noise are

- Use LEDs
- Use LASER having more longitudinal modes
- Use a fiber with large numerical aperture
- Use a single mode fiber

30. Define – Mode Partition Noise

The mode partition noise is associated with intensity fluctuations in the longitudinal modes of a LASER diode. It becomes more pronounced for the higher bit rates.

31. Give the range of system margin in link power budget.

The system margin is usually (6 -8)dB. A positive system margin ensures proper operation of the circuit. A negative value indicates that insufficient power will reach the detector to achieve the bit error rate, BER.

32. What is reflection noise?

It is the optical power that gets reflected at the refractive index discontinuities such as splices, couplers and filters or connectors. The reflected signals can degrade both the transmitter and receiver performance.

33. What are the effects of reflection noise in high speed systems?

They cause optical feedback which leads to optical instabilities that may lead to inter-symbol interference and intensity noise.

34. What are the system components of system rise time?

The four basic system components that contribute to the system rise time are

- Modal dispersion time of the link
- Material dispersion time of the fiber
- Transmitter (source) rise time
- Receiver rise time.

35. Define – Radiance

Radiance (or brightness) is a measure in watts, of the optical power radiated into a unit solid angle per unit area of the emitting surface.

PART-B

1. Explain the fundamental operation of receiver.
2. Explain different types of preamplifier with expressions.
3. Discuss about various error sources.
4. Derive the expression of probability of error. (or) Derive the expression of BER.
5. Remaining all measurement questions, just study the block diagram based on the diagram you can explain your answers. (For example attenuation, RI measurement questions you can write the answer, what you did in the laboratory).
6. Explain in detail with necessary circuit diagram and advantages of trans-impedance amplifier.
7. Explain any two methods used for measurement of refractive index profile of the fiber.
8. With schematic diagram explain the blocks and their functions of an optical receiver.
9. Consider a digital fiber optic link operating at a bit rate of 622Mbps at 1550nm. The InGaAs PIN detector has a quantum efficiency of 0.8. Find the minimum number of photons in a pulse required for a BER of 10^{-9}. Find the corresponding minimum incident power.
10. A digital fiber optic link operating 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.

UNIT V OPTICAL NETWORKS AND SYSTEM TRANSMISSION 9

Basic Networks – SONET / SDH – Broadcast – and –select WDM Networks –Wavelength Routed Networks – Non linear effects on Network performance –-Link Power budget -Rise time budget- Noise Effects on System Performance-Operational Principles of WDM Performance of WDM + EDFA system – Solutions – Optical CDMA – Ultra High Capacity Networks**.**

1. **What are the three topologies used for fiber optical network?**
   The three topologies used for fiber optical network are
   - Bus topology
   - Ring topology
   - Star topology
2. **Calculate the number of independent signals that can be sent on a single fiber in the 1525 – 1565 nm bands. Assume the spectral spacing as per ITU – T recommendation G.692.(A / M 2011).**
   Given: Mean frequency spacing as per ITU- T is 0.8nm.

   Wavelength = 1565nm – 1525nm = 40 nm.

   Number of independent channel = (40nm / 0.8nm) = 50 channels.
3. **Define – WDM (A / M 2011)**
   In fiber-optic communications, wavelength –division multiplexing(WDM) is a technology which multiplexes a number of optical carrier signals onto a single optical fiber by using different wavelengths (i.e. colors) of LASER light. This technique enables bidirectional communications over one strand of fiber, as well as multiplications of capacity.
4. **What are the advantages of WDM? (N / D 2007)**
   The advantages of WDM are
   - Various optical channels can support different transmission formats.
   - Increase in the capacity if optical fiber compared to point – to –point link.
5. **What are the drawbacks of broadcast and select networks for wide area network applications? (M / J 2012)**
   The drawbacks of broadcast and select networks for wide area network applications are
   - Without the use of optical booster amplifiers splitting losses occurs.
   - More wavelengths are needed as the number of nodes in the network grows.

6. **The specifications of the light sources are converted to equivalent rise time in rise time budget. Why?**

A rise time budget is a convenient method to determine the dispersion limitation of an optical link. This is particularly useful for digital systems. For this purpose, the specifications of the light sources (both the fiber and the photo detector) are converted to equivalent rise time. The overall system rise time is given in terms of the light source rise time, fiber dispersion time and the photo detector rise time.

7. **What is EDFA?**

An erbium-doped fiber amplifier (EDFA) is a device that amplifier an optical fiber signal. A trace in the form of a trivalent erbium ion is inserted into the optical fiber's silica core to alter its optical properties and permit signal amplification.

8. **What is chirping?**

Modulation of a single longitudinal mode semiconductor LASER can cause a dynamic shift of the peak wavelength emitter from the device. This phenomenon, which results in dynamic line width broadening under the direct modulation of the injection current, is referred to us frequency chirping.

9. **What is the best way to minimize chirping?**

It is to choose the LASER emission wavelength close to the zero-dispersion of the wavelength of the fiber.

10. **What do you mean by bidirectional WDM?**

A single WDM which operates as both multiplexing and demultiplexing device is said to be bidirectional WDM.

11. **What are the basic performances of the WDM?**

The basic performances of WDM are

- Insertion loss
- Channel width
- Cross talk

12. **What are the advantages of using soliton signals through fiber? (M / J 2009)**

The advantages of using soliton signals through fiber are, Solitons are very narrow, high-intensity optical pulses that retain their shape through the interaction of balancing pulse dispersion with nonlinear properties of an optical fiber.

13. **Distinguish between fundamental and higher order soliton. (N /D 2007)**

The families of pulses that do not change in shape are called fundamental Solitons. The families of pulses that undergo periodic shape changes are called higher order Solitons.

14. **What are Solitons? (N / D 2010)**

Solitons are nonlinear optical pulses which have the potential support very high optical transmission rates of many terabits per second over long distances.

15. What is SONET / SDH?

Synchronous optical networking (SONET) or synchronous Digital Hierarchy (SDH) is a standardized protocol that transfers multiple digital bit streams over optical fiber using lasers or highly coherent light emitting diodes. At low transmission rates data can also be transferred via an electrical interface.

16. What are the two different types of WDM?

The two different types of WDM are

- Unidirectional WDM
- Bidirectional WDM

17. What is DWDM?

Dense Wavelength Division Multiplexing (DWDM) is an optical technology used to increased bandwidth over existing fiber-optic bones. It works by combining and transmitting multiple signals simultaneously at different wavelengths on the same fibers.

18. Define – Crosstalk

Crosstalk is defined as the feed through one of the channel signals into another channel.

19. Give the important features of time-slotted optical TDM network.

The important features of time slotted optical TDM network are

- To provide backbone to interconnect high speed networks
- To transfer quickly very large data blocks
- To switch large aggregations of traffic
- To provide both high- rate.

20. How the speckle pattern can form?

The speckle patterns are formed by the interference of the modes from a coherent source when the coherence time of the source is greater than the intermodal dispersion time within the fiber.

21. Define – Full- Width Half- Maximum (FWHM)

The FWHM is a pulse defined as the full width at its half-maximum power level.

22. What are the types of broadcast and select network?

The types of broadcast and select network are

- Single – hop networks
- Multi – hop networks

23. What is meant by cross- phase modulation (XPM)?

Cross- phase modulation, which converts power fluctuations in particular wavelength channel to phase fluctuations in the co-propagating channels

24. What is meant by power penalty?

When nonlinear effects contribute to signal impairment, an additional amount of power will be needed at the receiver to maintain the same BER. This additional power(dB) is known as the power penalty.

25. Define – Network

Network is defined as to establish connections between these stations; one interconnects them by transmission paths to form a network.

26. What is meant by topology?

The topology is the logical manner in which nodes are linked together by information transmission channels to form a network.

PART-B

1. Explain SONET with neat diagram (16)
2. Discuss the WDM concept with detail.(16)
3. Derive the expression of Soliton parameters.(16)
4. Explain Optical CDMA with Ultra High Capacity Networks. (16)
5. Discuss the various noises associated with Optical networks. (16)
6. An engineer has the following components available:
    a. GaAlAs laser diode, operating at 850nm, fiber coupled power 0dBm.
    b. Ten section of cable each of which is 500m long has 4dB/km attenuation has connectors at both ends.
    c. 2dB/connector connector loss
    d. A PIN photodiode receiver, -45dBm sensitivity
    e. An avalanche photodiode receiver, -56dBm sensitivity

    The engineer wishes to construct a 5km link operating at 20Mb/s. analyze which receiver should be used if a 6dB operating margin is required.
7. Discuss about the principle of optical code division multiple accesses.
8. Discuss about the protection mechanism in UPSR and BLSR ring architecture with neat sketch.
9. Explain in detail different types of broadcast and select WDM networks.
10. Explain the layered architecture and transmission formats of SONET.

TWO MARKS
UNIT-1
INTRODUCTION TO EMBEDDED COMPUTING AND ARM PROCESSORS

1.Define Embedded System. What are the components of embedded system?
An Embedded system is one that has computer hardware with software embedded in it as one of its most important component. The three main components of an embedded system are

- Hardware
- Main application software
- RTOS

2.In what ways CISC and RISC processors differ?

CISC	RISC
It provides number of addressing modes	It provides very few addressing modes
It has a micro programmed unit with a control memory	It has a hardwired unit without a control memory
An easy compiler design	Complex compiler design
Provide precise and intensive calculations slower than a RISC	Provide precise and intensive calculations faster than a CISC

3.Define system on chip (SOC) with an example
Embedded systems are being designed on a single silicon chip called system on chip. SOC is a new design innovation for embedded system
Ex. Mobile phone.

4.Give any two uses of VLSI designed circuits
A VLSI chip can embed IPs for the specific application besides the ASIP or a GPP core. A system on a VLSI chip that has all of needed analog as well as digital circuits.
Eg. Mobile phone.

