Sinhgad College of Engineering

Department of Electronics and Telecommunication

Class: BE E &TC

FOC Oral Questions:

1. **Which are the four key elements/components of FOC (Fiber Optic Communication)?**

The four key components of Fiber Optic Communication (FOC) are:

Transmitter: Converts electrical signals into optical signals for transmission.

Fiber Optic Cable: The medium that carries the optical signals over long distances.

Receiver: Converts the received optical signals back into electrical signals.

Optical Amplifiers (optional): Boosts the strength of the optical signals during transmission.

These components enable high-speed and reliable data transmission through fiber optic cables.

2. **What is unit of Attenuation?**

The unit of attenuation, which measures the reduction in signal strength as it travels through a medium, is the decibel (dB). Attenuation is used to quantify the loss or decrease in signal power over a given distance or through a specific medium, such as a fiber optic cable or a transmission line. In fiber optic communication, attenuation is typically expressed in terms of decibels per kilometer (dB/km) to indicate the amount of signal loss that occurs over each kilometer of fiber length.

3. **What is range of visible wavelength and invisible wavelength**

The range of visible wavelengths refers to the portion of the electromagnetic spectrum that is visible to the human eye. It spans approximately from 400 to 700 nanometers (nm). This range includes colors from violet (shorter wavelength) to red (longer wavelength).
On the other hand, the term "invisible wavelengths" typically refers to wavelengths outside the visible range. It encompasses regions such as ultraviolet (UV), infrared (IR), X-rays, gamma rays, and radio waves. These wavelengths are not detectable by the human eye without the use of specialized equipment or sensors. The specific ranges for these invisible wavelengths vary, but they generally extend beyond the visible range in both shorter and longer wavelengths.

4. **Which are the ITU designated 6 spectral bands**

Radio-frequency (RF) Band: This band includes frequencies ranging from a few kilohertz (kHz) to hundreds of gigahertz (GHz). It is commonly used for various wireless communication applications, including radio broadcasting, television, mobile phones, Wi-Fi, and Bluetooth.
Very High Frequency (VHF) Band: The VHF band covers the frequency range of 30 megahertz (MHz) to 300 MHz. It is often used for FM radio broadcasting, amateur radio, and maritime communication.
Ultra High Frequency (UHF) Band: The UHF band spans the frequency range of 300 MHz to 3 gigahertz (GHz). It is widely utilized for television broadcasting, wireless microphones, wireless data communication, and satellite communication.
L band: The L band covers the frequency range from 1 to 2 gigahertz (GHz). It is commonly used for satellite communication, global positioning systems (GPS), and mobile satellite services.
S band: The S band encompasses frequencies from 2 to 4 gigahertz (GHz). It is utilized for various applications, including weather radar, satellite communication, and space research.
C band: The C band covers frequencies ranging from 4 to 8 gigahertz (GHz). It is commonly used for satellite communication, weather monitoring, and radar systems.

These spectral bands designated by the ITU are essential for allocating and regulating radio frequency usage globally to ensure efficient and coordinated communication systems.

5. What is Shannon Channel Capacity theorem

The Shannon Channel Capacity theorem is a fundamental concept in information theory that determines the maximum data rate that can be transmitted over a communication channel with low error probability. It states that the channel capacity is determined by the channel's bandwidth and the signal-to-noise ratio (SNR).

6. Draw and explain block diagram of OFC (Optical Fiber Communication) system

Transmitter: Converts electrical signals into optical signals using a light source, such as a laser diode or an LED, and modulation circuitry to encode the information onto the optical signal.

Optical Fiber: The fiber optic cable serves as the transmission medium, carrying the optical signals over long distances with minimal loss or distortion.

Receiver: Detects and converts the received optical signals back into electrical signals using a photodetector, typically a photodiode.

Signal Processing: Processes and decodes the electrical signals received from the photodetector, which may involve amplification, filtering, and demodulation to extract the original information.

Data Destination: Represents the final destination of the transmitted information, such as a computer, display device, or storage device, where the received data is utilized.

7. What are advantages of OFC

High bandwidth: OFC provides large data transmission capacity, enabling high-speed communication.

Long-distance transmission: Optical fibers can transmit signals over long distances without significant loss or degradation.

Low attenuation: OFC experiences minimal signal loss, allowing for long-distance communication without the need for frequent signal amplification.

Immunity to interference: Fiber optic cables are not affected by electromagnetic interference, ensuring reliable and secure communication.

Compact and lightweight: Fiber optic cables are small in size and lightweight, making them easy to install and manage.

Enhanced security: OFC offers a higher level of security as it is difficult to tap or intercept without detection.

No crosstalk: Optical fibers do not suffer from crosstalk, enabling multiple fibers to be bundled closely together without interference.

8. Compare Step Index (SI) and Graded Index (GI) fibers

Step Index (SI) Fiber:

Uniform refractive index profile throughout the core.

Light travels along a straight path, causing modal dispersion.

Limited bandwidth and not suitable for high-speed communication.

Relatively easier to manufacture.
Used in applications with lower bandwidth requirements and short-range communication.
Graded Index (GI) Fiber:
Refractive index gradually decreases from the center of the core towards the outer edges.
Light takes a curved or helical path, reducing modal dispersion.
Higher bandwidth and suitable for high-speed communication.
More complex to manufacture.
Used in high-speed communication systems, long-distance transmission, and high-capacity data transmission.

9. Compare Single mode and Multimode fibers

In summary, single mode fibers offer longer transmission distances, higher bandwidth, and lower signal loss, making them ideal for long-distance and high-speed communication. On the other hand, multimode fibers are suitable for shorter distances and have a lower bandwidth but can be more cost-effective for short-range applications.

10. What is scattering loss and dispersion in optical fiber.

In short, scattering loss refers to the loss of optical power due to light scattering within the fiber, while dispersion refers to the spreading or broadening of optical signals during transmission. Both scattering loss and dispersion can impact the performance and limitations of optical fiber communication systems.

