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**BE (2015)Pattern**

**404190 Broadband Communication Systems )**

**UNIT III: Multichannel Systems**

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**9. Questions & Answers on Integrated Optics and Photonics**

The section contains questions on photonics technologies, planar waveguides, photonic integrated circuits, optical bistability and digital optics.

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “Integrated Optics and Photonics Technologies”.

1. Integrated technology for optical devices are developed within optical fiber communication. a) True b) False View Answer

Answer: a Explanation: Integration of optical devices enable fabrication of the whole system onto a single chip. Integration of such devices has become a confluence of several optical terms.

2. When both active and passive devices are integrated on a single chip, in multilayered form, then these devices are known as \_\_\_\_\_\_\_\_\_\_\_\_\_ a) IP devices b) IO devices c) Wavelength converters d) Optical parametric amplifiers View Answer

Answer: a Explanation: IP technology enables fabrication of subsystems and systems. This is all realized on a single substrate. The integration on a single chip is done in IP technology.

3. \_\_\_\_\_\_\_\_\_ is a further enhancement of \_\_\_\_\_\_\_\_ a) IP, IO b) IO, IP c) IO, wavelength converters d) IP, wavelength converters View Answer

Answer: a Explanation: IP seems to be a miniaturization process and integration of optical systems on a single chip. IO devices are formed when both active and passive elements are interconnected. Thus, IP is a developed version of IO.

4. Thin transparent dielectric layers on planar substrates are used in \_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_ devices. a) Wavelength converters and amplification devices b) IP and IO c) IP and wavelength converters d) IO and amplification devices View Answer

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Answer: b Explanation: IP and IO provide an alternative to conversion of optical signal back to electrical signal. Thin transparent dielectric layers act as optical waveguides to produce small-scale and miniature circuits.

5. \_\_\_\_\_\_\_\_\_\_ did not make significant contribution to earlier optical fiber systems. a) IO b) IP c) Wavelength amplifiers d) Couplers View Answer

Answer: a Explanation: IO is based on single mode optical waveguides. Thus it is incompatible with multimode fiber systems. Thus, IO has less importance than IP.

6. Side or edge-emitting or conducting optical devices cannot be integrated on same substrate. a) True b) False View Answer

Answer: b Explanation: In serial integration of device, different elements of optical chip can be interconnected in a consecutive manner. Thus, integration of side or edge emitting optical devices can be done on a single substrate.

7. Hybrid \_\_\_\_\_\_\_\_ integration demands \_\_\_\_\_\_\_\_\_ IP circuits to be produced on a single substrate. a) IP, single-layered b) IO, multilayered c) IP, multilayered d) IO, multilayered View Answer

Answer: c Explanation: To gain control of optical signals, elements can be directly attached to IP circuit. Both active and passive devices should be on the same substrate. To make devices compatible with 3d structures of other IP/IO devices, hybrid IP integration demands multilayered IP circuits.

8. Using SOI integration technique \_\_\_\_\_\_\_\_\_\_ components can be coupled to IP devices. a) Passive b) Layered c) Demounted d) Active View Answer

Answer: d Explanation: SOI is used to produce micro-waveguide bends and couplers thereby maintaining compatibility with silicon fabrication techniques. Thus, active components like optical sources, detectors can be coupled to other IP devices using SOI technique.

9. Who invented the IO technology? a) Albert Einstein

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b) Anderson c) M.S Clarke d) Robert View Answer

Answer: b Explanation: The birth of IO can be traced back to the basic ideas outlined by Anderson in 1966. He suggested the micro-fabrication technology which in turn led to the term integrated optics in 1969.

10. Electronic circuits have a practical limitation on speed of operation at a frequency of around \_\_\_\_\_\_\_\_\_ a) 1010Hz b) 1012Hz c) 1014Hz d) 1011Hz View Answer

Answer: a Explanation: The speed of operation of electronic devices or circuits results from their use of metallic conductors to transport electronic charges and build up signals. It has a limitation to speed of operation of frequency around 1010Hz.

11. The use of light as an electromagnetic wave of high frequency provides high speed operation around \_\_\_\_\_\_\_\_\_\_\_\_ times the conceivable employing electronic circuits. a) 108Hz b) 105Hz c) 106Hz d) 104Hz View Answer

Answer: d Explanation: The use of light with its property as an electromagnetic wave offers the possibility of high speed operation. For this, the frequency should be high as 1014to 1015Hz.

12. How many layers are possessed by waveguide structures of silica-on-silicon(SOS)? a) Two b) Three c) Four d) One View Answer

Answer: b Explanation: The SOS is a part of IP technology. The waveguide structures provided by it comprises of three layers. They are buffer, the core and the cladding.

13. The \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is a versatile solution-based technique for making ceramic and glass materials. a) SOL gel process b) SSL gel process c) SDL gel process d) SAML gel process View Answer

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Answer: a Explanation: The SOL gel process involves the transition of system from a liquid to a gel. The SOL gel process along with SOS technique is used for the fabrication of ceramic fibers, film coatings and waveguide based optical amplifiers.

This set of Basic Optical Communications Questions and Answers focuses on “Planar Waveguides and Integrated Optical Devices”.

1. Optical fibre communications uses \_\_\_\_\_\_\_ dielectric waveguide structures for confining light. a) Rectangular b) Circular c) Triangular d) Planar View Answer

Answer: b Explanation: The use of circular dielectric waveguide structures is universally acceptable. This has been a boon for optical fibre communications.

2. \_\_\_\_\_\_\_\_\_\_ waveguide is formed when the film is sandwiched by layers of different refractive index. a) Planar b) Circular c) Asymmetric d) Symmetric View Answer

Answer: c Explanation: When the film is sandwiched between layers of same refractive index, symmetric waveguide is formed. Owing to the different refractive index, asymmetry is observed and hence asymmetric waveguide is formed.

3. When the dimensions of the guide are reduced, the number of \_\_\_\_\_\_\_\_\_\_\_ also decreases. a) Propagating nodes b) Electrons c) Holes d) Volume of photons View Answer

Answer: a Explanation: The dimensions of the guide are directly proportional to the number of propagating nodes. As the dimensions are reduced, the number of propagating nodes also decreases.

4. What does hff stands for in the equation hff = h+x+x2? a) Frequency of layer b) Diameter of curve c) Effective guide layer thickness d) Space propagation View Answer

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Answer: c Explanation: In the above equation, h is the height, x and x2 are the evanescent field penetration depths. hff Denotes the effective guided layer thickness.

5. \_\_\_\_\_\_\_\_\_\_\_ waveguides are plagued by high losses. a) Circular b) Planar c) Depleted d) Metal-clad View Answer

Answer: d Explanation: All suitable waveguide materials are subject to limitations in the confinement. However, metal-clad waveguides are not so limited. Hence, they are plagued by high losses.

6. The planar waveguides may be fabricated from glasses and other isotropic materials such as \_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_ a) Octane and polymers b) Carbon monoxide and diode c) Fluorides and carbonates d) Sulphur dioxide and polymers View Answer

Answer: d Explanation: These materials are isotropic. However, their properties do not affect the fabrication of planar waveguides. Their properties cannot be controlled by external energy sources.

7. Which of the following devices are less widely used in the field of optical fibre communications? a) Acousto-optic devices b) Regenerators c) Reflectors d) Optical translators View Answer

Answer: a Explanation: Acousto-optic devices are less widely used, mainly in the area of field deflection. Regenerators, reflectors form a base for the optical fibre communications.

8. Which of the following materials have refractive index near two? a) GA As b) Zinc c) InP d) AlSb View Answer

Answer: b Explanation: Two basic groups are distinguished on the basis of the respective refractive indices near two and near three. GaAs, InP, AlSb have refractive indices near 3.