5.List the important considerations when selecting a processor.

- Instruction set
- Maximum bits in an operand
- Clock frequency
- Processor ability

6.What are the types of embedded system?

- Small scale embedded systems
- Medium scale embedded systems
- Sophisticated embedded systems

7.What are the important embedded processor chips?

ARM 7 and ARM 9
i 960
AMD 29050

8.Classify the processors in embedded system?

General purpose processor

- Microprocessor
- Microcontroller
- Embedded processor
- Digital signal processor
- Media processor
- Application specific system processor
- Multiprocessor system using GPP and ASSP GPP core or ASIP core integrated into either an ASIC or a VLSI circuit or an FPGA core integrated with processor unit in a VLSI chip.

9.Name some DSP used in embedded systems?

TMS320Cxx
SHARC
5600xx

10.Name some of the hardware parts of embedded systems?

- Power source
- Clock oscillator circuit
- Timers
- Memory units
- DAC and ADC
- LCD and LED displays
- Keyboard/Keypad

11.What are the various types of memory in embedded systems?

- RAM internal External
- ROM/PROM/EEPROM/Flash
- Cache memory

12.What are the points to be considered while connecting power supply rails with embedded system?

- A processor may have more than two pins of Vdd and Vss
- Supply should separately power the external I/O driving ports, timers, and clock and
- From the supply there should be separate interconnections for pairs of Vdd and Vss pins analog ground analog reference and analog input voltage lines.

13.What is watch dog timer?

Watch dog timer is a timing device that resets after a predefined timeout.

14.What does the execution unit of a processor in an embedded system do?

The EU includes the ALU and also the circuits that execute instructions for a program control task. The EU has circuits that implement the instructions pertaining to data transfer operations and data conversion from one form to another.

15.Give examples for general purpose processor.

- Microprocessor
- Microcontroller

16.What are the two essential units of a processor on a embedded system?

- Program Flow control Unit
- Execution Unit

17.Define microprocessor.

A microprocessor is a single VLSI chip that has a CPU and may also have some other units for example floating point processing arithmetic unit pipelining and super scaling units for faster processing of instruction.

18.When is Application Specific System processors ASSPs) used in an embedded system?

An ASSP is used as an additional processing unit for running the application specific tasks in place of processing using embedded software.

19.Define ROM image.

Final stage software is also called as ROM image .The final implement able software for a product embeds in the ROM as an image at a frame. Bytes at each address must be defined for creating the image.

20.Define device driver.

A device driver is software for controlling, receiving and sending byte or a stream of bytes from or to a device.

21.Name some of the software's used for the detailed designing of an embedded system.

Final machine implement able software for a product

- Assembly language
- High level language
- Machine codes
- Software for device drivers and device management.

22.Give some examples for medium scale embedded systems

- Router, a hub and a gateway
- Entertainment systems
- Banking systems
- Signal tracking systems

23.Give some examples for small scale embedded systems.

- ACVM
- Stepper motor controllers for a robotic system
- Washing or cooking system
- Multitasking toys

24.Give some examples for sophisticated embedded systems

- Embedded system for wireless LAN
- Embedded systems for real time video
- Security products
- ES for space lifeboat.

25.What are the requirements of embedded system?

- Reliability
- Low power consumption
- Cost effectiveness
- Efficient use of processing power

26.What are the various models used in the design of an embedded system?

- Finite state machine
- Petri net
- Control and dataflow graph
- Activity diagram based UML model
- Synchronous data flow graph
- Timed Petri net and extended predicate/transition net
- Multithreaded graph

27.Give the characteristics of embedded system?

- a Single-functioned
- Tightly constrained
- Reactive and real time

28.What are the design metrics?

- Power
- Size
- NRE cost
- Performance

29.What are the challenges of embedded systems?

- Hardware needed
- Meeting the deadlines
- Minimizing the power consumption
- Design for upgradeability

30.Give the steps in embedded system design?

- Requirements
- Specifications
- System integeration
- Architecture
- Components

31.What are the requirements?

Before designing a system, it must to understand what has to be designed. This can be known from the starting steps of a design process.

32.Give the types of requirements?

- Functional requirements
- Non functional requirements

33. Define functional requirements?

It says the fundamental functions of an embedded system.

34.Give some examples of functional requirements?

- Performance
- Cost
- physical size and weight
- power

35.What is the use of requirements form?
It is used as a checklist in the requirements analysis. From this the fundamental properties of a system came to be known.

36. What are the entries of a requirement form?

- Name
- Purpose
- Inputs and outputs
- Functions
- Performance
- Manufacturing cost
- Power
- Physical size and weight

37. What is architecture design?
It says the way of implementing functions by a system. Actually architecture is a plan for whole structure of a system. While will bring the design of components

38. Define system integration?
It is a processor of combining the components into one system.

39. What are the functions of memory?
The memory functions are

- To provide storage for the software that it will run.
- To store program variables and the intermediate results
- Used for storage of information

40. Define RAM?
RAM refers Random Access Memory. It is a memory location that can be accessed without touching the other locations.

41. What is data memory?
When the program is executing, to save the variable and program stack, this type of memory is used

42. What is code memory?
The program code can be stored by using this area. The ROM is used for this purpose.

43. What are the uses of timers?

- The time intervals can be completed
- Precise hardware delays can be calculated
- The timeout facilities are generated

44. Give short notes on RAM processor?
It is said to be the family of RISC architecture. The ARM instructions are written one per line, starting after the first column.

45.What are the data types supported by RAM?
Standard ARM word is 32 bit long Word is splitted into 4 8 bit bytes

47.What is meant by specification?

- This is a bridge between Customer and Architect. It conveys the customer's needs. These
- needs are properly used in the design process.

46.What are the 3 types of operating modes?

- Normal mode
- Idle mode
- Power down mode

UNIT-II
EMBEDDED COMPUTING PLATFORM DESIGN

1. Differentiate synchronous communication and iso-synchronous communication.

Synchronous communication

When a byte or a frame of the data is received or transmitted at constant time intervals with uniform phase difference, the communication is called synchronous communication.

Iso-synchronous communication

Iso-synchronous communication is a special case when the maximum time interval can be varied.

2.What are the two characteristics of synchronous communication?

- Bytes maintain a constant phase difference
- The clock is not always implicit to the synchronous data receiver.

3.What are the three ways of communication for a device?

- Iso-synchronous communication
- synchronous communication
- Asynchronous communication

4.Expand a) SPI b) SCI

- SPI—serial Peripheral Interface
- SCI—Serial Communication Interface

5. Define software timer.

This is software that executes and increases or decreases a count variable on an interrupt from a timer output or form a real time clock interrupt. A software timer can also generate interrupt on overflow of count value or on finishing value of the count variable.

6.What is USB? Where is it used?

USB is a serial bus for interconnecting a system. It attaches and detaches a device from the network. It uses a root hub. Nodes containing the devices can be organized like a tree structure. It is mostly used in networking the IO devices like scanner in a computer system.

7.What are the features of the USB protocol?

A device can be attached, configured and used, reset, reconfigured and used, share the bandwidth with other devices, detached and reattached.

8. Explain briefly about PCI and PCI/X buses.

PCI and PCI/X buses are independent from the IBM architecture .PCI/X is an extension of PCI and support 64/100 MHZ transfers. Lately, new versions have been introduced for the PCI bus architecture.

9.Why are SPCI parallel buses important?

SPCI serial buses are important for distributed devices. The latest high speed sophisticated systems use new sophisticated buses.

10.What is meant by UART?

- UART stands for universal Asynchronous Receiver/Transmitter.
- UART is a hardware component for translating the data between parallel and serial interfaces.
- UART does convert bytes of data to and from asynchronous start stop bit.
- UART is normally used in MODEM.

11.What does UART contain?

- A clock generator.
- Input and Output start Registers
- Buffers.
- Transmitter/Receiver control.

12.What is meant by HDLC?

- HDLC stands for "High Level Data Link Control".
- HDLC is a bit oriented protocol.
- HDLC is a synchronous data Link layer.

13. Name the HDLC's frame structure?

Flag	Address	Control	Data	FCS	Flag

14.List out the states of timer?

There are eleven states as follows

- Reset state
- Idle state
- Present state
- Over flow state
- Over run state
- Running state
- Reset enabled state / disabled
- Finished state
- Load enabled / disabled
- Auto reload enabled / disabled
- Service routine execution enabled / disabled

15. Name some control bit of timer?

- Timer Enable
- Timer start
- Up count Enable
- Timer Interrupt Enable

16. What is meant by status flag?

Status flag is the hardware signal to be set when the timer reaches zeros.

17.List out some applications of timer devices?

- Real Time clock
- Watchdog timer
- Input pulse counting
- TDM
- Scheduling of various tasks

18.State the special features on I^2C?

- Low cost
- Easy implementation
- Moderate speed upto 100 kbps).

19.What are disadvantages of I^2C?

- Slave hardware does not provide much support
- Open collector drivers at the master leads to be confused

20.What are the two standards of USB?

- USB 1.1
- USB 2.0

21. Why do we need at least one timer in an ES?

The embedded system needs at least on timer device. It is used as a system clock.

22. What is the need of Advanced Serial High Speed Buses?

If the speed in the rate of 'Gigabits per second' then there is a need of Advanced Serial High Speed Buses.

23.What is meant by ISA?

ISA stands for Industry standard Architecture.
Used for connecting devices following IO addresses and interrupts vectors as per IBM pc architecture.

24.What is meant by PCI-X?

- PCI X offers more speed over PCI.
- 30 times more speed than PCI.

25.Define CPCI?

- CPCI stands for Compact peripheral component Interfaces.
- CPCI is to be connected via a PCI.
- CPCI is used in the areas of Telecommunication Instrumentation abd data communication applications.

26.Define half-duplex communication.