11. What are the central peak wavelength of 3 transmission windows?

In summary, the central peak wavelengths for the three transmission windows are approximately 1310 nm, 1550 nm, and 1625 nm. These windows are strategically chosen to take advantage of low attenuation and optimal transmission characteristics in optical fiber communication systems.

12. Which fibers are used for short and long-distance communication purpose respectively?

In short, single mode fibers (SMFs) are commonly used for long-distance communication purposes, while multimode fibers (MMFs) are often used for short-distance communication.

13. What are optical sources? State the types and material used for manufacturing?

Light Emitting Diodes (LEDs):
LEDs are a common type of optical source used in optical communication.
They are typically made from semiconductor materials such as gallium arsenide (GaAs) or indium gallium arsenide (InGaAs).
LEDs emit incoherent light and are commonly used for short-distance communication and low-cost applications.
Laser Diodes (LDs):
Laser diodes are another important type of optical source used in optical communication.
They are fabricated using semiconductor materials like gallium arsenide (GaAs) or indium phosphide (InP).
Laser diodes emit coherent and narrow-bandwidth light, allowing for high-speed and long-distance communication.
Vertical Cavity Surface Emitting Lasers (VCSELs):
VCSELs are a specialized type of laser diode with a vertical cavity design.
They are often fabricated using semiconductor materials such as gallium arsenide (GaAs) or indium phosphide (InP).
VCSELs offer advantages such as low power consumption, low cost, and compatibility with high-

volume manufacturing processes.

Rare-Earth Doped Fiber Amplifiers (EDFAs):

EDFAs are not direct optical sources but are used as optical amplifiers in optical communication systems.

They contain rare-earth dopants like erbium (Er) or ytterbium (Yb) in the fiber core.

EDFAs provide amplification to optical signals without the need for conversion to electrical signals.

14. **LED and LASER are supported by which type of fibers respectively?**

In short, Light Emitting Diodes (LEDs) are commonly supported by multimode fibers (MMFs), while Lasers (specifically laser diodes) are supported by both single mode fibers (SMFs) and multimode fibers (MMFs).

15. **By which principle light travels/propagates inside optical fiber?**

    In short, light travels inside optical fibers through the principle of total internal reflection, which ensures that the light is reflected and confined within the core of the fiber as it propagates along its length.

16. **What is total internal reflection and what is condition for the same. What are theapplications of total internal reflection**

In short, total internal reflection occurs when a light ray strikes a boundary between two mediums at an angle greater than the critical angle, leading to the complete reflection of the light ray. It has applications in optical fiber communication, prisms, fiber optic sensors, microscopy, and optical reflectors.

17. **What is refraction of light?**

    In short, refraction of light is the bending of light as it travels from one medium to another, resulting in a change in its direction.

18. **What is acceptance angle?**

The acceptance angle, in short, is the maximum angle at which light can enter an optical system or fiber for efficient transmission.

19. **What is NA (Numerical Aperture)? What is minimum and maximum value of NA. What is unitof NA**

    In short, Numerical Aperture (NA) is a measure of the light-capturing ability of an optical fiber or system. It has a minimum value of 0, a maximum value around 1.0, and is expressed in a dimensionless unit.

20. **What are the expressions for finding NA? NA depends on which factors?**

In short, the expression for finding the Numerical Aperture (NA) involves calculating the square root of the difference between the square of the refractive indices of the core and cladding. The NA depends on the refractive indices of the core and cladding materials as well as the difference between these refractive indices.

21. **What is the conversion formula to convert power in watt to dBm and viceversa?**

    In short, to convert power from watts to dBm, multiply the power in watts by 1000 and take the logarithm (base 10) multiplied by 10. To convert power from dBm to watts, subtract 30 from the power in dBm, divide by 10, and raise 10 to that power.

22. **What are different types of connectors used in OFC**

SC Connector (Subscriber Connector)

LC Connector (Lucent Connector)

ST Connector (Straight Tip Connector)
FC Connector (Ferrule Connector)
MPO/MTP Connector (Multi-Fiber Push-On/Pull-Off)
SMA Connector (SubMiniature version A)

23. What are DSF and DFF fibers

In short, DSF fibers are designed to minimize dispersion at a specific wavelength by shifting the zero-dispersion wavelength, while DFF fibers are designed to maintain relatively constant dispersion over a wider range of wavelengths.

24. Which are the different types of connectors in OFC

SC Connector (Subscriber Connector)
LC Connector (Lucent Connector)
ST Connector (Straight Tip Connector)
FC Connector (Ferrule Connector)
MPO/MTP Connector (Multi-Fiber Push-On/Pull-Off)
SMA Connector (SubMiniature version A)
MT-RJ Connector (Mechanical Transfer-Registered Jack)
E2000 Connector
DIN Connector (Deutsches Institut für Normung)

25. What is LED? What is E-O conversion efficiency of LED?

In short, an LED is a semiconductor device that emits light when an electric current is applied. The E-O conversion efficiency of an LED refers to its efficiency in converting electrical power to optical power.

26. What are different types of LED structures?

Single Heterostructure LED: This LED structure consists of a single semiconductor material with a heterojunction formed between the active region and the cladding layers.

Double Heterostructure LED: In this structure, the active region is sandwiched between two cladding layers with different bandgap energies, creating a heterojunction on both sides of the active region.

27. What is spectral width of LED

In short, the spectral width of an LED is the range of wavelengths emitted by the LED, indicating the spread of light wavelengths produced by the device.

28. What is electrical Bandwidth and Optical Bandwidth. Which bandwidth is greater and why?

In short, the Optical Bandwidth is typically greater than the Electrical Bandwidth in optical communication systems due to the broader range of frequencies (wavelengths) that optical signals can handle compared to electrical signals. In short, the Optical Bandwidth is typically greater than the Electrical Bandwidth in optical communication systems due to the broader range of frequencies (wavelengths) that optical signals can handle compared to electrical signals.