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9. Passive devices are fabricated by \_\_\_\_\_\_\_\_\_\_ technique. a) Fassbinder b) High density integration c) Radio-frequency sputtering d) Lithium implantation View Answer

Answer: c Explanation: Passive devices’ fabrication comes mainly from microelectronics industry. Radio frequency sputtering is used to deposit thin films of glass onto glass substrates.

10. Strip pattern in waveguide structures is obtained through \_\_\_\_\_\_\_\_\_\_\_\_ a) Lithography b) Cryptography c) Depletion of holes d) Implantation View Answer

Answer: a Explanation: Field strength is an important aspect when it comes to strip patterns in waveguide structures. The electron and laser beam lithography is used to obtain stripe pattern in waveguide structures.

11. Propagation losses in slab and strip waveguides are smaller than the single mode fibre losses. a) True b) False View Answer

Answer: b Explanation: The losses are in the range of 0.1 to 0.3 dB/cm. In case of slab and stripe waveguides, the losses are much higher whereas in case of single-mode fibres, they are much less.

12. A passive Y-junction beam splitter is fabricated from \_\_\_\_\_\_\_\_\_\_ a) GaAs b) ZnS c) AlbS d) LiNbO3 View Answer

Answer: d Explanation: A passive Y-junction splitter is used to combine signals from separate sources or to divide a signal into two or more channels. It is fabricated from the waveguide materials such as LiNbO3.

13. A passive Y-junction beam splitter is also used as a switch. a) True b) False View Answer

Answer: a Explanation: A passive junction beam splitter finds application where equal power division of the incident beam is required. It can be used as a switch if it is fabricated from an electro-optic material.

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14. The linear variation of refractive index with the electric field is known as the \_\_\_\_\_\_\_\_ a) Linear implantation b) Ionization c) Koppel effect d) Pockels effect View Answer

Answer: d Explanation: The change in refractive index is related by the applied field via the linear and quadratic electro-optic coefficients. The variation of R.I with the electric field is known as Pockels effect.

15. Planar waveguides are used to produce \_\_\_\_\_\_\_ coupler. a) MMI b) CMI c) Frequency d) Differential View Answer

Answer: a Explanation: MMI couplers are abbreviated as Multimode interference couplers. These are similar to fused fibre couplers. These are easily produced by using planar waveguides.

This set of Optical Communications Question Bank focuses on “Optoelectronic Integration and Photonic Integrated Circuits”.

1. Monolithic integration for optical sources are confined to the use of \_\_\_\_\_\_\_\_\_\_ semiconductors. a) Ⅲ-Ⅴ b) Ⅱ-Ⅲ c) Ⅰ-Ⅱ d) Ⅶ-Ⅷ View Answer

Answer: a Explanation: Ⅲ-Ⅴsemiconductor compounds are much useful. They possess both optical and electronic properties. These properties can be exploited to produce high performance devices.

2. Circuits fabricated from GaAs or AlGaAs operate in wavelength region of \_\_\_\_\_\_\_\_\_\_ a) 0.1 and 0.2 μm b) 0.8 and 0.9 μm c) 0.4 and 0.6 μm d) 0.6 and 0.7 μm View Answer

Answer: b Explanation: Circuits fabricated from GaAs use injection laser which is fabricated on GaAs with a MESFET. This is used to bias and modulate the laser.

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3. The OEICs realization \_\_\_\_\_\_\_\_\_\_ as compared to the other developments in IO. a) Scripted b) Decreased c) Lagged behind d) Increased View Answer

Answer: c Explanation: IO devices use dielectric materials such as lithium niobate. This lagging behind is caused by inherent difficulties in fabrication of OEICs even if Ⅲ-Ⅴ semiconductors are used.

4. Compositional and structural differences between photonic and electronic devices \_\_\_\_\_\_\_\_\_\_ a) Provide high efficiency b) Provide low efficiency c) Highly used d) Create problems View Answer

Answer: d Explanation: Compositional and structural differences cause epitaxial crystal growth, planarization for lithography, electrical interconnections. They also cause thermal and chemical stability of materials, electric matching and heat dissipation.

5. To avoid large chip \_\_\_\_\_\_\_\_\_\_ devices are used. a) InGaAsP b) InGa c) GaAs d) InGaAs View Answer

Answer: a Explanation: To avoid large chip, InGaAsP devices are used with directly modulated semiconductor lasers. This gives good dynamic characteristics at 40 Gbit/s at 1.55 μmwavelength.

6. Devices operating at transmission rates greater than 40 Gb/s are \_\_\_\_\_\_\_\_\_ a) GaAs and InP b) GaAs c) InGa d) InGaAs View Answer

Answer: a Explanation: Optoelectronic integrated circuits are based on heterojunction bipolar transistor and electron mobility transistor use GaAs and InP. These are capable of operating at transmission rates higher than 40 Gb/s.

7. HEMT based \_\_\_\_\_\_\_\_\_\_ have a spot-size convertor with a photodiode. a) p-n junction diode b) p-i-n photoreceiver c) IGBT

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d) BJT View Answer

Answer: b Explanation: P-I-N photoreceiver comprises of spot-size convertor with a photodiode. Spot-size convertor increases fiber alignment tolerances by one order of magnitude. This enables use of cleaved instead of lensed fiber.

8. P-I-N photoreceiver based on HEMT is integrated with \_\_\_\_\_\_\_\_\_ guiding layers. a) GaAs and InP b) GaAs c) InGa d) InGaAsP View Answer

Answer: d Explanation: P-I-N photoreceiver is integrated with InGaAsP guiding layers. In this HEMT based technology, InGaAsP provides more confinement.

9. An optical power splitter integrated with optical waveguide amplifier is more useful. a) True b) False View Answer

Answer: a Explanation: The aim of optical waveguide amplifier is to reduce the number of amplifiers in system. Alongwith, it also reaches maximum number of nodes.

10. The use of intelligent optical switches is necessary. a) False b) True View Answer

Answer: b Explanation: Most applications of OEICs in optical networks require large switching capacity to support a large number of WDM channels. This also provides control of both optical signal wavelength and signal power.

11. The wafer scale replication technology uses \_\_\_\_\_\_\_\_\_\_\_\_ a) SOL gel b) GaAs c) InGa d) InGaAsP View Answer

Answer: a Explanation: Replication technology employs hot embossing, molding and ultraviolet lithography. Ultraviolet curable SOL gel enables refractive and diffractive micro-optical elements to be replicated directly on glass substrates.

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12. \_\_\_\_\_\_\_\_\_\_\_ is useful for production of both planar micro-optical elements and stacked optical microsystems. a) Wavelength amplifier b) Wavelength convertor c) Replication technology d) Optical switching matrix View Answer

Answer: c Explanation: SOL gel materials used in replication technology allows combination of replication with lithography. This leaves selected areas material-free for sawing and bunding.

13. Optical interconnection between optoelectronic device is achieved in \_\_\_\_\_\_\_\_\_ a) Wavelength amplifier b) Wavelength convertor c) Replication technology d) Chip-to-chip interconnection View Answer

Answer: d Explanation: The chip-to-chip interconnection of optical components have a vertical cavity surface-emitting laser. These are assembled in micro-trenches in which embedded electrodes are connected through passive junction of poliver waveguide on alignment pits.

14. Multilevel interconnections are incorporated in \_\_\_\_\_\_\_ a) PIC b) AWG based coupler c) Convertors d) OEIC technologies View Answer

Answer: a Explanation: PIC reduces the overall size of optical functions. This causes the interconnection of several modules growing on same substrate.