Transmission occurs in both the direction, but not simultaneously.

27. Define full duplex communication.

Transmission occurs in both the direction, simultaneously

28. Define Real Time Clock RTC?

Real time clock is a clock which once the system stats does not stop and cant be reset and its count value cant be reloaded.

29. Define Time-out or Time Overflow?

A state in which the number of count inputs exceeded the last acquirable value and on reaching that state, an interrupt can be generated.

30.What is I2C?

I2C is a serial bus for interconnecting ICs .It has a start bit and a stop bit like an UART. It has seven fields for start,7 bit address, defining a read or a write, defining byte as acknowledging byte, data byte, NACK and end.

31.What are the bits in I2C corresponding to?
It has seven fields for start,7 bit address, defining a read or a write, defining byte as acknowledging byte, data byte, NACK and end

32.What is a CAN bus? Where is it used?
CAN is a serial bus for interconnecting a central Control network. It is mostly used in automobiles. It has fields for bus arbitration bits, control bits for address and data length data
bits, CRC check bits, acknowledgement bits and ending bits.

UNIT-III
PROCESSES AND OPERATING SYSTEMS

1.What are the states of a process?
- Running
- Ready
- Waiting

2.What is the function in steady state?
Processes which are ready to run but are not currently using the processor are in the 'ready' state.

3.Define scheduling.
This is defined as a process of selection which says that a process has to use the processor at given time.

4.What is scheduling policy?
It says the way in which processes are chosen to get promotion from ready state to running state.

5.Define hyper period?
It refers the duration of time considered and also it is the least common multiple of all the processes.

6.What is schedulability?
It indicates any execution schedule is there for a collection of process in the system's functionality.

7.What are the types of scheduling?
- Time division multiple access scheduling.
- Round robin scheduling.

8.What is cyclostatic scheduling?
In this type of scheduling, interval is the length of hyper period 'H'. For this interval, a cyclostatic schedule is separated into equal sized time slots.

9.Define round robin scheduling?
This type of scheduling also employs the hyperperiod as an interval. The processes are run in the given order.

10.What is scheduling overhead?
It is defined as time of execution needed to select the next execution process.

11.What is meant by context switching?
The actual process of changing from one task to another is called a context switch.

12.Define priority scheduling?
A simple scheduler maintains a priority queue of processes that are in the runnable state.

13. What is rate monotonic scheduling?
Rate monotonic scheduling is an approach that is used to assign task priority for a preemptive system.

14.What is critical instant?
It is the situation in which the process or task posses' highest response time.

15.What is critical instant analysis?
It is used to know about the schedule of a system. Its says that based on the periods given, the priorities to the processes has to be assigned.

16. Define earliest deadline first scheduling?
This type of scheduling is another task priority policy that uses the nearest deadline as the criterion for assigning the task priority.

17.What is IDC mechanism?
It is necessary for a 'process to get communicate with other process' in order to attain a specific application in an operating system.

18.What are the two types of communication?
- Blocking communication
- Non blocking communication

19.Give the different styles of inter process communication?
- Shared memory.
- Message passing.

UNIT 1V
SYSTEM DESIGN TECHNIQUES AND NETWORKS

1.Name the important terms of RTOS?
- Task
- State
- Scheduler
- Shared data
- Reentrancy

2.Define process.
Process is a computational unit that processes on a CPU under the control of a scheduling kernel of an OS. It has a process structure, called Process control block. A process defines a sequentially executing program and its state.

3.Define task and Task state.
A task is a set of computations or actions that processes on a CPU under the control of a scheduling kernel. It also has a process control structure called a task control block that saves at the memory. It has a unique ID. It has states in the system as follows: idle, ready, running, blocked and finished

4.What is meant by PCB?
Process Control Block' is abbreviated as PCB.PCB is a data structure which contains all the information and components regarding with the process.

5.What are the semaphores related functions supported by MUCOS?

- OS_Event OSSemCreateunsigned short sem val)
- Void OSSemPendOS_Event *eventPointer,unsigned short timeout,unsigned byte *SemErrPointer
- unsigned short OSSemAccept(OS_Event*eventPointer
- unsigned short OSSemPost(OS_Event*eventPointer

6. Define Task Control Block TCB)

A memory block that holds information of program counter, memory map, the signal dispatch table, signal mask, task ID, CPU state and a kernel stack.

7.What is a thread?

Thread is a concept in Java and UNIX and it is a light weight sub process or process in an application program. It is controlled by the OS kernel. It has a process structure, called thread stack, at the memory. It has a unique ID .It have states in the system aswwwfollows:.annauniverzitystating,.com running, blocked and finished.

8.Define Inter process communication.

An output from one task passed to another task through the scheduler and use of signals, exception, semaphore, queues, mailbox, pipes, sockets, and RPC.

9.What is shared data problem?

If a variable is used in two different processes and another task if interrupts before the operation on that data is completed then the value of the variable may differ from the one expected if the earlier operation had been completed .This ids known as shared data problem.

10.Define Semaphore.

Semaphore provides a mechanism to let a task wait till another finishes. It is a way of synchronizing concurrent processing operations. When a semaphore is taken by a task then that task has access to the necessary resources. When given the resources unlock. Semaphore can be used as an event flag or as a resource key.

11.Define Mutex.

A phenomenon for solving the shared data problem is known as semaphore. Mutex is a semaphore that gives at an instance two tasks mutually exclusive access to resources.

12.Differentiate counting semaphore and binary semaphore.

Binary semaphore

When the value of binary semaphore is one it is assumed that no task has taken it and that it has been released. When the value is 0 it is assumed that it has been taken.

Counting semaphore

Counting semaphore is a semaphore which can be taken and given number of times. Counting semaphores are unsigned integers.

13.What is Priority inversion?

A problem in which a low priority task inadvertently does not release the process for a higher priority task.

14. What is deadlock situation?

A set of processes or threads is deadlocked when each process or thread is waiting for a resource to be freed which is controlled by another process.

15.Define Message Queue.
A task sending the multiple FIFO or priority messages into a queue for use by another task using queue messages as an input.

16. Define Mailbox and Pipe.
A message or message pointer from a task that is addressed to another task.

17. Define Socket.
It provides the logical link using a protocol between the tasks in a client server or peer to peer environment.

18. Define Remote Procedure Call.
A method used for connecting two remotely placed methods by using a protocol. Both systems work in the peer to peer communication mode and not in the client server mode.

19.What are the goals of RTOS?

- Facilitating easy sharing of resources
- Facilitating easy implantation of the application software
- Maximizing system performance
- Providing management functions for the processes, memory, and I/Os and for other functions for which it is designed.
- Providing management and organization functions for the devices and files and file like devices.
- Portability
- Interoperability
- Providing common set of interfaces.

20.What is RTOS?
An RTOS is an OS for response time controlled and event controlled processes. RTOS is an OS for embedded systems, as these have real time programming issues to solve.

21.What are the functions of device manager?

- Device detection and addition
- Device deletion
- Device allocation and registration
- Detaching and deregistration
- Device sharing

22.What are the two methods by which a running requests resources?

- Message
- System call

23.List the functions of a kernel.

- Process management
- Process creation to deletion
- Processing resource requests
- Scheduling
- IPC
- Memory management
- I/O management
- Device management

24.List the set of OS command functions for a device

- Create and open
- Write
- Read
- Close and delete

25.List the set of command functions of POSIX file system

- Open
- Write
- Read
- Seek
- Close

26. What are the three methods by which an RTOS responds to a hardware source call on interrupt?

- Direct call to ISR by an interrupt source
- Direct call to RTOS by an interrupt source and temporary suspension of a scheduled task.
- Direct call to RTOS by an interrupt source and scheduling of tasks as well as ISRs by the RTOS.

27. Name any two important RTOS.

- MUCOS
- VxWorks

28. Write short notes on Vxworks?

- Vxworks is a popular Real-time multi-tasking operating system for embedded microprocessors and systems.
- Vxworks can run on many target processors.
- It is a UNIX like Real time operating system.

29.What is meant by well tested and debugged RTOS?

An RTOS which is thoroughly tested and debugged in a number of situations.

30. What is sophisticated multitasking embedded system?

A system that has multitasking needs with multiple features and in which the tasks have deadlines that must be adhered to.

31. What are the features of UC/OS II?

- Preemptive
- Portable
- Scalable
- Multitasking

32. What are the real time system level functions in UC/OS II? State some?

- Initiating the OS before starting the use of the RTOS fuctions.
- Starting the use of RTOS multi-tasking functions and running the states.
- Starting the use of RTOS system clock.

33. Write the interrupt handling functions?

int connect is the function for handling the Interrupt
int Lock -> Disable Interrupts.
int unlock -> Enable functions.

34. What is MICRO C/OS II?

- It stands for micro-controller operating systemUC/OS II.
- It is a real time kernel
- The other names of MICROC/OS II are MUCOS and UCOS.
- The codes are in ‘C’ and Assembly language.

35. Write down the seven task priorities in embedded 'C++'?. define

Task _Read ports priority
define Task _Excess Refund priority
define Task _Deliver priority
define Task _Refund priority define
Task _Collect priority define Task
_Display Priority
define Task _Time Date Display priority

36. Name any two mailbox related functions.

- OS_Event *OSMboxCreatevoid *mboxMsg
- Void *OSMboxAccept(OS_EVENT *mboxMsg

37. Name any two queue related functions for the inter task communications.

- OS_Event OSQCreatevoid **QTop,unsigned byte qSize
- Unsigned byte OSQPostFront(OS_EVENT *QMsgPointer,void *qmsg

38. How is Vx Works TCB helpful for tasks?

- Provide control information for the OS that includes priority, stack size, state and options.
- CPU context of the task that includes PC, SP, CPU registers and task variables.