29. Draw ideal V-I and P-I Characteristics of LED?

V-I Characteristics of LED: The V-I characteristics of an LED show the relationship between the voltage applied across the LED and the resulting current flowing through it.

P-I Characteristics of LED: The P-I characteristics of an LED depict the relationship between the current flowing through the LED and the power (light) output. In an ideal scenario, the power output increases linearly with the increase in current until it reaches a saturation point.

30. Why P-I Characteristics of LED is linear?

1. Auger Recombination: At higher current levels, Auger recombination becomes more significant. Auger recombination is a nonradiative process in which the energy of charge carriers is dissipated as heat instead of being emitted as light. This phenomenon contributes to the nonlinearity in the P-I characteristics.
2. Thermal Effects: Temperature variations can affect the P-I characteristics of an LED. As the temperature increases, the efficiency of the LED may decrease, leading to nonlinear behavior in the power output.

31. What is driving current of LED?

In short, the driving current of an LED is the electrical current that activates the LED and allows it to emit light.

32. What is full form of LASER. Draw ideal P-I Characteristics of LASER?

LASER stands for Light Amplification by Stimulated Emission of Radiation.

1. Threshold Region: At low currents, the laser operates below the threshold where the power output is very low or negligible. The laser does not achieve sufficient gain to sustain lasing.
2. Slope Region: Once the threshold current is surpassed, the laser enters the slope region. In this region, there is a linear relationship between the current and the power output.

33. What is population inversion in LASER? Why it is necessary

n short, population inversion in a laser is necessary for stimulated emission, amplification of light, and the generation of coherent and intense laser light. It allows for the efficient operation of a laser as an optical source.

34. Why LASER exhibits non-linear characteristics? Name LASERS used in industrial applications?

1. Nonlinear Gain: The gain of the laser medium, which determines the amplification of light, is not directly proportional to the input power or current. The relationship between input and output can be nonlinear, leading to non-linear characteristics.
2. Saturation Effects: At higher input power or current levels, the gain of the laser medium can saturate, resulting in a reduced increase in output power. This saturation effect contributes to non-linear behavior.
3. Thermal Effects: Changes in temperature can affect the laser's performance and introduce non-linearities. Heat generated within the laser medium can influence the gain and other optical properties, leading to non-linear behavior.

35. What is practical formula to compute attenuation in dB/m and neper/m

36. Attenuation (dB/m) = 10 * log10(P1 / P2)

37. Attenuation (Np/m) = ln(P1 / P2)

38. What is bending loss? What is the effect of bending on fiber? How bending loss can beminimized?

Bending loss refers to the loss of optical power that occurs when an optical fiber is subjected to tight bends or curves. When a fiber is bent, some of the light propagating through the fiber can escape due to increased optical leakage, resulting in a reduction in transmitted power.

The effect of bending on a fiber can include increased attenuation, degraded signal quality, and potential signal loss. Bending can introduce additional optical modes, causing mode mixing and interference, which can lead to signal distortion and increased loss.

To minimize bending loss, several measures can be taken:

1. Use Larger Bend Radii: Increasing the bend radius of the fiber reduces the curvature and allows for a smoother bend. This helps to minimize the amount of light that escapes the fiber.
2. Use Fiber with Bend-Optimized Designs: Some fiber types are specifically designed to have lower bending loss characteristics. These fibers have a modified core/cladding structure that enhances the confinement of light even in tight bends.
3. Avoid Excessive Bending: Avoid subjecting the fiber to sharp bends or excessive bending, as it can significantly increase bending loss. Proper handling and installation techniques should be followed to minimize excessive bending.
4. Use Bend-Insensitive Fiber: Bend-insensitive fibers are designed to minimize the effects of bending on optical performance. These fibers are more tolerant to bending and offer lower bending loss compared to standard fibers.
5. Use Protective Measures: Implementing protective measures such as using cable ducts, flexible conduits, or strain-relief devices can help maintain the integrity of the fiber and minimize the chances of excessive bending.

39. What is optical detector? Which are different bias configurations used in practical to finddetector characteristics.

1. Zero Bias: In this configuration, no external bias voltage or current is applied to the photodetector. The photodetector operates in a zero bias condition, relying solely on the incident light to generate a photocurrent.
2. Forward Bias: The photodetector is biased with a forward bias voltage or current. This configuration improves the speed of the photodetector, allowing for faster response times.
3. Reverse Bias: The photodetector is biased with a reverse bias voltage or current. This configuration enhances the sensitivity and efficiency of the photodetector by creating a larger depletion region, which increases the chances of absorbing photons and generating a stronger photocurrent.

40. What is APD. On which principle APD works on. State advantages of APD

APD stands for Avalanche Photodiode. It is a type of photodetector that operates based on the principle of avalanche multiplication.

APDs work by applying a high reverse bias voltage to the photodiode, creating a strong electric field across the depletion region.

1. Wide Dynamic Range: APDs have a wide dynamic range, allowing for the detection of both weak and strong optical signals without saturation.
2. Fast Response Time: APDs can have fast response times, making them suitable for applications requiring high-speed detection.
3. Wider Wavelength Range: APDs can operate over a wider wavelength range, including the ultraviolet, visible, and infrared regions.
4. Compact Size: APDs can be designed to be compact, allowing for integration into small-scale devices and systems.

41. What is responsivity of optical detector? State its unit?

Responsivity of an optical detector refers to the measure of its output electrical signal per unit optical input power. It indicates the efficiency of the detector in converting optical power into electrical current or voltage.

The unit of responsivity depends on the type of detector and the quantity being measured. For a photodiode, the responsivity is typically given in amperes per watt (A/W) or volts per watt (V/W)

42. What is Quantum efficiency of optical detector?

Quantum efficiency of an optical detector refers to the measure of its efficiency in converting photons into electrical current or charge carriers. It represents the ratio of the number of electrons or charge carriers generated by the detector per incident photon.