15. When there is M number of WDM channels present at N input ports, then the output port 1 produces a \_\_\_\_\_\_\_\_\_ a) CW signal b) WDM signal c) Amplified signal d) Distorted signal View Answer

Answer: b Explanation: The reconstituted spectrum of WDM signal at any output port consists of a different set of wavelength channels with at least one wavelength channel from each input port producing a WDM signal having wavelength signal from each of input ports.

1. \_\_\_\_\_\_\_\_\_\_\_ provides a series of optical processing functions. a) Wavelength convertors

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b) Wavelength amplifiers c) Detectors d) Bi-stable optical devices View Answer

2. \_\_\_\_\_\_\_\_\_\_\_ comprise of Fabry-Perot cavity. a) Wavelength convertors b) Wavelength amplifiers c) Bi-stable optical devices d) Detectors View Answer

Answer: c Explanation: Fabry-Perot cavity consists of a material in which there are variations in refractive index with optical intensity. These variations are nonlinear giving rise to bistability.

3. The optical path length in nonlinear medium is integer number of \_\_\_\_\_\_ wavelength. a) Half b) Double c) Three-fourth d) Single View Answer

Answer: a Explanation: Fabry-Perot cavity exhibits a sharp resonance to optical power passing into and through it. This is achieved when optical path length is integer number of half wavelength in nonlinear medium.

4. As compared to laser, the value of \_\_\_\_\_\_\_\_\_ in the cavity controls the optical transmission. a) Amplification b) Refractive index c) Rectification d) Reflection View Answer

Answer: b Explanation: The refractive index value in the Fabry-Perot cavity controls the optical transmission. This provides high optical output on resonance and low optical output off resonance.

5. \_\_\_\_\_\_\_\_\_\_\_ are able to latch between two distinct optical states. a) Wavelength converters b) Wavelength amplifiers c) Detectors d) Bistable optical devices View Answer

Answer: d Explanation: The transfer characteristic for Bistable optical devices exhibit two state hysteresis resulting from turning in and out of resonance. So they can be latched between two states responding to external signal acting as flip-flop.

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6. \_\_\_\_\_\_\_\_\_\_ can act as AND, OR, NOT gate. a) Wavelength converters b) Wavelength amplifiers c) Detectors d) Bistable optical devices View Answer

Answer: d Explanation: BOD’s exhibit 2-state hysteresis. Thus they are able to latch between two operating states (0 and 1) thereby providing logic functions.

7. \_\_\_\_\_\_\_ proves superior to \_\_\_\_\_\_\_ a) BOD’s, electronic devices b) Electronic devices, BOD’s c) BOD’s, convertors d) Convertors, BOD’s View Answer

Answer: a Explanation: There is also a thing of picosecond switching using only Pico-joules of energy. A BOD comprises of these switching properties. Thus, it proves superior to electronic devices.

8. \_\_\_\_\_\_\_\_ BOD’s provides optical feedback. a) Extrinsic b) Intrinsic c) Detector d) Bistable View Answer

Answer: b Explanation: All optical or intrinsic devices which utilize a nonlinear optical medium between a pair of partially reflecting mirrors forming a nonlinear etalon in which feedback is provided optical.

9. \_\_\_\_\_\_\_\_\_\_\_ devices employ artificial nonlinearity. a) Extrinsic b) Intrinsic c) Hybrid d) Bistable View Answer

Answer: c Explanation: Hybrid devices have artificial nonlinearity in an electro-optic medium in the cavity. This produces variations in refractive index through electro-optic effect.

10. Hybrid devices have limited \_\_\_\_\_\_\_\_ speed. a) Switching b) Planar c) Curvature d) Electrical View Answer

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Answer: a Explanation: Hybrid BOD’s provides flexibility. But at the same time their switching speeds are limited by use of electrical feedback. These devices are interconnected to provide a more complex logic circuit.

11. \_\_\_\_\_\_\_ exhibit optical bistability. a) Extrinsic lasers b) Intrinsic lasers c) Detectors d) Semiconductor lasers View Answer

Answer: d Explanation: Semiconductor lasers have optical bistability. This is due to nonlinearities in absorption, gain, dispersion, wave guiding and the selection of output polarization.

12. \_\_\_\_\_\_\_\_\_\_\_ is fabricated with tandem electrode. a) Full convertor b) Semiconductor c) Detector diode d) Bistable laser diode View Answer

Answer: d Explanation: Bistable laser diode is fabricated with tandem electrode. The tandem electrode provides two gain sections. Also it has a loss region between them.

13. Optical pulsing can be obtained using \_\_\_\_\_\_\_\_\_ a) BODs b) WDM c) Detector d) Semiconductor View Answer

Answer: a Explanation: BODs with a very narrow bi-stable loop can provide optical pulsing. This type of device can be used to shape, clean up and amplify a noisy input pulse.

14. A weak second beam is introduced in \_\_\_\_\_\_\_\_\_ a) BOD differential amplifier b) WDM c) Detector d) Semiconductor laser View Answer

Answer: a Explanation: A weak second beam in BOD differential amplifier is introduced into the nonlinear optical cavity. This is used to control the resonance and transmission of the main beam through effects of its own stored energy.

**10. Questions on Optical Fiber Systems 1 : Intensity Modulation**

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The section contains questions and answers on optical transmitter and receiver circuit, system design and planing considerations, analog systems, multiplexing strategies, dispersion management and optical amplifier applications.

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “The Optical Transmitter Circuit”.

1. \_\_\_\_\_\_\_\_\_\_\_\_\_ must be operated in stimulated emission region. a) Injection laser b) LED’s c) Detector d) Receiver View Answer

Answer: a Explanation: Injection laser is a threshold device. In stimulated emission region, continuous optical output power levels are in the range of 1 to 10mW.

2. Coherent radiation is relatively \_\_\_\_\_\_\_\_\_\_ a) Parabolic b) Elliptic c) Directional d) Rectangular View Answer

Answer: c Explanation: Most of the light output is coupled into optical fibre. This is because of the isotropic distribution of narrow-line width, coherent radiation is directional.

3. \_\_\_\_\_\_\_\_\_\_\_\_\_ are capable of launching powers between 0.5 and several mW. a) LED’s b) Injection laser c) Attenuator d) Reflector View Answer

Answer: b Explanation: Coupling efficiency up to 30% may be obtained by placing a fiber close to laser mirror. These can approach 90% with suitable lens and optical coupling arrangements. So they can launch 0.5 to several mW of optical power into fiber.

4. LED’s display good linearity. a) True b) False View Answer

Answer: a Explanation: LED’s appear to be suited to analog transmission. This is because of its output which is directly proportional to the drive current.

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5. Which behaviour may prove as a limitation for injection lasers and LED’s? a) Isotropic b) Radioactive c) Thermal d) Photosensitive View Answer

Answer: c Explanation: The thermal behaviour of the injection lasers and the LED’s limits their operation within the optical transmitter. The main problem is caused by the variation of injection laser threshold current.

6. Optical output power from an LED is directly proportional to the device junction temperature. a) False b) True View Answer

Answer: b Explanation: Output power is dependent on the junction temperature in case of LED’s. Most LED’s exhibit a decrease in the optical output power following an increase in junction temperature.

7. \_\_\_\_\_\_\_\_\_\_\_\_\_ from the LED is dependent on the effective minority carrier lifetime in the semiconductor material. a) Spontaneous emission b) Stimulated emission c) Absorption d) Diffusion View Answer

Answer: a Explanation: The speed of the response of the LED is dictated by the respective emission mechanism. Spontaneous emission is related to the carrier lifetime and hence dictating the speed of response.