39. What are the various features of Vx Works?

VxWorks is a scalable OS

RTOS hierarchy includes timers, signals, TCP/IP sockets, queuing functions library, Berkeley ports and sockets, pipes, UNIX compatible loader, language interpreter, shell, debugging tools, linking loader for UNIX.

40. What is an active task in the context of Vx Works?

Active task means that it is in one of the three states, ready, running, or waiting.

41. What are the task service functions supported by Vx Works?

- taskSpawn
- taskResume
- taskSuspand
- taskDelay
- taskSuspand
- taskInit(
- exit(
- taskDelete

42. Name any four interrupt service functions supported by Vx Works?

- intLock
- intVectSet(
- intVectGet(
- intContext(

43. Name some of the inter process communication function.

- semBCreate
- semMCreate
- semCCreate
- semTake
- semDelete

44. Name some of the inter process communication function used for messaging.

- msgQCreate
- msgQDelete
- msgQSend
- msgQReceive

45. What are Vx Works pipes?

VxWorks pipes are thec queues that can be opened and closed like a pipe.pipes are like virtual IO devices that store the messages as FIFO.

46. What are the different types of scheduling supported by Vx Works?

Preemptive priority
Time slicing

47. What are the task service functions supported by MUCOS?

- Void OSInit void
- Void OSStart(void
- voidOSTickInit(void
- void OSIntEntervoid
- void OSIntExit(void

UNIT V
CASE STUDY

1. What is a PIC?

PIC refers to Programmable Intelligent Computer. PIC is microprocessor lies inside a personal computer but significantly simpler, smaller and cheaper. It can be used for operating relays, measuring sensors etc.

2. What are the main elements inside a PIC?

Processing engine, Program memory, data memory and Input/Output.

3.What are the types of program memory in a PIC?

Read-only, EPROM and EEPROM, Flash

4.What is MBasic Compiler Software?

From version 5.3.0.0 onward, Basic Micro offers one version of its MBasic compiler, the Professional" version. MBasic runs under Microsoft's Windows operating system in any version from Windows 95 to Windows XP. The computer requires an RS-232 port for connection to the ISP-PRO programmer board.

5. Define pseudo-code.

Pseudo-code is a useful tool when developing an idea before writing a line of true code or when explaining how a particular procedure or function or even an entire program

.

Unit I - INTRODUCTION TO EMBEDDED COMPUTING

Part B (16 Marks)

1. Explain in details about Model train controller.
2. Explain in details about Embedded System Design Process.
3. What is Formalisms for system Design?
4. What is Instruction Sets and explain in details about ARM instruction sets?
5. Explain in details Supervisor mode, Exceptions and traps.
6. Explain in details about Memory System Mechanisms.
7. Write the flow of control in ARM.8. Explain in detail the operation of ARM processor and coprocessor.

Unit II-COMPUTING PLATFORM AND DESIGN ANALYSIS

1. Explain in details about Memory Devices.
2. Explain in details about I/O Devices.
3. Explain in details about different Bus Structures.
4. Design a system with microprocessors in detail.
5. Explain in details about Development and Debugging techniques.
6. What is analysis and optimization of execution time, power, energy and program size?
7. Explain the component interfacing.8. Describe the basic compilation techniques.9. Explain the debugging process.

Unit III-PROCESS AND OPERATING SYSTEMS

1. Explain in details about Real time Operating systems
2. What are the different types of Scheduling Policies and explain?
3. Explain in details about Inter Process communication mechanisms.
4. Explain evaluating operating system performance in detail.
5. Explain in detail about Power optimization strategies for processes.
6. Explain the services of operating system in handling multiprocess scheduling and communication.
7. Discuss the power management and optimization for process.

Unit IV-HARDWARE ACCELERATES & NETWORKS

1. Explain in details about Accelerated system design.
2. What is distributed embedded architecture and explains?
3. Explain in details about Network based design.
4. What is Internet enabled systems explain?
5. Discuss about Accelerator based embedded system and network based embedded systems.
6. Explain networks for embedded systems and Internet-enabled embedded system.

Unit V-CASE STUDY

1. Explain in details about Hardware and software co-design.
2. What is Data Compressor and explain its operation in detail?
3. What is the function of Software modem explains in details?
4. Explain the FOS tools for embedded system development.
5. Explain embedded hardware and software co-design.
6. Describe how PDA is designed.
7. Explain in details about System – on – silicon.
8. Demonstrate the sequence diagram of taking picture with digital still camera.
9. With neat sketch explain the operation of telephone answering machine.
10. With necessary block diagram explain video accelerator.
11. Demonstrate in detail about design example of audio player.
12. Justify the engine control unit is an embedded system. Explain in detail the hardware and software components of engine control unit.

V.S.B ENGINEERING COLLEGE, KARUR
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
EC6009-ADVANCED COMPUTER ARCHITECTURE

UNIT 1

Fundamentals of Computer Design

2 Marks

1.What are the five classic components of a computer?

The five classic components of a computer are input, output, memory, datapath, and control, with the last two sometimes combined and called the processor.

2. Define ISA

The instruction set architecture, or simply architecture of a computer is the interface between the hardware and the lowest-level software. It includes anything programmers need to know to make a binary machine language program work correctly, including instructions, I/O devices, and so on.

3. What are the advantages of network computers?

Networked computers have several major advantages:

- Communication: Information is exchanged between computers at high speeds.
- Resource sharing: Rather than each computer having its own I/O devices, computers on the network can share I/O devices.
- Nonlocal access: By connecting computers over long distances, users need not be near the computer they are using.

4. what are the functions of control unit ?

The memory arithmetic and logic ,and input and output units store and process information and perform i/p and o/p operation, the operation of these unit must be co ordinate in some way this is the task of control unit the cu is effectively the nerve center that sends the control signal to other units and sence their states.

5. Define Response Time

Response time is also called execution time. The total time required for the computer to complete a task, including disk accesses, memory accesses, I/O activities, operating system overhead, CPU execution time, and so on is called response time.

6. Define Throughput

Throughput or bandwidth is the total amount of work done in a given time.

7. Write the CPU performance equation.

The Classic CPU Performance Equation in terms of instruction count (the number of instructions executed by the program), CPI, and clock cycle time:

8. What are the basic components of performance?

The basic components of performance and how each is measured are

Components of Performance	Units of measure
CPU execution time for a program	Seconds for the program
Instruction count	Instruction executed for the program
Clock cycles per instruction(CPI)	Average number of clock cycles per instruction
Clock cycle time	Seconds per clock cycle

9. Define dependability.

- Dependability is a measure of a system's availability, reliability, and its maintainability, and maintenance support performance, and, in some cases, other characteristics such as durability, safety and security.
- In software engineering, dependability is the ability to provide services that can defensibly be trusted within a time-period. This may also encompass mechanisms designed to increase and maintain the dependability of a system or software

10. Define latency.

- The term memory latency is used to refer to the amount of time it takes to transfer a word of data to or from the memory.
- The term latency is used to denote the time it takes to transfer the first word of data.
- This time is usually substantially longer than the time needed to transfer each subsequent word of a block.

11. Define bandwidth.

Bandwidth is a product of the rate at which the data are transferred (and accessed) and the width of the data bus.

16 Marks

1. Classes of parallelism
2. Quantitative principle of computer design
3. Multithreading architectures
4. Classes of computers, trends in technology, power energy and cost(any one 8marks)

UNIT 2
Instruction Level Parallelism
2 Marks

1.What is meant by ILP?

Pipelining exploits the potential parallelism among instructions. This parallelism is called instruction-level parallelism (ILP). There are two primary methods for increasing the potential amount of instruction-level parallelism. 1. Increasing the depth of the pipeline to overlap more instructions. 2. Multiple issue.

2.What are the needs of ILP?

- •Sufficient resources
- •Parallel scheduling
- –Hardware solution
- –Software solution
- •Application should contain ILP

3. What is multiple issue? Write any two approaches.

Multiple issue is a scheme whereby multiple instructions are launched in one clock cycle. It is a method for increasing the potential amount of instruction-level parallelism. It is done by replicating the internal components of the computer so that it can launch multiple instructions in every pipeline stage.

The two approaches are:

1. Static multiple issue (at compile time)
2. Dynamic multiple issue (at run time)

4. What is meant by speculation?

One of the most important methods for finding and exploiting more ILP is speculation. It is an approach whereby the compiler or processor guesses the outcome of an instruction to remove it as dependence in executing other instructions. For example, we might speculate on the outcome of a branch, so that instructions after the branch could be executed earlier

5**. Define Static Multiple Issue**

Static multiple issue is an approach to implement a multiple-issue processor where many decisions are made by the compiler before execution.

6. Define Issue Slots and Issue Packet

Issue slots are the positions from which instructions could be issued in a given clock cycle. By analogy, these correspond to positions at the starting blocks for a sprint. Issue packet is the set of instructions that issues together in one clock cycle; the packet may be determined statically by the compiler or dynamically by the processor.

7. Define VLIW

Very Long Instruction Word (VLIW) is a style of instruction set architecture that launches many operations that are defined to be independent in a single wide instruction, typically with many separate opcode fields.

8. Define Superscalar Processor

Superscalar is an advanced pipelining technique that enables the processor to execute more than one instruction per clock cycle by selecting them during execution. Dynamic multiple-issue processors are also known as superscalar processors, or simply superscalars.

9. What is meant by loop unrolling?

An important compiler technique to get more performance from loops is loop unrolling, where multiple copies of the loop body are made. After unrolling, there is more ILP available by overlapping instructions from different iterations.

10. What is meant by anti-dependence? How is it removed?

Anti-dependence is an ordering forced by the reuse of a name, typically a register, rather than by a true dependence that carries a value between two instructions. It is also called as name dependence. Register renaming is the technique used to remove anti-dependence in which the registers are renamed by the compiler or hardware.

11.What is the use of reservation station and reorder buffer?