43. State factors which affect response of photodiode

1. Wavelength: The response of a photodiode can vary with different wavelengths of incident light. Photodiodes are designed to be sensitive to specific wavelength ranges, so the response may be higher or lower depending on the wavelength of the incoming light.
2. Quantum Efficiency: The quantum efficiency of a photodiode determines its ability to convert incident photons into electrical current or charge carriers. A higher quantum efficiency results in a stronger response to the incident light.

44. Compare PIN, APD and phototransistor.

1. PIN Photodiode:
   - Structure: Consists of a p-type region, an intrinsic (i) region, and an n-type region.
   - Operation: Relies on the internal electric field to separate photo-generated electron-hole pairs and generate a photocurrent.
   - Sensitivity: Provides moderate sensitivity and responsivity.
   - Quantum Efficiency: Generally lower compared to APD.
   - Linearity: Exhibits good linearity.
   - Speed: Offers fast response times.
   - Amplification: Does not provide internal amplification.
2. Avalanche Photodiode (APD):
   - Structure: Similar to PIN photodiode but with additional avalanche multiplication region.
   - Operation: Utilizes avalanche multiplication process to amplify the photocurrent.
   - Sensitivity: Offers high sensitivity due to internal amplification.
   - Quantum Efficiency: Generally higher than PIN photodiode.
   - Linearity: Non-linear characteristics due to avalanche multiplication.
   - Speed: Can achieve fast response times.
   - Amplification: Provides internal amplification.
3. Phototransistor:
   - Structure: Consists of a photodiode and a transistor connected in a common-emitter configuration.
   - Operation: Photons are absorbed by the photodiode, generating a photocurrent that controls the base current of the transistor, resulting in amplified output current.
   - Sensitivity: Moderate sensitivity.
   - Quantum Efficiency: Generally lower than PIN photodiode and APD.
   - Linearity: Offers good linearity.

- Speed: Generally slower response compared to PIN photodiode and APD.
- Amplification: Provides internal amplification due to transistor configuration.

45. What is value of Planks constant? How to convert charge in eV to Joule?

The value of Planck's constant is approximately 6.62607015 × 10^-34 joule-seconds (J·s).

To convert a charge given in electron volts (eV) to joules (J), you can use the following conversion:

1 eV = 1.602176634 × 10^-19 J

Simply multiply the charge value in eV by the conversion factor to obtain the equivalent value in joules.

46. What is the normalized frequency or V number or value of the fiber? Based on V number what is expression to find number of modes supported by step index (SI) and graded index(GI) fiber?

Based on the V number, we can determine the number of modes supported by a step index (SI) or graded index (GI) fiber.

For a step index fiber, the number of modes (M) can be approximated using the expression:

M ≈ 2 * V^2

For a graded index fiber, the number of modes (M) can be approximated using the expression:

M ≈ (2 / 3) * V^2

47. What is expression to compute percentage power flowing in cladding

The expression to compute the percentage of power flowing in the cladding of an optical fiber is given by:

Percentage of Power in Cladding = (Power in Cladding / Total Power) * 100

48. What is cut off wavelength for fiber? Write its expression in terms of V

The cutoff wavelength for a fiber is the longest wavelength of light that can be transmitted through the fiber in a single mode. It represents the boundary between single-mode and multimode propagation.

The expression to calculate the cutoff wavelength (λc) in terms of the V number (V) is given by:

$\lambda c = (2\pi / V) * a * NA$

49. What is expression to find signal attenuation?

The expression to find the signal attenuation in an optical fiber is given by:

Attenuation = -10 * log10(Pout / Pin)

50. What is splicing? How number of splices are determined based on fiber length?

Splicing in the context of optical fibers refers to the process of joining two fiber ends together to create a continuous, low-loss connection. It is typically done using specialized equipment that aligns and fuses the fibers together.

The number of splices required for a given fiber length depends on the specific application and the length limitations of the splicing equipment being used. In general, the number of splices required for a fiber length can be determined by dividing the total fiber length by the maximum length that can be spliced in a single operation.

For example, if the maximum splice length that can be achieved is 2 kilometers and the total fiber length is 10 kilometers, then the number of splices required would be:

Number of Splices = Total Fiber Length / Maximum Splice Length

Number of Splices = 10 km / 2 km = 5 splices

In this case, five splices would be needed to connect the 10-kilometer fiber length. It's important to consider the specific capabilities and limitations of the splicing equipment being used to determine the optimal number of splices required for a given fiber length.

Regenerate response

51. What is expression for power generated internally by LED ?

The expression for the power generated internally by an LED (Light-Emitting Diode) can be given by:

Pinternal = η * Pinput

52. What is internal quantum efficiency of LED ?

In short, the internal quantum efficiency of an LED quantifies how effectively the LED converts electrical energy into light energy. It is an important parameter that affects the overall performance and efficiency of the LED.

53. What is DFB Laser? State its principle of operation? How number of modes and frequencyseparation is calculated

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A DFB (Distributed Feedback) laser is a type of semiconductor laser that operates based on the principle of distributed feedback. It is designed to emit a narrow, single-frequency output.

The principle of operation of a DFB laser involves the integration of a periodic grating structure into the laser cavity. This grating structure acts as a distributed feedback mechanism, providing optical feedback at a specific wavelength while suppressing other competing modes. The grating causes constructive interference for the desired wavelength, creating a resonant cavity that supports only a single longitudinal mode.

The number of modes and frequency separation in a DFB laser can be calculated using the following expressions:

Number of modes (M) ≈ L / λ Where L is the length of the DFB laser cavity and λ is the wavelength of operation.

Frequency separation (Δf) ≈ c / (2 * n * L) Where c is the speed of light in vacuum, n is the refractive index of the laser medium, and L is the length of the DFB laser cavity.