8. The \_\_\_\_\_\_\_\_\_ of the LED is twice that of the effective minority carrier lifetime. a) Dwell time b) Reflection scatters c) Sensitivity d) Rise time View Answer

Answer: d Explanation: The response of the optical fiber source is specified in terms of the rise time. This rise time is reciprocally related to the device frequency response.

9. The finite spectral width of the optical source causes \_\_\_\_\_\_\_\_\_\_\_ a) Depletion b) Frequency burst c) Pulse broadening d) Efficient reflection View Answer

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Answer: c Explanation: The finite spectral width causes pulse broadening due to material dispersion on an optical fiber communication link. This results in a limitation on the bandwidth-length product.

10. The coherent emission from an injection laser has a line width of \_\_\_\_\_\_\_\_ a) 2 nm b) 3nm c) 8 nm d) 1nm View Answer

Answer: d Explanation: An optical source such as an injection laser is a narrow line width device as compared to the LED. It has a narrow line width of 1 nm or less.

11. Extinction ratio is denoted by symbol \_\_\_\_\_\_\_\_\_\_ a) ε b) σ c) β d) ρ View Answer

Answer: a Explanation: Extinction ratio is defined as the ratio of the optical energy emitted in the 0 bit period to that emitted during the 1 bit period. It is denoted by ε.

12. The use of low impedance driving circuit may increase \_\_\_\_\_\_\_\_\_\_\_\_\_ a) Noise b) Width c) Intensity d) Switching speed View Answer

Answer: d Explanation: Pulse shaping is usually required to increase the switching speed. However, increased switching speed may be obtained from an LED without a speed-up element by use of a low-impedance driving circuit.

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “The Optical Receiver Circuit”.

1. \_\_\_\_\_\_\_\_\_\_\_\_ limits receiver sensitivity. a) Noise b) Depletion layer c) Avalanche d) Current View Answer

Answer: a Explanation: Receiver noise affects receiver sensitivity. It can dictate the overall system design. The noise can be temperature, environmental factor or due to components.

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2. A \_\_\_\_\_\_\_\_\_\_\_\_ performs the linear conversion of the received optical signal into an electric current. a) Receiver b) Converter c) Detector d) Reflector View Answer

Answer: c Explanation: An optical signal is always fed to a detector. A detector is an optoelectronic converter which linearly converts the received optical signal into an electric current.

3. \_\_\_\_\_\_\_\_\_\_ are provided to reduce distortion and to provide a suitable signal shape for the filter. a) Detector b) Equalizer c) Filters d) Amplifier View Answer

Answer: b Explanation: Optical detectors are linear devices. They do not introduce distortion themselves but other components may exhibit nonlinear behaviour. To compensate for distortion, an equalizer is provided in the receiver circuit.

4. A \_\_\_\_\_\_\_\_\_ maximizes the received signal-to-noise ratio in the receiver circuitry. a) Filter b) Equalizer c) Detector d) Reflector View Answer

Answer: a Explanation: A filter reduces the noise bandwidth as well as inbounds noise levels. A filter maximizes the received signal-to-noise ratio while preserving the essential features of the signal. It also reduces ISI.

5. \_\_\_\_\_\_\_\_ can be operated in three connections. a) Reflectors b) Diodes c) LED’s d) FET’s View Answer

Answer: d Explanation: FET’s or bipolar transistors are operated in three useful connections. These are the common emitter, the common base or gate, and the emitter or source follower.

6. How many structures of pre-amplifiers exist? a) Two b) Three c) Four

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d) One View Answer

Answer: b Explanation: The basic structures of pre-amplifiers are observed in three forms. These are low-impedance, high-impedance and trans-impedance front end preamplifier structures.

7. What is the main factor contributing to the choice of the operational amplifier? a) Gain b) Impedance c) Conductance d) Gain-Bandwidth product View Answer

Answer: d Explanation: A TTL interface stage is always used with the operational amplifier. A device that requires higher accuracy often tends to depend on gain-bandwidth product. The choice of amplifier for receiver accuracy is dependant on gain-bandwidth product.

8. The multiplication factor for the APD varies with the device temperature. a) True b) False View Answer

Answer: a Explanation: Optimum multiplication factor is required for smooth voltage variance. The multiplication factor for APD varies with the device temperature thus making provision of fine control for bias voltage.

9. How many categories of dynamic gain equalizers are available? a) One b) Two c) Three d) Four View Answer

Answer: b Explanation: Dynamic gain equalizers are categorized into two types. These are single-channel and multichannel equalizers, thus providing operation using single or multiple wavelengths.

10. How many simultaneous channels can be provided in a band DGE(Dynamic gain equalizer)? a) Six b) Two c) Eight d) Ten View Answer

Answer: c Explanation: Generally, eight channels are provided simultaneously in a band DGE. These are for the attenuation purpose of channels along with gain equalization.

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This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “System Design Considerations”.

1. \_\_\_\_\_\_\_\_\_\_ is the unique property of the glass fiber. a) Transmission b) Opaque property c) Ductile d) Malleable View Answer

Answer: a Explanation: Glass fibres have a unique property as a transmission medium which enables their use in the communication. The major transmission characteristics are dispersion and attenuation.

2. \_\_\_\_\_\_\_\_\_\_ limits the maximum distance between the optical fiber transmitter and receiver. a) Attenuation b) Transmission c) Equipment d) Fiber length View Answer

Answer: a Explanation: Attenuation along with dispersion and the conductor size are some of the factors that limit the maximum distance between the optical transmitter and the receiver. The associated constraints within the equipment also affect the distance.

3. The \_\_\_\_\_\_\_\_\_\_\_ incorporates a line receiver in order to convert the optical signal into the electrical regime. a) Attenuator b) Transmitter c) Repeater d) Designator View Answer

Answer: c Explanation: Repeaters are a mediator between transmitter and receiver. The weak signal is strengthened back by the repeaters on its path to the receiver.

4. A regenerative repeater is called as \_\_\_\_\_\_\_\_\_\_\_\_ a) Repetitive repeater b) Regenerator c) Attenuator d) Gyrator View Answer

Answer: b Explanation: When digital transmission techniques are used, the repeater also regenerates the original digital signal in the electrical signal before it is retransmitted as an optical signal via a line transmitter.

5. The wavelength range of \_\_\_\_\_\_\_\_\_\_ will be fruitful for the operating wavelength of the system referring to the system performance.

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a) 0.8 – 0.9 μm b) 1.1 – 2 μm c) 5.2 – 5.7 μm d) 3.1 – 3.2 μm View Answer

Answer: a Explanation: It is useful if the operating wavelength of the system is established to range of 0.8-0.9 μm. This will be dictated by the overall requirements for the system performance, cost, etc.

6. How many encoding schemes are used in optical fiber communication system design requirements? a) Three b) One c) Two d) Four View Answer

Answer: c Explanation: Encoding schemes are used for digital transmission of data. These are bi-phase and delay modulation codes. They are also called as Manchester and Miller codes respectively.

7. In \_\_\_\_\_\_\_\_ the optical channel bandwidth is divided into non-overlapping frequency bands. a) Time division multiplexing b) Frequency division multiplexing c) Code division multiplexing d) De-multiplexing View Answer

Answer: b Explanation: In FDM, the non-overlapping frequency bands are divided to the individual frequencies. These individual signals can be extracted from the combined FDM signal by electrical filtering at the receiver terminal.

8. A multiplexing technique which does not involve the application of several message signals onto a single fiber is called as \_\_\_\_\_\_\_\_\_ a) Time division multiplexing b) Frequency division multiplexing c) Code division multiplexing d) Space division multiplexing View Answer

Answer: d Explanation: In SDM, each signal channel is carried on a separate fiber within a fiber bundle or multi-fiber cable form. The cross coupling between channels is negligible.