Reservation station is a buffer within a functional unit that holds the operands and the operation. Reorder buffer is the buffer that holds results in a dynamically scheduled processor until it is safe to store the results to memory or a register.

12. Differentiate in-order execution from out-of-order execution.

Out-of-order execution is a situation in pipelined execution when an instruction is blocked from executing does not cause the following instruction to wait. It preserves the data flow order of the program. In-order execution requires the instruction fetch and decode unit to issue instructions in order, which allows dependences to be tracked, and requires the commit unit to write results to registers and memory in program fetch order. This conservative mode is called in-order commit.

13. What is meant by hardware multithreading?

Hardware multithreading allows multiple threads to share the functional units of a single processor in an overlapping fashion to try to utilize the hardware resources efficiently. To permit this sharing, the processor must duplicate the independent state of each thread. It Increases the utilization of a processor.

14. What are the two main approaches to hardware multithreading?

There are two main approaches to hardware multithreading. Fine-grained multithreading switches between threads on each instruction, resulting in interleaved execution of multiple threads. This interleaving is often done in a round-robin fashion, skipping any threads that are stalled at that clock cycle. Coarse-grained multithreading is an alternative to fine-grained multithreading. It switches threads only on costly stalls, such as last-level cache misses.

15.What is meant by pipelining?

Pipelining is an implementation technique in which multiple instructions are overlapped in execution. Pipelining improves performance by increasing instruction throughput, as opposed to decreasing the execution time of an individual instruction.

16.What is meant by forwarding?

Forwarding, also called bypassing, is a method of resolving a data hazard by retrieving the missing data element from internal buffers rather than waiting for it to arrive from programmer visible registers or memory.

17. What is pipeline stall?

Pipeline stall, also called bubble, is a stall initiated in order to resolve a hazard. They can be seen elsewhere in the pipeline.

18. What is meant by branch prediction?

Branch prediction is a method of resolving a branch hazard that assumes a given outcome for the branch and proceeds from that assumption rather than waiting to ascertain the actual outcome.

19.How to calculate the value of CPI.

The value of the CPI (cycles per instruction) for a pipelined processor is the sum of the base CPI and all contributions from stalls:

Pipeline CPI = Ideal pipeline CPI+Structural stalls+Data hazard stalls + Control stalls

20.What are the four steps involved in instruction execution.

1.Issue

2.Execute
3.Writeresult
4.Commit

21.What are the various data hazards.

- RaW read after write
- WaR write after read
- WaW write after write

J tries to read a source before i writes it, so j incorrectly gets the old value. This hazard is the mostcommon type and corresponds to a true data dependence. pogram order must be preserved to ensure hat j receives the value from i.

16 Marks

1.Compiler Technique for exposing ILP
2.Dynamic Scheduling
3.Hardware based speculation
4.dynamic branch prediction

UNIT 3
Data-Level Parallelism
2 Marks

1. What is a vector processor?

- A vector processor or array processor is a central processing unit (CPU) that implements an instruction set containing instructions that operate on one-dimensional arrays of data called vectors, compared to scalar processors, whose instructions operate on single data items.
- Vector processors can greatly improve performance on certain workloads, notably numerical simulation and similar tasks.

2. Define vector mask registers

- This register, which contains 16 Boolean values, indicates whether or not the result values are to be written to the destination register. The mask enables the use of a technique called predication.
- In the case of an if-then-else test, rather than trying to predict the result of the test to continue execution of the program without loss of performance, both branches are executed in parallel and only the appropriate one is kept when this register is used.
- When the code to be executed is in relatively short parts, this is more efficient because it avoids the risk of wrong branch predictions.

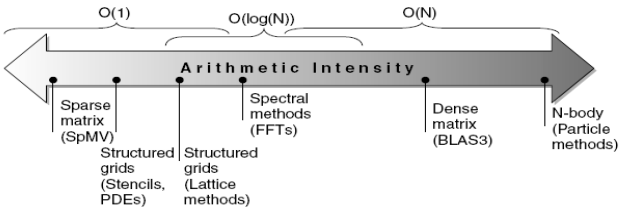
3. What is a stride?

- A stride is the distance separating elements in a given operation
- The optimal stride is 1 but for the above code, we would either have difficulty when accessing b[i][k] or d[k][j] depending on loop ordering resulting in a stride of as large as 100
- The larger the stride, the less effective the vector operations may be because multiple vector register loads will be needed cycle-after-cycle
- blocking (refer back to one of the compiler optimizations for cache) can be used to reduce the impact

4. What is a roofline model?

- Roofline is a visually intuitive performance model used to bound the performance of various numerical methods and operations running on multicore, manycore, or accelerator processor architectures.
- Rather than simply using percent-of-peak estimates, the model can be used to assess the quality of attained performance by combining locality, bandwidth, and different parallelization paradigms into a single performance figure.

- One can examine the resultant Roofline figure in order to determine both the implementation and inherent performance limitations



5. What are the primary components of VIMPS?

- *Vector registers* — VMIPS has eight vector registers, and each holds 64 elements. Each vector register must have at least two read ports and one write port.
- *Vector functional units* — Each unit is fully pipelined and can start a new operation on every clock cycle.
- *Vector load-store unit* —The VMIPS vector loads and stores are fully pipelined, so that words can be moved between the vector registers and memory with a bandwidth of 1 word per clock cycle, after an initial latency.
- *A set of scalar registers* —Scalar registers can also provide data as input to the vector functional units, as well as compute addresses to pass to the vector load-store unit.

6. List the factors that depend on execution of vector operations

The execution time of a sequence of vector operations primarily depends on these factors:

(1) The length of the operand vectors,

(2) Structural hazards

7. What is strip mining?

Strip mining: generation of code such that each vector operation is done for a size £ to the MVL

• 1st loop do short piece (n mod MVL), rest VL = MVL low = 1

VL = (n mod MVL) /*find the odd size piece*/ do 1 j = 0,(n / MVL) /*outer loop*/ do 10 i = low,low+VL-1 /*runs for length VL*/ Y(i) = a*X(i) + Y(i) /*main operation*/ 10 continue low = low+VL /*start of next vector*/ VL = MVL /*reset the length to max*/

8. What is the limitation of VLIW processors?

- Very smart compiler needed (but largely solved!)
- Loop unrolling increases code size
- Unfilled slots waste bits
- Cache miss stalls whole pipeline

9.Define a thread.

Thread is a basic unit of CPU utilization-program counter, CPU state information and stack

10. Define CUDA thread and thread block

- Since all threads in a grid execute the same kernel function, they rely on unique coordinates to distinguish themselves from each other and to identify the appropriate portion of the data to process.
- These threads are organized into a two-level hierarchy using unique coordinates, called blockId and threadId, assigned to them by the CUDA runtime system.
- The blockId and threadId appear as built-in variables that are initialized by the runtime system and can be accessed within the kernel functions.

- When a thread executes the kernel function, references to the blockId and threadId variables return the appropriate values that form coordinates of the thread.

11. What is loop carry dependency?
Loop-carried dependence: dependence exists across iterations; i.e., if the loop is removed, the dependence no longer exists.

16 Marks

1.Vector architecture
2.Graphics processing units
3.SIMD instruction set

UNIT 4
Thread Level Parallelism
2 Marks

1. What is write serialization?
Serializing the writes ensures that every processor will see the write done the case that some processor could see the write of P2 first and then see the write of P1, maintaining the value written by P1 indefinitely. The simplest way to avoid such difficulties is to ensure that all writes to the same location are seen in the same order; this property is called write serialization.

2. What is snoop cache and write through cache?(may 2011)
Every cache that has a copy of the data from a block of physical memory also has a copy of the sharing status of the block, but no centralized state is kept. The caches are all accessible via some broadcast medium (a bus or switch), and all cache controllers monitor or Snoop on the medium to determine whether or not they have a copy of a block that is requested on a bus or switch access. We focus on this approach in this section.

3. What. is symmetric shared memory ?
Symmetric shared-memory machines usually support the caching of both shared and private data.

4.What is private data and shared data?
Private data are used by a single processor, while shared data are used by multiple processors, essentially providing communication among the processors through reads and writes of the shared data.

5. What happens when a private and shared item is cached?
When a private item is cached, its location is migrated to the cache, reducing the average access time as well as the memory bandwidth required. Since no other processor uses the data, the program behavior is identical to that in a uni processor.

6. What is cache coherence?
When shared data are cached, the shared value may be replicated in multiple caches. In addition to the reduction in access latency and required memory bandwidth, this replication also provides a reduction in contention that may exist for shared data items that are being read by multiple processors simultaneously. Caching of shared data, however, introduces a new problem. This problem is called as cache coherence.

7. What Is Multiprocessor Cache Coherence?
Unfortunately, caching shared data introduces a new problem because the view of memory held by two different processors is through their individual caches, which, without any additional precautions, could end up seeing two different values. Two different processors can have two different values for the same location. This difficulty is generally referred to as the cache coherence problem.

8. What is meant by coherence?
Informally, we could say that a memory system is coherent if any read of a data item returns the

most recently written value of that data item. This aspect, is called coherence, which defines what values can be returned by a read.

9. What is meant by consistency?

The aspect, called consistency, determines when a written value will be returned by a read.

10. What are the schemes provided by coherent multiprocessor?

In a coherent multiprocessor, the caches provide both migration and replication of shared data items.

11. The overall cache performance is based on what attributes?

The overall cache performance is a combination of the behavior of uniprocessor cache miss traffic and the traffic caused by communication, which results in invalidations and subsequent cache misses.

12. What are types of coherence misses?

Similarly, the misses that arise from interprocessor communication, which are often called coherence misses, can be broken into two separate sources. The first source is called as true sharing misses and the second source is called as false sharing misses.