54. What is energy of one photon?

The energy of one photon can be calculated using the equation:

E = h * f

In short, the energy of one photon is directly proportional to its frequency. The higher the frequency, the greater the energy of the photon. Planck's constant is a fundamental constant in quantum mechanics that relates the energy of a photon to its frequency.

55. What is mean by link, digital link?

In short, a link is a connection that enables communication between devices or locations, while a digital link specifically refers to a link that transmits digital signals.

56. How the bandwidth is calculated in digital link experiment ? What ar the application sofdigital link?

The applications of digital links are widespread and include telecommunications, computer networking, internet connectivity, digital audio and video transmission, data storage systems, and many more. Digital links enable the reliable and efficient transmission of digital data over various communication networks, enabling the exchange of information in various domains.

57. Which software is used to simulate optical power budget analysis? State the blocks involvedin simulation. How to change the properties of elements/devices in simulation platform?

There are several software tools available for simulating optical power budget analysis, and one commonly used software is OptiSystem. OptiSystem is a comprehensive optical communication system simulation software that allows users to model and analyze various aspects of optical systems.

The blocks involved in the simulation of optical power budget analysis typically include:

1. Optical sources: Representing the light sources such as lasers or LEDs.
2. Fiber components: Including fibers, connectors, and splices.
3. Optical amplifiers: Such as erbium-doped fiber amplifiers (EDFAs).
4. Photodetectors: Representing the optical detectors for converting light signals into electrical signals.
5. Signal processing blocks: For analyzing and manipulating the transmitted signals.

58. What is BER? For which link is it generally referred

BER stands for Bit Error Rate. It is a measure of the number of erroneous bits received in a communication system compared to the total number of transmitted bits. It is often used as a metric to evaluate the quality and performance of a digital communication link.

59. What is full form of OTDR? What is principle of OTDR?

The full form of OTDR is Optical Time Domain Reflectometer.

The principle of an OTDR involves the measurement of the backscattered or reflected light along an optical fiber. It operates based on the principle of time-domain reflectometry.

60. Which are different examples of events in FOC?

In the context of Fiber Optic Communication (FOC), here are some examples of events that can occur:

1. Splices: Splicing is the process of joining two optical fibers together. It is commonly done using fusion splicing or mechanical splicing techniques. The splice event is important to ensure a continuous and reliable optical connection.

61. Which parameters are important in OTDR display? Which are basic building blocks of OTDR?

1. Distance: The distance along the fiber is a crucial parameter displayed by the OTDR. It indicates the location of events or faults in the fiber, such as splices, connectors, or breaks.
2. Reflectance/Backscatter: The reflectance or backscatter level indicates the amount of light reflected or scattered back along the fiber. It provides information about the quality of the fiber and any irregularities or discontinuities.

Blocks:

3. Laser Source: The laser source provides a short pulse of light to be launched into the fiber for testing. It emits light at a specific wavelength and power level.
4. Optical Splitter/Coupler: The splitter or coupler divides the light into two paths—one for transmission into the fiber under test and the other for reference measurement.
5.

62. Draw and explain basic building block of OTDR? How fiber spools are connected to observedifferent events in OTDR

The basic building blocks of an OTDR include:

1. Laser Source: The laser source emits a short pulse of light at a specific wavelength and power level. It provides the optical signal that is launched into the fiber under test.
2. Optical Splitter/Coupler: The optical splitter or coupler divides the optical signal into two paths. One path directs the signal into the fiber under test, and the other path serves as a reference for comparison.

63. What is dead zone in OTDR event? What is pulse width of OTDR?

n an OTDR (Optical Time Domain Reflectometer), the dead zone refers to a specific distance range along the fiber where events or reflections cannot be accurately detected or resolved. It occurs immediately after the launch of the optical pulse or after a high-power reflection.

64. What is maximum OTDR measurement range?

The maximum OTDR (Optical Time Domain Reflectometer) measurement range refers to the maximum distance that an OTDR can effectively measure along an optical fiber. The measurement range of an OTDR is determined by several factors, including the dynamic range of the OTDR, the pulse width of the optical signal, and the attenuation characteristics of the fiber.

65. Draw power Vs Distance OTDR trace showing events

66. Which are the different optical link budgets?

1. Power Link Budget: It calculates the power budget of an optical link by considering the transmitter power, fiber loss, connector losses, and receiver sensitivity. The power link budget helps ensure that the received power is above the minimum required power level for reliable communication.
2. Loss Link Budget: It accounts for the losses in the optical link, including fiber attenuation, splice losses, connector losses, and other optical losses. The loss link budget helps determine the maximum allowable losses in the system to maintain the desired performance.

67. Which optical budgets are used for analog and digital transmission systems?

Power Link Budget: The power link budget is used for both analog and digital transmission systems. It calculates the power budget of the optical link, taking into account the transmitter power, fiber loss, connector losses, and receiver sensitivity.

Dispersion Link Budget: The dispersion link budget is mainly used for digital transmission systems that rely on high-speed data transmission. It considers the effects of chromatic dispersion and other types of dispersion in the optical link

68. State the expressions of system rise time based on components individual rise times? Whatis expression for maximum bit rate incorporating RZ and NRZ data format.

$t_{sys} = \sqrt{(tr^2 + tf^2 + trcv^2)}$

This expression considers the square root of the sum of the squares of the individual rise times. It accounts for the contributions of each component to the overall rise time of the system.