9. Which of the following is not an optical fiber component? a) Fiber b) Connector c) Circulator d) Detector View Answer

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Answer: c Explanation: Circulator is a device used in electromagnetic theory. All others are optical components.

10. \_\_\_\_\_\_\_\_technique involves an increase in the number of components required. a) Time division multiplexing b) Space division multiplexing c) Code division multiplexing d) Frequency division multiplexing View Answer

Answer: b Explanation: SDM involves good optical isolation due to the negligible cross coupling between channels. It uses separate fiber and thus requires more number of components.

11. Time division multiplexing is inverse to that of frequency division multiplexing. a) True b) False View Answer

Answer: a Explanation: TDM involves distribution of channels in time slots whereas FDM involves bands that are run on different frequencies. Both of these techniques improve accuracy and reduce complexity.

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “Digital System Planning Considerations”.

1. Sampling rate for each speech channel on 32-channel PCM is 8 KHz each encoded into 8 bits. Determine number of bits in a frame. a) 64 b) 128 c) 32 d) 256 View Answer

Answer: d Explanation: Number of bits in a frame can be calculated as follows: Bits in a frame = No. of channels \* Sampling rate for each channel.

2. Sampling rate for each speech channel on 32-channel PCM is 8 KHz each encoded into 8 bits. Determine the transmission rate for system with 256 bits in a frame. a) 2.96 Mbits/s b) 2.048 Mbits/s c) 3.92 Mbits/s d) 4 Mbits/s View Answer

Answer: b Explanation: Transmission rate can be determined by- Transmission rate = Sampling rate \* No. of bits in a frame.

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3. Sampling rate for each speech channel on 32-channel PCM is 8 KHz each encoded into 8 bits. Determine the bit duration with transmission rate of 2.048 M bits/s. a) 388 ns b) 490 ns c) 488 ns d) 540 ns View Answer

Answer: c Explanation: Bit duration is the reciprocal of the transmission rate. Thus, it is given by- Bit duration = 1/transmission rate.

4. The bit duration is 488 ns. Sampling rate for each channel on 32-channel PCM is 8 KHz encoded into 8 bits. Determine the time slot duration. a) 3.2 μs b) 3.1 μs c) 7 μs d) 3.9 μs View Answer

Answer: d Explanation: Time slot duration is given by – Time slot duration = Encoded bits \* bit duration.

5. Sampling rate for each speech channel on 32-channel PCM is 8 KHz each encoded into 8 bits. Determine duration of frame with time slot duration of 3.9μs. a) 125 μs b) 130 μs c) 132 μs d) 133 μs View Answer

Answer: a Explanation: Duration of a frame is determined by – Duration of a frame = 32 \* time slot duration.

6. Sampling rate for each speech channel on 32-channel PCM is 8 KHz each encoded into 8 bits. Determine the duration of multi-frame if duration of a frame is 125μs. a) 2ms b) 3ms c) 4ms d) 10ms View Answer

Answer: a Explanation: Multi-frame duration can be determined by – Multi-frame duration = 16 \* Duration of a single frame.

7. Determine excess avalanche noise factor F(M) if APD has multiplication factor of 100, carrier ionization rate of 0.02.

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a) 3.99 b) 3.95 c) 4.3 d) 4 View Answer

8. Compute average number of photons incident at receiver in APD if quantum efficiency is 80%, F (M) = 4, SNR = 144. a) 866 b) 865 c) 864 d) 867 View Answer

Answer: c Explanation: Average number of photons arezm=[2βςF(M)]\*[S/N\*η] Here, η = quantum efficiency, S/N = signal to noise ratio.

9. Determine incident optical power if zm=864, wavelength = 1μm. a) -85 dBm b) -80 dBm c) -69.7 dBm d) -60.7 dBm View Answer

Answer: d Explanation: Incident optical power is P0=zmhcBT/2λ. Here zm=average number of photons, hc=Planck’s constant.

10. Determine wavelength of incident optical power if zm=864, incident optical power is -60.7 dB, BT=1 \* 107. a) 1 μs b) 2 μs c) 3 μs d) 4 μs View Answer

Answer: a Explanation: Wavelength is determined by λ=zmhcBT/2P0. Here zm=average number of photons, hc=Planck’s constant, P0=incident optical power.

11. Determine total channel loss if connector loss at source and detector is 3.5 and 2.5 dB and attenuation of 5 dB/km. a) 34 dB b) 35 dB c) 36 dB d) 38 dB View Answer

Answer: a Explanation: The total channel loss is CL=(αfc+αj)L + αcr. Here αcr=loss at detector and source combined, αfc = attenuation in dB/km.

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12. Determine length of the fiber if attenuation is 5dB/km, splice loss is 2 dB/km, connector loss at source and detector is 3.5 and 2.5. a) 5 km b) 4 km c) 3 km d) 8 km View Answer

Answer: b Explanation: Length of the fiber is L = CL/(αfc+αj) – αcr. Here αcr = loss at detector and source combined, αfc = attenuation in dB/km.

13. Determine total RMS pulse broadening over 8 km if RMS pulse broadening is 0.6ns/km. a) 3.6 ns b) 4 ns c) 4.8 ns d) 3 ns View Answer

Answer: c Explanation: Total RMS pulse broadening is given by – σT = σ\*L Where σ = rms pulse broadening and L = length of the fiber.

14. Determine RMS pulse broadening over 8 km if total RMS pulse broadening is 5.8ns/km. a) 0.2ns/km b) 0.1ns/km c) 0.4ns/km d) 0.72ns/km View Answer

Answer: d Explanation: RMS pulse broadening is given by – σ = σT/L where σ = rms pulse broadening and L = length of the fiber.

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “Analog Systems”.

1. Determine dispersion equalization penalty if total RMS pulse broadening is 4.8ns, BT is 25 Mbits/s. a) 0.03 dB b) 0.08 dB c) 7 dB d) 0.01 dB View Answer

Answer: a Explanation: Dispersion equalization penalty is denoted by DL. It is given by- DL = 2 (2σTBT√2)4. Here σT=RMS pulse broadening.

2. Determine RMS pulse broadening with mode coupling if pulse broadening is 0.6 over 8km. a) 1.6ns

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b) 1.7ns c) 1.5ns d) 1.4ns View Answer

Answer: b Explanation: Total RMS pulse broadening with mode coupling is given by- σT = σ√L. Here σT = RMS pulse broadening, L = length of the fiber.

3. Determine dispersion equalization penalty with mode coupling of 1.7ns if BT is 25 Mbits/s. a) 4.8 \* 104dB b) 4 \* 104dB c) 4.2 \* 104dB d) 3.8 \* 104dB View Answer

Answer: c Explanation: Dispersion equalization penalty is denoted by DL. With mode coupling, it is given by- DL=2 (2σTBT√2)4. Here σT=RMS pulse broadening.

4. Determine dispersion equalization penalty without mode coupling if BT is 150 Mbits/s and total rms pulse broadening is 4.8ns. a) 34 dB b) 33 dB c) 76.12 dB d) 34.38 dB View Answer

Answer: d Explanation: Dispersion equalization penalty is denoted by DL(WM). It is given by- DL(WM) = 2 (2σTBT√2)4. Here σT = RMS pulse broadening, (WM) = without mode coupling.

5. Determine ratio of SNR of coaxial system to SNR of fiber system if peak output voltage is 5V, quantum efficiency of 70%, optical power is 1mW, wavelength of 0.85μm. a) 1.04 \* 104 b) 2.04 \* 104 c) 3.04 \* 104 d) 4.04 \* 104 View Answer

Answer: a Explanation: Ratio of SNR of coaxial system to SNR of fiber system is given by- Ratio = V2hc/2KTZ0ηPiλ. Here, η=quantum efficiency, Pi = 0ptical power in mW, V=optical output voltage.