13. What is true sharing miss?

The first source is the so-called true sharing misses that arise from the communication of data through the cache coherence mechanism. In an invalidation based protocol, the first write by a processor to a shared cache block causes an invalidation to establish ownership.

16 Marks

1. Symmetric an distributed shared memory architectures (8 marks)
2. Model of memory consistency & interconnection
3. cachecoherence, performance synchronization issues(any one 8marks)

UNIT 5
Memory and I/O
2 Marks

1. What Is Meant By Cache Memory?

A Memory That Is Smaller And Faster Than Main Memory And That Is Interposed Between The CPU and Main Memory. The Cache Acts As A Buffer For Recently Used Memory Location.

2. What are the various memory technologies?

The various memory technologies are:

1. SRAM semiconductor memory
2. DRAM semiconductor memory
3. Flash semiconductor memory
4. Magnetic disk

3. Differentiate SRAM from DRAM.

SRAMs are simply integrated circuits that are memory arrays with a single access port that can provide either a read or a write. SRAMs have a fixed access time to any datum.
SRAMs don't need to refresh and so the access time is very close to the cycle time. SRAMs typically use six to eight transistors per bit to prevent the information from being disturbed when read. SRAM needs only minimal power to retain the charge in standby mode.

In a dynamic RAM (DRAM), the value kept in a cell is stored as a charge in a capacitor. A single transistor is then used to access this stored charge, either to read the value or to overwrite the charge stored there. Because DRAMs use only a single transistor per bit of storage, they are much denser and cheaper per bit than SRAM.

4. Define − Rotational Latency.

Rotational latency, also called rotational delay, is the time required for the desired sector of a disk to rotate under the read/write head, usually assumed to be half the rotation time.

5. What is direct-mapped cache?

Direct-mapped cache is a cache structure in which each memory location is mapped to exactly one location in the cache. For example, almost all direct-mapped caches use this mapping to find a block, (Block address) modulo (Number of blocks in the cache)

6. Define memory access time?

The time that elapses between the initiation of an operation and completion of that operation ,for example ,the time between the READ and the MFC signals .This is Referred to as memory access time.

7. Define memory cycle time.

The minimum time delay required between the initiations of two successive memory operations, for example, the time between two successive READ operations.

8. Define Static Memories.

Memories that consist of circuits capable of retaining the state as long as power is applied are known as static memories.

9. Distinguish Between Static RAM and Dynamic RAM?

Static RAM are fast, but they come at high cost because their cells require several transistors. Less expensive RAM can be implemented if simpler cells are used. However such cells do not retain their state indefinitely; Hence they are called Dynamic RAM.

10. Distiguish between asynchronies DRAM and synchronous RAM.

The specialized memory controller circuit provides the necessary control signals, RAS And CAS ,that govern the timing. The processor must take into account the delay in the response of the memory. Such memories are referred to as asynchronous DRAMS. The DRAM whose operations is directly synchronized with a clock signal. Such Memories are known as synchronous DRAM

11. What is a bus?

A collection of wires that connects several devices is called a bus.

12. what is an I/O channel?

An i/o channel is actually a special purpose processor, also called peripheral processor. The main processor initiates a transfer by passing the required information in the input output channel. the channel then takes over and controls the actual transfer of data.

13. Why program controlled I/O is unsuitable for high-speed data transfer?

1. in program controlled i/o considerable overhead is incurred.. because several program instruction have to be executed for each data word transferred between the external devices and MM. 2. many high speed peripheral; devices have a synchronous modes of operation. that is data transfer are controlled by a clock of fixed frequency, independent of the cpu.

14. What is the function of i/o interface?

The function is to coordinate the transfer of data between the cpu and external devices.

15. What are the basic cache optimizations?.

Reduces miss rate
Larger block size
Bigger cache
Higher associativity
Reduces conflict rate
Reduce miss penalty
Multi-level caches
Give priority to read misses over write misses reduce hit time
Avoid address translation (from virtual to physical addr.) during indexing of the cache

16. What are the advanced cache optimizations?

•Reducing hit time
•Increasing cache bandwidth
•Reducing Miss Penalty
•Reducing Miss Rate
•Reducing miss penalty or miss rate via parallelism

17. What is hit under miss?

"hit under miss" reduces the effective miss penalty by continuing during a miss.by overlapping multiple misses.

18. How to calculate Average memory access time2-way ?

Average memory access time2 -way = Hit time + Miss rate × Miss penalty

19. What is false sharing miss?

- False sharing, arises from the use of invalidation based coherence algorithm with a single valid bit per cache block. False sharing occurs when a block is invalidated (and a subsequent reference causes a miss) because some word in the block, other than the one being read, is written into.
- If, however, the word being written and the word read are different and the invalidation does not cause a new value to be communicated, but only causes an extra cache misses, then it is a false sharing miss.
- In a false sharing miss, the block is shared, but no word in the cache is actually shared, and the miss would not occur if the block size were a single word.

20.What is non-blocking cache?

- Non-blocking cache or lockup-free cache
- allow data cache to continue to supply cache hits during a miss

21.Define hit rate.

A successful access to data in a cache is called a hit. Number of hits stated as a fraction of all attempted accesses is called the hit rate.

22.Define miss rate.

A miss rate is the number of misses stated as a fraction of attempted accesses. Extra time needed to bring the desired information into the cache is called the miss penalty.

16 Marks

1. Cache memory
2. memory Technologies
3. types of memory
4. RAID

V.S.B ENGINEERING COLLEGE, KARUR.
DEPARTMENT OF ECE
DIGITAL IMAGE PROCESSING
VII SEMESTER
TWO MARK QUESTION AND ANSWERS

UNIT I - Digital Image Fundamentals

1. Define Image?
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 Dynamic Range?
The range of values spanned by the gray scale is called dynamic range of an image. Image will have high contrast, if the dynamic range is high and image will have dull washed out gray look if the dynamic range is low.

3. Define Brightness?
Brightness of an object is the perceived luminance of the surround. Two objects with different surroundings would have identical luminance but different brightness.

4. Define Tapered Quantization?
If gray levels in a certain range occur frequently while others occurs rarely, the quantization levels are finely spaced in this range and coarsely spaced outside of it. This method is sometimes called Tapered Quantization.

5. What do you meant by Gray level?
Gray level refers to a scalar measure of intensity that ranges from black to grays and finally to white.

6. What do you meant by Color model?
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.

7.List the hardware oriented color models?
1.RGB model
2.CMY model
3.YIQ model
4.HSI model

8.What is Hue of saturation?
Hue is a color attribute that describes a pure color where saturation gives a measure of the degree to which a pure color is diluted by white light.

9. List the applications of color models?
1.RGB model--- used for color monitor & color video camera
2.CMY model---used for color printing
3.HIS model----used for color image processing
4.YIQ model---used for color picture transmission

10. What is Chromatic Adoption?

The hue of a perceived color depends on the adoption of the viewer. For example, the American Flag will not immediately appear red, white, and blue of the viewer has been subjected to high intensity red light before viewing the flag. The color of the flag will appear to shift in hue toward the red component cyan.

11. Define Resolutions?

Resolution is defined as the smallest number of discernible detail in an image. Spatial resolution is the smallest discernible detail in an image and gray level resolution refers to the smallest discernible change is gray level.

12. What is meant by pixel?

A digital image is composed of a finite number of elements each of which has a particular location or value. These elements are referred to as pixels or image elements or picture elements or pels elements.

13. Define Digital image?

When x, y and the amplitude values of f all are finite discrete quantities , we call the image digital image.

14.What are the steps involved in DIP?

1.Image Acquisition
2.Preprocessing
3.Segmentation
4.Representation and Description
5.Recognition and Interpretation

15.What is recognition and Interpretation?

Recognition means is a process that assigns a label to an object based on the information provided by its descriptors.
Interpretation means assigning meaning to a recognized object.

16.Specify the elements of DIP system?

1.Image Acquisition
2.Storage
3.Processing
4.Display

17.Explain the categories of digital storage?

1.Short term storage for use during processing.
2.Online storage for relatively fast recall.
3.Archical storage for infrequent access.

18.What are the types of light receptors?

The two types of light receptors are
1.Cones and
2.Rods

19.Differentiate photopic and scotopic vision?

Photopic vision Scotopic vision
1.The human being can resolve the fine details with these cones because each one is connected to its own nerve end.

2.This is also known as bright light vision. Several rods are connected to one nerve end. So it gives the overall picture of the image. This is also known as thin light vision.

20.How cones and rods are distributed in retina?
In each eye, cones are in the range 6-7 million and rods are in the range75-150 million.

21. Define subjective brightness and brightness adaptation?
Subjective brightness means intensity as preserved by the human visual system. Brightness adaptation means the human visual system can operate only from scotopic to glare limit. It cannot operate over the range simultaneously. It accomplishes this large variation by changes in its overall intensity.

22. Define weber ratio
The ratio of increment of illumination to background of illumination is called as weber ratio. (ie)_i/i
If the ratio (_i/i) is small, then small percentage of change in intensity is needed (ie) good brightness adaptation.
If the ratio (_i/i) is large , then large percentage of change in intensity is needed (ie) poor brightness adaptation.

23. What is meant by machband effect?
Machband effect means the intensity of the stripes is constant. Therefore it preserves the brightness pattern near the boundaries, these bands are called as machband effect.

24. What is simultaneous contrast?
The region reserved brightness not depend on its intensity but also on its background. All centre square have same intensity. However they appear to the eye to become darker as the background becomes lighter.

25. What is meant by illumination and reflectance?
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).

26. Define sampling and quantization
Sampling means digitizing the co-ordinate value (x, y).
Quantization means digitizing the amplitude value.

27.Find the number of bits required to store a 256 X 256 image with 32 gray levels?
32gray levels = 25 = 5 bits
256* 256 * 5 = 327680 bits.