Regarding the maximum bit rate for data transmission incorporating Return-to-Zero (RZ) and Non-Return-to-Zero (NRZ) data formats, the expression can be given as:

Maximum Bit Rate = $1 / (2 \times t_{sys})$

69. State the expression of channel loss

The expression for channel loss in a fiber optic communication system can be calculated using the following formula:

Channel Loss = P_transmitted - P_received

70. How to develop power loss model and when it is said to be viable?

To develop a power loss model, the following steps are typically involved:

1. Identify Components: Identify the components in the optical link, such as transmitters, fiber optic cables, connectors, splices, and receivers.
2. Determine Loss Factors: Determine the factors that contribute to power loss in each component. These include fiber attenuation, connector losses, splice losses, scattering losses, and other optical losses.
3. Quantify Losses: Quantify the power loss associated with each component based on the specific characteristics and specifications. This may involve measurements, calculations, or data provided by manufacturers.
4. Calculate Total Loss: Sum up the individual power losses from each component to calculate the total power loss in the optical link.

71. State the relation between input power, output power and channel loss with and withoutdispersion equalization penalty

1. Without Dispersion Equalization Penalty:
    - Input Power: The power of the optical signal transmitted into the fiber.
    - Channel Loss: The power loss experienced by the signal as it propagates through the fiber optic channel.

- Output Power: The power of the optical signal received at the output end of the fiber.
- Relation: Output Power = Input Power - Channel Loss

2. With Dispersion Equalization Penalty:
   - Dispersion Equalization Penalty: The additional power loss incurred due to the compensation or equalization of chromatic dispersion in the fiber.
   - Relation: Output Power = Input Power - Channel Loss - Dispersion Equalization Penalty

72. What is system margin? what is normally system margin for LED and LASER as a source

System margin refers to the difference between the available power budget and the power required to achieve a desired performance level in a fiber optic communication system. It represents the extra power margin or headroom available in the system to account for variations in component characteristics, aging, temperature effects, and other uncertainties.

73. What is WDM? Explain with block schematic? State the blocks involved in simulating WDM inopti system software

WDM stands for Wavelength Division Multiplexing, which is a technology used in fiber optic communication to simultaneously transmit multiple optical signals at different wavelengths over a single fiber.

Block Schematic of WDM: In a WDM system, the block schematic typically includes the following components:

1. Transmitters: Multiple optical transmitters that generate signals at different wavelengths.
2. WDM Multiplexer: The WDM multiplexer combines the individual optical signals from the transmitters onto a single fiber.
3. Fiber Optic Cable: The optical signals are transmitted over a single fiber optic cable.
4. WDM Demultiplexer: The WDM demultiplexer separates the combined optical signals back into their individual wavelengths.
5. Receivers: Multiple optical receivers that receive the demultiplexed signals at different wavelengths.

74. Which are two types of WDM?

1. Coarse Wavelength Division Multiplexing (CWDM): CWDM is a WDM technique that uses a wider spacing between wavelengths compared to Dense Wavelength Division Multiplexing (DWDM). CWDM typically operates in the 1310 nm and 1550 nm wavelength bands, with a channel spacing of

around 20 nm. It is commonly used for short to medium-distance transmissions.

2. Dense Wavelength Division Multiplexing (DWDM): DWDM is a WDM technique that utilizes a closely spaced grid of wavelengths, allowing for high-capacity transmission over long distances. DWDM systems typically operate in the C-band (1530 nm to 1565 nm) or the L-band (1565 nm to 1625 nm) and can have channel spacing as narrow as 0.8 nm. DWDM enables the transmission of multiple channels, often ranging from 40 to 80 channels or more, over a single fiber.

75. For 2 x 2 fiber coupler what is mean by excess loss , insertion loss, cross talk/return loss andcoupling ratio/splitting ratio

n a 2x2 fiber coupler, the following terms describe different aspects of its performance:

1. Excess Loss: Excess loss refers to the additional loss incurred when light is coupled from one input port to one output port compared to an ideal lossless coupler. It represents the loss that occurs due to imperfections in the coupler's design or manufacturing process.
2. Insertion Loss: Insertion loss is the overall loss of power when light is transmitted through the coupler from one input port to one output port. It includes both the coupling loss and any additional losses due to factors such as fiber mismatches or imperfections.
3. Cross Talk/Return Loss: Cross talk, also known as return loss, is a measure of the power reflected back from one port to another port in the coupler. It represents the amount of signal leakage between the ports and is typically expressed in terms of decibels (dB). A high return loss indicates low cross talk and better isolation between the ports.
4. Coupling Ratio/Splitting Ratio: The coupling ratio or splitting ratio of a fiber coupler defines the proportion of power coupled from one input port to each output port. For a 2x2 coupler, it typically represents the ratio of power split equally between the two output ports when light is input through a single input port.

76. What if FBG? State applications of FBG

FBG stands for Fiber Bragg Grating. It is a type of optical fiber device that consists of a periodic variation in the refractive index of the fiber core. This variation creates a wavelength-specific reflection or transmission characteristic known as the Bragg wavelength.

Applications of FBG include:

1. Fiber Optic Sensing: FBGs are widely used in fiber optic sensing applications. They can be used as strain sensors, temperature sensors, pressure sensors, and vibration sensors. The Bragg wavelength of the FBG changes in response to the physical quantity being measured, allowing for accurate and precise sensing.
2. Wavelength Division Multiplexing (WDM): FBGs are used in WDM systems to selectively reflect or transmit specific wavelengths of light. They are used as filters to separate different channels or wavelengths of light in optical communication networks.

77. Compare LED AND LASER

1. Operation: LED operates on the principle of spontaneous emission, where electrons recombine with electron holes in a semiconductor material, releasing photons. LASER operates on the principle of stimulated emission, where photons are emitted due to the stimulation of already excited electrons.
2. Coherence: LED emits incoherent light, meaning the emitted photons have different frequencies and phases. LASER emits coherent light, which means the emitted photons have the same frequency and phase, resulting in a highly focused and directional beam.

78. What is optical isolator, circulator?

In summary, an optical isolator is used to block unwanted reflections and maintain signal integrity, while an optical circulator is used to route light signals in a specific direction without interference. Both components play important roles in ensuring efficient and reliable operation of fiber optic systems.