6. Determine the peak output voltage if efficiency is 70%, wavelength is 0.85μm and output power is 1mW. a) 7V b) 8V c) 5V d) 6V View Answer

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Answer: b Explanation: Peak output voltage is given by- V2 = (2KTZ0ηPiλ \* Ratio)/hc. Here, η = quantum efficiency, Pi=0ptical power in mW, V=optical output voltage.

7. Determine the efficiency of a coaxial cable system at 17 degree Celsius with peak output voltage 5V, 0.85 μm wavelength and SNR ratio of 1.04 \* 104. a) 80% b) 70% c) 40% d) 60% View Answer

Answer: b Explanation: The efficiency of a coaxial cable system is η=V2hc/2KTZ0ηPiλ \* Ratio. Hereη=quantum efficiency, Pi = 0ptical power in mW, V=optical output voltage.

8. Determine the wavelength of a coaxial cable system operating at temperature 17 degree Celsius at output voltage of 5V, 100Ω impedance, optical power of 1mW, 70% quantum efficiency. a) 0.39μm b) 0.60μm c) 0.85μm d) 0.98μm View Answer

Answer: c Explanation: The wavelength can be determined by – λ = V2hc/2KTZ0ηPi \* Ratio. Hereη=quantum efficiency, Pi = 0ptical power in mW, V = optical output voltage.

9. Determine the impedance of a coaxial cable system operating at temperature 17 degree Celsius at output voltage of 5V, 0.85μmwavelength, optical power of 1mW, 70% quantum efficiency and SNR ratio of 1.04 \* 104. a) 80Ω b) 50Ω c) 90Ω d) 100Ω View Answer

Answer: d Explanation: The impedance is given by-Z0=V2hc/2KTPi \* Ratio. Hereη=quantum efficiency, Pi = Optical power in mW, V=optical output voltage.

10. The 10-90% rise times for components used in D-IM analog optical link is given. (LED=10ns, Intermodal=9ns/km, Chromatic=2ns/km, APD = 3ns). Link is of 5km. Determine the total rise time. a) 62ns b) 53ns c) 50ns d) 52ns View Answer

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Answer: d Explanation: Total rise time is given by- Tsyst=1.1[Ts2+Tn2+Tc2+TD2]1/2. Here Ts = rise time, Tn = intermodal time, Tc = Chromatic time.

11. The 10-90% rise times for components used in D-IM analog optical link is given. (LED=10ns, Intermodal=9ns/km, Chromatic=2ns/km, APD = 3ns). Link is of 5km. It has an optical bandwidth of 6MHz. Determine maximum permitted system rise time. a) 58.3ns b) 54ns c) 75ns d) 43.54ns View Answer

Answer: a Explanation: The maximum permitted system rise time is given by- Tsyst(Max) = 0.35/Bopt. Here, Bopt=Optical Bandwidth.

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “Multiplexing Strategies”.

1. What is the full form of ETDM? a) Electronic tube di-cyclic mechanism b) Electrical time division multiplexing c) Emphasis tier division mechanism d) Electrical tube dielectric medium View Answer

Answer: b Explanation: ETDM is the major baseband digital strategy. It allows for greater exploitation of available fiber bandwidth.

2. The practical limitations of the speed of electronic circuits have been pushed towards operational frequencies around \_\_\_\_\_\_\_\_\_\_\_ a) 100 MHz b) 120 MHz c) 100GHz d) 80 Hz View Answer

Answer: c Explanation: The speed of the circuitry in the fiber optic communication plays an important role in its performance. It is pushed around 100 GHz frequency allowing for 100 Gbit/s feasibility.

3. A strategy used for increasing the bitrate of digital optical fiber systems beyond the bandwidth capabilities of the drive electronics is known as \_\_\_\_\_\_\_\_\_\_\_ a) Optical time division multiplexing b) Electrical time division multiplexing c) Frequency division multiplexing d) Code division multiplexing View Answer

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Answer: a Explanation: OTDM is favourable for long distance transmission of signal. It is designed to push the bitrate of the fiber systems beyond the bandwidth limits to gain performance.

4. \_\_\_\_\_\_\_\_\_\_\_\_ semiconductor laser sources provide low duty cycle pulse streams for subsequent time multiplexing. a) Diameter preferred b) Mode locked c) Divine d) Depletion View Answer

Answer: b Explanation: Mode locked semiconductor laser sources were used at the transmitter side. They provide effective distribution of time multiplexing providing low duty cycle pulse streams.

5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_ are the devices which are employed to eliminate the laser chirp. a) Optical intensity modulators b) Demodulators c) Circulators d) Optical Isolators View Answer

Answer: a Explanation: Optical intensity modulators eliminate the laser chirp. This laser chirp may result in dispersion of the transmitted pulses as they propagate within the single mode fiber, thus limiting the achievable transmission distance.

6. \_\_\_\_\_\_\_\_\_\_\_\_\_ provides operation at high transmission rate. a) Optical intensity modulators b) Demodulators c) Circulators d) Electro-absorption modulators View Answer

Answer: d Explanation: Electro-absorption modulators are employed at the transmitter and receiver sections. They provide operation at high transmission rate and for field trial.

7. In \_\_\_\_\_\_\_\_\_\_ the microwave frequency are modulated with an optical carrier and transmitted using a single wavelength channel. a) Subcarrier multiplexing b) TDM c) FDM d) Code division multiplexing View Answer

Answer: a Explanation: Optical Subcarrier multiplexing (SCM) is transmitted using a single wavelength channel. It enables multiple broadband signals to be transmitted over single-mode fiber.

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8. Which of the following techniques is easy to implement? a) Amplitude shift keying b) Phase shift keying c) Frequency shift keying d) SCM View Answer

Answer: c Explanation: Frequency shift keying has an advantage of being simple to implement at the modulator as well as demodulator side. It is formed by up converting to a narrowband channel at high frequency employing frequency.

9. Which of the following is the disadvantage of SCM? a) Source nonlinearity b) Linearity c) Distortion d) Narrow bandwidth View Answer

Answer: a Explanation: The problem associated with SCM is source nonlinearity. The distortion caused by this becomes noticeable when several subcarriers are transmitted from a single optical source.

10. In CATV, the signal must be received with a carrier to noise ratio of between \_\_\_\_\_\_\_\_\_\_ a) 90 and 100 dB b) 10 and 30 dB c) 60 and 70 dB d) 45 and 55 dB View Answer

Answer: d Explanation: The CATV multichannel spectrum tends to minimize the required bandwidth. The carrier to noise ratio must be between to avoid degradation of picture quality.

11. The IF signal can be input to a demodulator to recover the baseband signal. a) True b) False View Answer

Answer: a Explanation: The IF signal is obtained through SCM at the receive terminals. The baseband video signal in a CATV is obtained through IF signal by using it with a demodulator input.

This set of Optical Communications Multiple Choice Questions & Answers (MCQs) focuses on “Application of Optical Amplifiers “.

1. Which of the following is not a drawback of regenerative repeater? a) Cost b) Bandwidth c) Complexity

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d) Long haul applications View Answer

Answer: d Explanation: The regenerative repeaters are useful in long haul applications. However, such devices increase the cost and complexity of the optical communication system. It act as a bottleneck by restricting the system operational bandwidth.