28.Write the expression to find the number of bits to store a digital image?
The number of bits required to store a digital image is b=M X N X k
When M=N, this equation becomes b=N^2k

30. What do you meant by Zooming of digital images?
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.

31. What do you meant by shrinking of digital images?

Shrinking may be viewed as under sampling. To shrink an image by one half, we delete every row and column. To reduce possible aliasing effect, it is a good idea to blue an image slightly before shrinking it.

32. Write short notes on neighbors of a pixel.

The pixel p at co-ordinates (x, y) has 4 neighbors (ie) 2 horizontal and 2 vertical neighbors whose co-ordinates is given by (x+1, y), (x-1,y), (x,y-1), (x, y+1). This is called as direct neighbors. It is denoted by N4(P)

Four diagonal neighbors of p have co-ordinates (x+1, y+1), (x+1,y-1), (x-1,y-1), (x-1, y+1). It is denoted by ND(4).

Eight neighbors of p denoted by N8(P) is a combination of 4 direct neighbors and 4 diagonal neighbors.

33.Explain the types of connectivity.

1.4 connectivity
2.8 connectivity
3.M connectivity (mixed connectivity)

34.What is meant by path?

Path from pixel p with co-ordinates (x, y) to pixel q with co-ordinates (s,t) is a sequence of distinct pixels with co-ordinates.

35. Give the formula for calculating D4 and D8 distance.

D4 distance (city block distance) is defined by

$D4(p, q) = |x-s| + |y-t|$

D8 distance(chess board distance) is defined by

$D8(p, q) = \max(|x-s|, |y-t|)$.

UNIT II - Image Enhancement

1. Specify the objective of image enhancement technique.

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.

i)Spatial domain refers to image plane itself & approaches in this category are based on direct manipulation of picture image.

ii)Frequency domain methods based on modifying the image by fourier transform.

3. What is contrast stretching?

Contrast stretching reduces an image of higher contrast than the original by darkening the levels below m and brightening the levels above m in the image.

4. What is grey level slicing?

Highlighting a specific range of grey levels in an image often is desired. Applications include enhancing features such as masses of water in satellite imagery and enhancing flaws in x-ray images.

5. Define image subtraction.

The difference between 2 images f(x,y) and h(x,y) expressed as,g(x,y)=f(x,y)-h(x,y) is obtained by computing the difference between all pairs of corresponding pixels from f and h.

6. What is the purpose of image averaging?
An important application of image averagingis 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.

7. What is meant by masking?
Mask is the small 2-D array in which the values of mask co-efficient determine the nature of process.
The enhancement technique based on this type of approach is referred to as mask processing.

8. Give the formula for negative and log transformation.
Negative: S=L-1-rLog: S = c log(1+r)
Where c-constant and r 0

9. What is meant by bit plane slicing?
Instead of highlighting gray level ranges, 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.

10. Define histogram.
The histogram of a digital image with gray levels in the range [0, L-1] is a discrete function h(rk)=nk. rk-kth gray level nk-number of pixels in the image having gray level rk.

11.What is meant by histogram equalization?
Sk= T(rk) = _ Pr(rj) = _ nj/n wherek=0,1,2,….L-1 j=0 j=0
This transformation is called histogram equalization.

12. Explain spatial filtering?
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.

13. What is a Median filter?
The median filter replaces the value of a pixel by the median of the gray levels in the neighborhood of that pixel.

14. What is maximum filter and minimum filter?
The 100th percentile is maximum filter is used in finding brightest points in an image. The 0th percentile filter is minimum filter used for finding darkest points in an image.

15. Write the application of sharpening filters?
1.Electronic printing and medical imaging to industrial application
2.Autonomous target detection in smart weapons.

16. Name the different types of derivative filters?
1.Perwitt operators
2.Roberts cross gradient operators
3.Sobel operators

17. What is smoothing spatial filter?
It is used for blurring and for noise reduction. Blurring is removal of small details from an image.

18. What is sharpening spatial filter?
To highlight fine detail in an image. Used in electronic printing and medical imaging and in military 8/ms.

19. Define gradient operators.
The gradient of an image f(x,y) at the location (x,y) is given by
Del(f)= [G(f)/G(x)
G(f)/G(y)]

20. Define Laplacian.
The laplacian of the two dimensional image f(x,y) is defined as
Del^2(f)= [G^2(f)/G(x^2)+ G^2(f)/G(y^2)

UNIT III - Image Restoration and Segmentation

1. What is meant by Image Restoration?
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 two properties in Linear Operator?
Additivity _ Homogenity

3.Explain additivity property in Linear Operator?
H[f1(x,y)+f2(x,y)]=H[f1(x,y)]+H[f2(x,y)]
The additive property says that if H is the linear operator,the response to a sum of two is equal to the sum of the two responses.

4. What is meant by Noise probability density function?
The spatial noise descriptor is the statistical behavior of gray level values in the noise component of the model.

5. Why the restoration is called as unconstrained restoration?
In the absence of any knowledge about the noise 'n', a meaningful criterion function is to seek an f^ such that H f^ approximates of in a least square sense by assuming the noise term is as small as possible.
Where H = system operator. f^ = estimated input image. g = degraded image.

6.Which is the most frequent method to overcome the difficulty to formulate the spatial relocation of pixels?
The point is the most frequent method, which are subsets of pixels whose location in the input (distorted) and output (corrected) imaged is known precisely.

7. What are the types of noise models?
Guassian noise
Rayleigh noise
Erlang noise
Exponential noise
Uniform noise

Impulse noise

8.Give the relation for guassian noise?
Guassian noise:
The PDF guassian random variable Z is given by P(Z)=e-(Z-μ)2/2_2/_2__
Z->Gray level value_->standard deviation_2->varianze of Z
μ->mean of the graylevel value Z

9.Give the relation for rayleigh noise?
Rayleigh noise: The PDF is
P(Z)= 2(z-a)e-(z—a)2/b/b for Z>=a
0for Z<a
mean μ=a+__b/4
standard deviation _2=b(4-_)/4

10.Give the relation for Gamma noise?
Gamma noise: The PDF is
P(Z)=ab zb-1 ae-az/(b-1) for Z>=0
0for Z<0 mean μ=b/a
standard deviation _2=b/a2

11.Give the relation for Exponential noise?
Exponential noise The PDF is
P(Z)= ae-az Z>=0
0Z<0 mean μ=1/a
standard deviation _2=1/a2

12.Give the relation for Uniform noise?
Uniform noise: The PDF is
P(Z)=1/(b-a) if a<=Z<=b
0otherwise mean μ=a+b/2
standard deviation _2=(b-a)2/12

13.Give the relation for Impulse noise?
Impulse noise: The PDF is
P(Z) =Pa for z=a Pb for z=b
0 Otherwise

14. What is inverse filtering?
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.
F^ (u,v) = G^(u,v)/H(u,v)

15. What is pseudo inverse filter?
It is the stabilized version of the inverse filter.For a linear shift invariant system with frequency response H(u,v) the pseudo inverse filter is defined asH-(u,v)=1/(H(u,v) H=/0
0 H=0

16. What is meant by least mean square filter?
The limitation of inverse and pseudo inverse filter is very sensitive noise.The
wiener filtering is a method of restoring images in the presence of blurr as well as noise.

17. What is blur impulse response and noise levels?

Blur impulse response: This parameter is measured by isolating an image of a suspected object within a picture.

Noise levels: The noise of an observed image can be estimated by measuring the image covariance over a region of constant background luminence.

18. Give the difference between Enhancement and Restoration?

Enhancement technique is based primarily on the pleasing aspects it might present to the viewer. For example: Contrast Stretching.

Whereas Removal of image blur by applying a deblurrings function is considered a restoration technique.

19. What is segmentation?

Segmentation subdivides on image in to its constitute regions or objects. The level to which the subdivides is carried depends on the problem being solved .That is segmentation should when the objects of interest in application have been isolated.

20. Write the applications of segmentation.

* Detection of isolated points.
* Detection of lines and edges in an image.

21.What are the three types of discontinuity in digital image?

Points, lines and edges.

22.How the derivatives are obtained in edge detection during formulation?

The first derivative at any point in an image is obtained by using the magnitude of the gradient at that point. Similarly the second derivatives are obtained by using the laplacian.

23.Write about linking edge points.

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.

24.What are the two properties used for establishing similarity of edge pixels?

(1) The strength of the response of the gradient operator used to produce the edge pixel.
(2) The direction of the gradient.

25.What is edge?

An edge isa set of connected pixels that lie on the boundary between two regions edges are more closely modeled as having a ramplike profile. The slope of the ramp is inversely proportional to the degree of blurring in the edge.

26. Give the properties of the second derivative around an edge?

*The sign of the second 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 straightline joining the extreme positive and negative values of the second derivative would cross zero near the midpoint of the edge.

27. Define Gradient Operator?
First order derivatives of a digital image are based on various approximation of the 2-D gradient. The gradient of an image f(x,y) at location(x,y) is defined as the vector
Magnitude of the vector is _f=mag(_f)=[Gx2+ Gy2]1/2_(x,y)=tan-1(Gy/Gx)
_(x,y) is the direction angle of vector _f

28. What is meant by object point and background point?
To execute the objects from the background is to 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.

29. What is global, Local and dynamic or adaptive threshold?
When Threshold T depends only on f(x,y) then the threshold is called global . If T depends both on f(x,y) and p(x,y) is called local. If T depends on the spatial coordinates x and y the threshold is called dynamic or adaptive where f(x,y) is the original image.

30. Define region growing?
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 these neighbouring pixels that have properties similar to the seed.

31. Specify the steps involved in splitting and merging?
Split into 4 disjoint quadrants any region Ri for which P(Ri)=FALSE. Merge any adjacent regions Rj and Rk for which P(RjURk)=TRUE. Stop when no further merging or splitting is positive.