79. Which are different passive and active optical devices?

Different passive and active optical devices used in fiber optic systems include:

Passive Optical Devices:

1. Optical Fiber: The core component of a fiber optic system, used for transmitting and guiding light signals.

2. Connectors: Used to join optical fibers together, allowing for easy connection and disconnection.
3. Splitters/Couplers: Used to split or combine optical signals into multiple or single fibers, respectively.
4. WDM (Wavelength Division Multiplexer): Used to combine or separate different wavelengths of light signals in a single fiber.
5. Attenuators: Used to reduce the power of optical signals when needed.
6. Filters: Used to selectively transmit or block specific wavelengths of light.

Active Optical Devices:

1. Light Sources: Such as LEDs (Light Emitting Diodes) or Lasers, used to generate light signals for transmission.
2. Photodetectors: Used to convert optical signals into electrical signals for detection and processing.
3. Optical Amplifiers: Used to amplify optical signals to compensate for signal loss and extend transmission distances.
4. Modulators: Used to modulate the intensity, phase, or frequency of light signals for encoding information.
5. Transceivers: Combination devices that integrate both a light source and a photodetector for bi-directional communication.

80. What is Optical Amplifier. State different types of Optical Amplifier.

An optical amplifier is a device used to amplify optical signals without the need for converting them into electrical signals. It boosts the power of optical signals, compensates for signal loss, and extends the transmission distance in fiber optic communication systems. Different types of optical amplifiers include:

1. Erbium-Doped Fiber Amplifier (EDFA): It is the most widely used type of optical amplifier. It uses erbium-doped fiber to amplify signals in the 1550 nm wavelength range, which is commonly used in long-haul optical transmission systems.
2. Semiconductor Optical Amplifier (SOA): It is based on semiconductor materials and provides amplification by controlling the injection current. SOAs are versatile and can amplify a wide range of wavelengths, making them suitable for various applications.
3. Raman Amplifier: It utilizes the Raman scattering effect in optical fibers to amplify signals. It can amplify signals in both the 1550 nm and 1310 nm wavelength ranges and is often used in long-haul and ultra-long-haul transmission systems.
4. Hybrid Amplifier: It combines different types of amplifiers, such as EDFA and Raman amplifiers, to leverage their complementary benefits. Hybrid

amplifiers offer enhanced performance and flexibility in amplifying optical signals.

81. State the principle of SOA and EDFA (Erbium Doped Fiber Amplifier)

Semiconductor Optical Amplifier (SOA): SOA operates based on the principle of stimulated emission. When a signal-carrying optical input is injected into the SOA, it passes through a semiconductor material that is biased with an injection current. The signal interacts with the semiconductor's active region, which contains a population of electrons and holes. As the signal interacts with the active region, it stimulates the emission of photons in phase with the input signal, amplifying the optical signal. The injected current controls the gain and amplification level of the SOA.

Erbium-Doped Fiber Amplifier (EDFA): EDFA operates based on the principle of rare-earth doping and stimulated emission. In an EDFA, a section of optical fiber is doped with erbium ions. When a signal-carrying optical input is injected into the EDFA, it passes through the erbium-doped fiber. The erbium ions are excited by a pump laser, which raises the energy level of the erbium ions to a higher state. When the signal interacts with the excited erbium ions, it stimulates the emission of additional photons in phase with the input signal. This stimulated emission process amplifies the optical signal, resulting in gain. The pump laser provides the necessary energy to maintain the population inversion of erbium ions for continuous amplification.

82. What is analog link. State the applications of analog link.

An analog link refers to a communication link or system that transmits analog signals over a medium, such as fiber optic cables. Analog links are used to transmit continuous, non-discrete signals, which can represent audio, video, or other analog signals. The applications of analog links include:

1. Audio Transmission: Analog links are commonly used in audio systems, such as sound reinforcement systems, broadcasting, and audio distribution. They enable the transmission of high-quality audio signals over long distances with minimal loss and distortion.
2. Video Transmission: Analog links are used in video surveillance systems, CCTV (Closed-Circuit Television) systems, and video broadcasting. They allow for the transmission of analog video signals from cameras or other video sources to monitoring or display devices.

83. Why analog link is a linear element?

An analog link is considered a linear element because it preserves the linearity of the input signal during transmission. Linearity refers to the property of a system where the output is directly proportional to the input. In an analog link, the goal is to faithfully transmit the analog signal without introducing significant distortion or nonlinear effects.

The linearity of an analog link is important because it ensures that the transmitted signal accurately represents the original input signal. Any deviation or distortion introduced by the link would result in a loss of information and fidelity.

84. How frequency response and bandwidth is obtained in analog link experiment.

1. Signal Generation: A known input signal is generated, such as a sinusoidal waveform, with a range of frequencies.
2. Transmission: The generated signal is transmitted through the analog link, which may consist of components like cables, connectors, amplifiers, and filters.
3. Signal Reception: The transmitted signal is received at the output of the analog link.

85. State different types of noise which affects receiver performance.

1. Thermal Noise: Also known as Johnson-Nyquist noise, it is caused by the random motion of electrons in a conductor at finite temperature. Thermal noise is present in all electronic components and increases with temperature.
2. Shot Noise: Shot noise is due to the statistical nature of the arrival of photons in the optical receiver. It occurs when the light intensity is low, and the number of photons arriving at the detector is discrete. Shot noise is particularly significant in direct detection systems.
3. Dark Current Noise: Dark current noise is caused by the random generation and flow of electrons in a photodetector even in the absence of light. It is typically present in photodiodes and can be minimized by cooling the detector.