2. The term flexibility, in terms of optical amplifiers means the ability of the transmitted signal to remain in the optical domain in a long haul link. a) True b) False View Answer

Answer: a Explanation: Repeaters are usually used to maintain the transmitted signal in the optical domain. But, it has its own drawbacks. Thus, flexible systems which include optical amplifiers are used for such purpose.

3. How many configurations are available for employment of optical amplifiers? a) Three b) Four c) Two d) Five View Answer

Answer: a Explanation: Optical amplifiers can be employed in three configurations. These are simplex mode, duplex mode, multi-amplifier configuration.

4. Repeaters are bidirectional. a) True b) False View Answer

Answer: b Explanation: Repeaters are unidirectional. Optical amplifiers have the ability to operate simultaneously in both directions at the same carrier wavelength.

5. It is necessary to \_\_\_\_\_\_\_\_\_\_\_\_ the optical carriers at different speeds to avoid signal interference. a) Inculcate b) Reduce c) Intensity-modulate d) Demodulate View Answer

Answer: c Explanation: Optical amplifiers are bidirectional. They operate in both directions at the same carrier wavelength. In order to avoid interference, the optical carriers should be intensity modulated.

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6. The \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ increases the system reliability in the event of an individual amplifier failure. a) Simplex configuration b) Duplex configuration c) Serial configuration d) Parallel multi-amplifier configuration View Answer

Answer: d Explanation: The optical amplifiers with spectral bandwidths in the range 50 to 100 nm allow amplifiers to be more reliable than repeaters. The parallel multi-amplifier configuration increases system reliability and relaxes the linearity.

7. Which of the following is not an application of optical amplifier? a) Power amplifier b) In-line repeater amplifier c) Demodulator d) Preamplifier View Answer

Answer: c Explanation: Optical amplifiers have a wide variety of applications in the transmitter as well as receiver side. It is used as the power amplifier in the transmitter side and as preamplifier at the receiver side.

8. \_\_\_\_\_\_\_\_\_ reconstitutes a transmitted digital optical signal. a) Repeaters b) Optical amplifiers c) Modulators d) Circulators View Answer

Answer: a Explanation: Optical amplifiers simply act as gain blocks on an optical fiber link. However, in contrast, the regenerative repeaters reconstitute a transmitted digital optical signal.

9. \_\_\_\_\_\_\_\_\_\_\_\_\_ are transparent to any type of signal modulation. a) Repeaters b) Optical amplifiers c) Modulators d) Circulators View Answer

Answer: b Explanation: The main benefit of acting as a gain block for optical amplifier is that it can be transparent to modulation bandwidth. However, both the noise and signal distortions are continuously amplified.

10. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ imposes serious limitations on the system performance. a) Fiber attenuation b) Fiber modulation c) Fiber demodulation

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d) Fiber dispersion View Answer

Answer: d Explanation: The fiber dispersion calculation does not take into account the non-regenerative nature of the amplifier repeaters. In this, the pulse spreading and the noise is accumulated.

11. \_\_\_\_\_\_\_\_\_\_ is the ratio of input signal to noise ratio to the output signal to noise ratio of the device. a) Fiber dispersion b) Noise figure c) Transmission rate d) Population inversion View Answer

Answer: b Explanation: Noise figure judges the performance factor of the devices. It is the in and out the ratio of signal to noise degradation for any device.

12. How many factors govern the noise figure of the device? a) Four b) Three c) Two d) One View Answer

Answer: a Explanation: Noise figure is governed by factors such as the population inversion, the number of transverse modes in the amplifier cavity, the number of incident photons on the amplifier and the optical bandwidth of the amplified spontaneous emissions.

13. What is the typical range of the noise figure? a) 1 – 2 dB b) 3 – 5 dB c) 7 – 11 dB d) 12 – 14 dB View Answer

Answer: c Explanation: Typical noise figures range from 7 to 11 dB. The SOAs are generally at the bottom end of the range and the fiber amplifiers towards the top end.

This set of Optical Communications Problems focuses on “Dispersion Management and Soliton Systems”.

1. Calculate second order dispersion coefficient for path length L2 20km and L1 160km. Dispersion coefficient for L2 is 17. a) -2.125ps/nm km b) -3.25ps/nm km c) -3.69ps/nm km d) -1.28ps/nm km View Answer

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Answer: a Explanation: The second order dispersion coefficient for path length is given by- β21 = -β22L2/L1. Here, β22 = Dispersion coefficient forL2, L2 and L1 are path lengths.

2. Calculate the path length L2 if L1is 160, dispersion coefficient of L2 is 17, dispersion coefficient of L1 is -2.25 ps/nmkm. a) 40 km b) 20 km c) 30 km d) 10 km View Answer

Answer: b Explanation: The path length L2 is given by- L2 = β21L1/-β22. Here, β22 = Dispersion coefficient forL2, β21 = Dispersion coefficient for L1, L2 and L1 are path lengths.

3. Calculate path length L1 if L2 is 20, dispersion coefficient of L2 is 17, dispersion coefficient of L1 is -2.25 ps/nmkm. a) 180 km b) 30 km c) 160 km d) 44 km View Answer

Answer: c Explanation: The path length L1is given by- L1 = β21L2/-β22. Here, β22 = Dispersion coefficient forL2, β21 = Dispersion coefficient for L1, L2 and L1 are path lengths.

4. Calculate second order dispersion coefficient for path length L1 20 km and L1 160 km. Dispersion coefficient for L1 is -2.125\*10-12s/nmkm. a) 20 b) 19 c) 18 d) 17 View Answer

Answer: d Explanation: The second order dispersion coefficient for path length is given by- β22=-β21L2/L1. Here, β21 = Dispersion coefficient forL1, L2 and L1 are path lengths.

5. Calculate dispersion slope for second path fiber if L1 is 150, L2 is 10 and s1 is 0.075. a) 1.125 b) 2.125 c) 3.125 d) 1.9 View Answer

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Answer: a Explanation: Dispersion slope for second path fiber is s2 = -s1(L1/L2). Here s1 and s2 are dispersion slopes for L1, L2. L2 and L1 are path lengths.

6. Calculate dispersion slope for first path fiber if L1 is 160, L2 is 20 and s2 is 0.6ps/nm km. a) 0.1 b) 0.432 c) 0.236 d) 0.075 View Answer

Answer: d Explanation: Dispersion slope for first path fiber is s1 = -s2(L1/L2). Here s1 and s2 are dispersion slopes for L1, L2. L2 And L1 are path lengths.

7. Calculate L2 if dispersion slope for first path fiber is 0.075 and L1 is 160 km and s2 is -0.6ps/nm km. a) 20 km b) 30 km c) 40 km d) 50 km View Answer

Answer: a Explanation: L2 is determined by – L2 = (-s1/s2)\*L1. Here s1 and s2 are dispersion slopes for L1, L2. L2 and L1 are path lengths.

8. Calculate L1 if dispersion slope for first path fiber is 0.075 and L2 is 20 km and s2 is -0.6ps/nm km. a) 170 km b) 160 km c) 180 km d) 175 km View Answer

Answer: b Explanation: L1 is determined by – L2 = (-s1/s2)\* L2. Here s1 and s2 are dispersion slopes for L1, L2. L2 and L1 are path lengths.

9. Calculate separation of soliton pulses over a bit period length if R2 pulse width is 6 ps for bit period of 70 ps. a) 5.9 b) 5.7 c) 5.8 d) 5.4 View Answer

Answer: c Explanation: The separation of soliton pulses over a bit period length is calculated by – q0 = T0/2ς. Here ς = pulse width and T0 = bit period.

10. Calculate RZ pulse width if bit period is 60ps and separation of soliton pulses is 5.4. a) 5.5ps

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b) 8.1ps c) 4.3ps d) 2.3ps View Answer

Answer: a Explanation: RZ pulse width can be calculated by – ς = T0/q0. Here ς = pulse width and T0 = bit period.