32. What is meant by markers?
An approach used to control over segmentation is based on markers.
marker is a connected component belonging to an image. We have internal markers, associated with objects of interest and external markers associated with background.

33. What are the 2 principles steps involved in marker selection?
The two steps are
1.Preprocessing
2.Definition of a set of criteria that markers must satisfy.

UNIT IV – Wavelets and Image Compression

1. What is image compression?
Image compression refers to the process of redundancy amount of data required to represent the given quantity of information for digital image. The basis of reduction process is removal of redundant data.

2. What is Data Compression?
Data compression requires the identification and extraction of source redundancy. In other words, data compression seeks to reduce the number of bits used to store or transmit information.

3. What are two main types of Data compression?

Lossless compression can recover the exact original data after compression. It is used mainly for compressing database records, spreadsheets or word processing files, where exact replication of the original is essential.

Lossy compression will result in a certain loss of accuracy in exchange for a substantial increase in compression. Lossy compression is more effective when used to compress graphic images and digitised voice where losses outside visual or aural perception can be tolerated.

4. What is the need for Compression?

In terms of storage, the capacity of a storage device can be effectively increased with methods that compress a body of data on its way to a storage device and decompresses it when it is retrieved.

In terms of communications, the bandwidth of a digital communication link can be effectively increased by compressing data at the sending end and decompressing data at the receiving end.

At any given time, the ability of the Internet to transfer data is fixed. Thus, if data can effectively be compressed wherever possible, significant improvements of data throughput can be achieved. Many files can be combined into one compressed document making sending easier.

5. What are different Compression Methods?

Run Length Encoding (RLE) Arithmetic coding
Huffman coding and Transform coding

6. Define is coding redundancy?

If the gray level of an image is coded in a way that uses more code words than necessary to represent each gray level, then the resulting image is said to contain coding redundancy.

7. Define interpixel redundancy?

The value of any given pixel can be predicted from the values of its neighbors.

The information carried by is small. Therefore the visual contribution of a single pixel to an image is redundant. Otherwise called as spatial redundant geometric redundant or

8. Define compression ratio.

Compression Ratio = original size / compressed size: 1

9. Define psycho visual redundancy?

In normal visual processing certain information has less importance than other information. So this information is said to be psycho visual redundant.

10. Define encoder

Source encoder is responsible for removing the coding and interpixel redundancy and psycho visual redundancy.

There are two components
A)Source Encoder
B)Channel Encoder

11. Define source encoder

Source encoder performs three operations

1)Mapper -this transforms the input data into non-visual format. It reduces the interpixel redundancy.

2)Quantizer - It reduces the psycho visual redundancy of the input images .This step is omitted if the system is error free.
3)Symbol encoder- This reduces the coding redundancy .This is the final stage of encoding process.

12. Define channel encoder
The channel encoder reduces reduces the impact of the channel noise by inserting redundant bits into the source encoded data. Eg: Hamming code

13.What are the types of decoder?
Source decoder- has two components
a) Symbol decoder- This performs inverse operation of symbol encoder. b) Inverse mapping- This performs inverse operation of mapper. Channel decoder-this is omitted if the system is error free.

14.What are the operations performed by error free compression?
1) Devising an alternative representation of the image in which its interpixel redundant are reduced.
2) Coding the representation to eliminate coding redundancy

15. What is bit plane Decomposition?
An effective technique for reducing an image's interpixel redundancies is to
process the image's bit plane individually. This technique is based on the concept of decomposing multilevel images into a series of binary images and compressing each binary image via one of several well-known binary compression methods.

16. What are three categories of constant area coding?
The three categories of constant area coding areAll white
All blackMixed intensity.
The most probable or frequency occurring is assign a 1 bit code '0', other two categories area assigned as 2 bit code '10' and '11'

17. How effectiveness of quantization can be improved?
Introducing an enlarged quantization interval around zero, called a dead zero.
Adapting the size of the quantization intervals from scale to scale. In either case, the selected quantization intervals must be transmitted to the decoder with the encoded image bit stream.

18. What are the coding systems in JPEG?
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.

19. What is JPEG?
The acronym is expanded as "Joint Photographic Expert Group". It is an international standard in 1992. It perfectly Works with color and grayscale images, Many applications e.g., satellite, medical.

20. What are the basic steps in JPEG?

The Major Steps in JPEG Coding involve: _ DCT (Discrete Cosine Transformation) _Quantization_ Zigzag Scan_ DPCM on DC component _ RLE on AC Components _ Entropy Coding

21. What is MPEG?
The acronym is expanded as "Moving Picture Expert Group". It is an international standard in 1992. It perfectly Works with video and also used in teleconferencing Input image Wavelet transform Quantizer Symbol
encoder Symbol decoder Inverse wavelet transform Compressed image

22.What is zig zag sequence?
The purpose of the Zig-zag Scan:
_ To group low frequency coefficients in top of vector. _ Maps 8 x 8 to a 1 x 64 vector

23.Define I-frame
I-frame is Intraframe or Independent frame. An I-frame is compressed independently of all frames. It resembles a JPEG encoded image. It is the reference point for the motion estimation needed to generate subsequent P and P-frame.

24. Define P-frame
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

25. Define B-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-frameor next P-frame. Accordingly the decoder must have access to both past and future reference frames.

UNIT V – Image Representation and Recognition

1. Define chain codes?
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?
*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?
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
Chain codes
Polygonal approximationBoundary segments

5.What is polygonal approximation method ?
Polygonal approximation is a image representation approach in which a digital boundary can be approximated with arbitary 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
Minimum perimeter polygonsMerging techniquesSplitting techniques

7.Name few boundary descriptors
Simple descriptorsShape numbersFourier descriptors

8.Give the formula for diameter of boundary
The diameter of a boundary B is defined as Diam(B)=max[D(pi,pj)]i,j
D-distance measurepi,pj-points on the boundary

9.Define length of a boundary.
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
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
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. Describe Fourier descriptors
Fourier descriptor of a boundary can be defined asK-1
a(u)=1/K_s(k)e-j2_uk/Kk=0
for u=0,1,2……K-1.The complex coefficients a(u) are called Fourier descriptor of a boundary.
The inverse Fourier descriptor is K-1
s(k)= _ a(u)ej2_uk/K u=0
for k=0,1,2,……K-1

13. Give the Fourier descriptors for the following transformations
(1)Identity (2)Rotation (3)Translation (4)Scaling (5)Starting point (1)Identity – a(u)
(2)Rotation -ar(u)= a(u)ej_
(3) Translation-at(u)=a(u)+_xy_(u)(4)Scaling-as(u)=_a(u)
(5)Startingpoint-ap(u)=a(u)e-j2_uk 0/K

14.Specify the types of regional descriptors
Simple descriptorsTexture

15.Name few measures used as simple descriptors in region descriptors
AreaPerimeterCompactness
Mean and median of gray levelsMinimum and maximum of gray levels
Number of pixels with values above and below mean

16.Define compactness

Compactness of a region is defined as (perimeter)^2/area.It is a dimensionless quantity and is insensitive to uniform scale changes.

17. Describe texture

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:
StatisticalStructuralSpectral

18. Describe statistical approach

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.

19. Define gray-level co-occurrence matrix.

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.

20. Explain structural and spectral approach

Structural approach deals with the arrangement of image primitives such as description of texture based on regularly spaced parallel lines.
Spectral approach is 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.There are 3 features of Fourier spectrum that 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 leaves non- periodic image elements.

16 MARKS

UNIT I - Digital Image Fundamentals

1. Explain the steps involved in digital image processing. (or)
Explain various functional block of digital image processing
2. Describe the elements of visual perception.
3. Describe image formation in the eye with brightness adaptation and discrimination
4. Write short notes on sampling and quantization.
5. Describe the functions of elements of digital image processing system with a diagram.
6. Explain the basic relationships between pixels?
7. Describe the various color models in digital image processing?

UNIT II - Image Enhancement

1. Explain the types of gray level transformation used for image enhancement.
2. What is histogram? Explain histogram equalization.
3. Discuss the image smoothing filter with its model in the spatial domain.
4. What are image sharpening filters? Explain the various types of it.
5. Explain spatial filtering in image enhancement.
6. Explain image enhancement in the frequency domain.
7. Explain the procedure involved in enhancing the image using histogram specification.
8. Explain the various spatial domain filter approaches for image enhancement.
9. Explain the various frequency domain filter approaches for image enhancement.

UNIT III - Image Restoration and Segmentation

1. Explain the algebra approach in image restoration.
2. What is the use of wiener filter in image restoration? Explain.
3. What is meant by inverse filtering? Explain.
4. Explain singular value decomposition and specify its properties.
5. Explain image degradation model /restoration process in detail.
6. What are the two approaches for blind image restoration? Explain in detail.
7. What is image segmentation? Explain in detail.

8. Explain Edge Detection in details?
9. Define Thresholding and explain the various methods of thresholding in detail?
10. Discuss about region based image segmentation techniques. Compare threshold region based techniques.

UNIT IV – Wavelets and Image Compression

1. What is data redundancy? Explain three basic data redundancy?
2. What is image compression? Explain any four variable length coding compression schemes.
3. Explain about Image compression model?
4. Explain about Error free Compression?
5. Explain about Lossy compression?
6. Explain the schematics of image compression standard JPEG.
7. Explain how compression is achieved in transform coding and explain about DCT
8. Explain about Image compression standards?
9. Discuss about MPEG standard and compare with JPEG
10. Define wavelets and its types in detail.

UNIT V – Image Representation and Recognition

1. Define and explain the various representation approaches?
2. Explain Boundary descriptors.
3. Explain regional descriptors
4. Explain the two techniques of region representation.
5. Explain the segmentation techniques that are based on finding the regions directly.
6. How is line detected? Explain through the operators.
7. Explain about texture.
8. Write short notes on boundary representation using chain codes.
9. Explain polygonal approximation.