86. What is S/N ratio for p-n or p-i-n photodiode receiver

The signal-to-noise ratio (S/N ratio) for a p-n or p-i-n photodiode receiver is typically given by the formula:

S/N = (Psignal / Pnoise) * (1 / (2 * q * Id * B * RL))

87. What is maximum bandwidth expression in terms of load resistance R_L and detector andamplifier capacitance

The maximum bandwidth (Bmax) expression for a receiver in terms of the load resistance (RL) and the detector and amplifier capacitance is given by:

$B_{max} = 1 / (2\pi * R_L * (C_d + C_a))$

88. What is point to point link . What are Key system requirements needed to analyze opticalfiber links

A point-to-point link refers to a direct optical fiber connection between two endpoints, such as two communication devices or network nodes. It is a dedicated link that allows for the transmission of data, signals, or information between the two points.

Key system requirements needed to analyze optical fiber links include:

1. Optical Power Budget Analysis: This involves calculating the power budget of the link, considering factors such as transmitter power, receiver sensitivity, fiber attenuation, connector losses, and splicing losses. It helps determine if the link meets the power requirements for proper signal transmission.
2. Dispersion Analysis: Dispersion refers to the spreading of the optical signal as it travels through the fiber, leading to signal degradation. Analyzing dispersion helps ensure that the link can support the desired data rate and distance without significant signal distortion.

89. What are different network topologies.

1. Bus Topology: In a bus topology, all network devices are connected to a single communication line, called a bus. Each device shares the same communication medium, and data is transmitted in both directions along the bus.
2. Star Topology: In a star topology, each network device is connected to a central device, such as a hub or switch. All communication between devices passes through the central device, which manages the network traffic.

90. What are the properties of optical network

1. High Bandwidth: Optical networks can provide high bandwidth capacity, allowing for the transmission of large amounts of data at high speeds. This makes them suitable for applications that require fast and efficient data transfer, such as multimedia streaming, cloud computing, and data centers.
2. Low Latency: Optical networks offer low latency, which refers to the delay or lag in transmitting data. Low latency is crucial for real-time applications like video conferencing, online gaming, and financial transactions, where even a small delay can have significant consequences.

3. Long Distance Transmission: Optical networks enable long-distance transmission of data without significant signal degradation. Optical fibers have low attenuation, allowing data to be transmitted over hundreds or even thousands of kilometers with minimal loss.

91. Which are different optical networking node elements

1. Optical Transmitters: These devices generate optical signals that carry data. They can be in the form of lasers or light-emitting diodes (LEDs).
2. Optical Receivers: These devices receive and convert optical signals back into electrical signals for processing and interpretation.
3. Optical Amplifiers: These devices amplify optical signals to compensate for signal loss during transmission. Examples include erbium-doped fiber amplifiers (EDFAs) and semiconductor optical amplifiers (SOAs).
4. Optical Switches: These devices selectively route optical signals between different paths or fibers. They can be used to establish connections, switch traffic, or create network redundancy.

92. What is AON and PON?

In summary, AON uses active components for signal management and offers greater flexibility, while PON uses passive components for signal distribution and provides cost-effective shared access to the network.

93. Explain PON with suitable block What is SONET? State elements of SONET diagram

PON (Passive Optical Network) is an optical network architecture that uses passive components, such as splitters and couplers, to distribute optical signals to multiple endpoints. It is commonly used in access networks to provide shared broadband connectivity to multiple users.

In a PON, the optical signal is transmitted from a central office (OLT - Optical Line Terminal) to multiple subscriber locations (ONT - Optical Network Terminal) through a single fiber. The signal is split and distributed using passive splitters, allowing multiple users to share the same fiber infrastructure.

The basic block diagram of a PON consists of three main components:

1. Optical Line Terminal (OLT): The OLT is located at the central office and serves as the main interface between the optical network and the service provider's core network. It receives data from the core network, converts it into optical signals, and transmits them downstream to the subscriber locations.

2. Optical Network Unit (ONU)/Optical Network Terminal (ONT): The ONU or ONT is located at the subscriber location and serves as the interface between the optical network and the user's premises. It receives the optical signals from the OLT and converts them into electrical signals that can be used by the user's devices.
3. Passive Splitters: The passive splitters are used to split the optical signal from the OLT into multiple paths, allowing it to be distributed to multiple ONUs/ONTs. The splitters divide the signal power evenly among the different paths, ensuring that each subscriber receives an appropriate signal level.

94. What is GPON?

GPON (Gigabit Passive Optical Network) is a type of PON (Passive Optical Network) technology that enables high-speed broadband communication over fiber-optic networks. It is designed to provide gigabit-level bandwidth to multiple subscribers using a shared fiber infrastructure.

95. What are long haul , MAN and access network

These network categories serve different geographical areas and have specific characteristics and technologies tailored to their respective requirements. Long haul networks focus on long-distance transmission, MANs cater to metropolitan areas, and access networks deliver connectivity to end-users at their premises.

96. What is FDDI?

FDDI stands for Fiber Distributed Data Interface. It is a high-speed networking technology that uses optical fiber as the transmission medium. FDDI was primarily designed for use in local area networks (LANs) that require high bandwidth and fault tolerance.

97. What is FTTX?

FTTX stands for Fiber to the X, where X represents various destinations or points of network termination. It is a generic term used to describe different architectures and technologies that bring fiber optic communication directly to various locations, such as homes, businesses, or multiple dwelling units (MDUs).

98. **What is FTTH, FTTC,FTTB**?

FTTH stands for Fiber to the Home, which is a type of fiber optic network architecture where the fiber optic cables are extended directly to individual residences or homes. It provides high-speed broadband connectivity directly to the customer premises.

FTTC stands for Fiber to the Curb/Cabinet, which is a fiber optic network architecture where the fiber optic cables are extended to a point near the customer premises, typically a street cabinet or curb. From there, the connection is then delivered to the customer's location using existing copper or coaxial cables.

FTTB stands for Fiber to the Building, which is a fiber optic network architecture where the fiber optic cables are extended to a building, such as an apartment complex or office building. The connectivity is then distributed to individual units within the building using other means, such as Ethernet or copper wiring.