11. Calculate bit period if RZ pulse width is 50ps and separation of soliton pulses is 5.6. a) 570ps b) 540ps c) 430ps d) 560ps View Answer

Answer: d Explanation: Bit period can be calculated by – T0 = 2T2q0. Here T2=pulse width and T0=bit period.

12. Calculate value of dimensionless parameter if bit period is 45ps and RZ pulse width is 4 ps. a) 5.625 b) 5.0 c) 4 d) 6.543 View Answer

Answer: a Explanation: Dimensionless parameter is given by – q0 = T0/2ς. Here ς=pulse width and T0=bit period.

**11. Questions & Answers on Optical Fiber Systems 2 : Coherent and Phase Modulated**

The section contains questions on coherent transmission, modulation formats, demodulation schemes, receiver sensitivities and multi carrier systems.

This set of Optical Communications Questions and Answers for Entrance exams focuses on “Practical Constraints of Coherent Transmission”.

1. Which technology development has helped the field of optical fiber communication? a) Glass technology b) Component technology c) Multiplexing d) Power View Answer

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Answer: b Explanation: Substantial developments in component technology have allowed the initial difficulties in the optical fiber communication to go away. The coherent factor experienced most of the difficulties.

2. \_\_\_\_\_\_\_\_\_\_ dictates the performance characteristics required from components and devices which are to be utilized in coherent optical fiber systems. a) System considerations b) Bluetooth technology c) Multiplexing d) Practical constraints View Answer

Answer: d Explanation: Practical constraints inhibit the development of coherent optical fiber communications. These constraints are derived from factors associated with the elements of the coherent optical fiber communication.

3. Coherent optical transmission is degraded by the \_\_\_\_\_\_\_\_ associated with the transmitter and local oscillator lasers. a) Phase noise b) White noise c) Dissipation d) Power View Answer

Answer: a Explanation: Phase noise is determined by the laser line width. The phase noise associated with both the transmitter and the mid-tier section severely degrades the coherent optical transmission as well as reception.

4. \_\_\_\_\_\_\_\_\_\_\_ improves the spectral purity of the device output and noise current. a) Power dissipation b) Laser line width reduction c) Laser line width injection d) Phase noise View Answer

Answer: b Explanation: Laser line width determines the level of phase noise and long term phase stability. The reduced phase noise is obtained using narrow-line width devices. This improves the spectral purity as well as reduces the noise current.

5. \_\_\_\_\_\_\_\_\_\_\_\_ is the principal cause of line width broadening in the coherent devices. a) Electromagnetic field b) Power dissipation c) Injection laser phase noise d) Gaussian noise View Answer

Answer: c Explanation: Injection laser phase noise affects the system performance. The system performance considerations include receiver noise, power loss and line width broadening.

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6. Which technique was started for narrowing of injection laser line widths? a) External resonator cavity b) Long-hauled oscillator c) Circulator d) Gyrator View Answer

Answer: a Explanation: Many approaches evolved in time for laser line width problem. The one which sustained and showed effects was the use of external resonator cavity in the lasers.

7. The line width tolerance is wider for heterodyne receivers. a) False b) True View Answer

Answer: b Explanation: The laser line width requirements depend on the modulation format, coherent detection mechanism which includes the use of heterodyne and homodyne receivers. The line width tolerance is wider for heterodyne receivers when employing FSK modulation.

8. \_\_\_\_\_\_\_\_\_\_\_ is an alternative to reduce phase noise and line width requirements. a) Homodyne detection b) Heterodyne detection c) FSK modulation d) Phase diversity reception View Answer

Answer: d Explanation: The more sensitive coherent transmission techniques are most affected by phase noise problem. A specially configured reception technique called as phase diversity reception technique is used to overcome phase noise problem.

9. \_\_\_\_\_\_\_\_\_\_\_\_\_\_ is the progressive spatial separation between the two polarization modes as they propagate along the fiber. a) Fiber birefringence b) Fiber dispersion c) Fiber separation d) Fiber coupling View Answer

Answer: a Explanation: In a perfectly formed fiber, both modes would travel together. But, in practice, the fiber contains random manufacturing irregularities. This result in a progressive spatial separation called as fiber birefringence.

10. How many compensator devices are required to provide full polarization-state control? a) Three b) One c) Four

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d) Two View Answer

Answer: d Explanation: At least two compensator devices are required to provide full polarization-state control. They can be placed in either the incoming signal path or the local oscillator output path.

11. Which technique was found to be providing an infinite range of polarization control? a) Homodyne detection b) Fiber squeezers c) Heterodyne detection d) Power dissipation View Answer

Answer: b Explanation: Four fiber squeezers provide an infinite range of adjustment or endless polarization control. Stress was applied to the fiber in the local oscillator path using the squeezers which are angled at 45 degrees to each other.

12. What is the main drawback of the squeezer? a) Damages the fiber b) Attenuation c) Dispersion d) Signal degradation View Answer

Answer: a Explanation: The squeezers are simple to configure. The main drawback of squeezer is that they tend to damage the fiber and could not be engineered into reliable transducers for practical systems.

13. The use of balanced receiver compensates the losses due to coupling optics. a) True b) False View Answer

Answer: a Explanation: The losses due to coupling optics and the suppression of the excess noise in the local oscillator signal are eliminated by the use of balanced receiver. It is also called as balanced-mixer receiver.

14. \_\_\_\_\_\_\_\_\_\_\_ is the phenomenon which occurs in the single carrier systems due to small refractive index changes induced by the optical power fluctuations. a) SBS gain b) Self-phase modulation c) FSK modulation d) Birefringence View Answer

Answer: b Explanation: It occurs only in the single-carrier systems. It affects the phase of the transmitted signal.

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**Short Answers Questions**

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**BE (2015)Pattern**

**404190 Broadband Communication Systems )**

**Topic : Optical Fibre Communication**

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**I N T R O D U C T I O N**

**Fiber optics lighting is not a revolutionary or new technology, in essence is only about carrying light, from one point to another by means of a lens, more or less flexible and long.**

The problem is the air of mysticism surrounding the industry\*.

The result is a strange industry where it is difficult to know for sure the result of the system being ins- talled and where disappointment, in part due to unfair hopes, is common.

The present work is a collection of the questions most often made by professionals during seminars, consulting, and projects over a quarter of a century. The questions are worded in a short straight- forward manner and answered based on objective scientific criteria, without publicity, trademarks, or personal preferences, in an effort to help the general understanding of these systems.

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**F I B E R S**

1. . What is a f iber opt ic?

Fiber optics are long lenses. A cylinder or rod of transparent material forming a core surrounded by an external cladding with a slightly different material. Light, when entering the fiber, rebounds on the outer cladding towards the core. This way the light advances through the fiber in bounds or steps, until it exits at the other end.

2. . How many kinds of f ibers are there?

In truth, there is only one fiber optic. The term "fiber optics" applies really to a branch of light physics dealing with the properties of certain materials that display a phenomenon called "total internal reflection", and not to an object. All optical elements such as lenses, prisms and rods use total internal reflection as a mecha- nism for light transportation. In the elements described as fiber optics light travels by virtue of this effect but it does so in a number of ways; monomode, multimode, step index, gradient index and so on.

For lighting purposes or, to be more exact, to handle visible light, the standard type or fibers are the so-called multimode step index fibers. The use of the other types is confined exclusively to data or signal transmission.

3. . What are f iber opt ics made off?

For lighting purposes or visible light spectrum transmission, several kinds of fibers are used. Glass in very fine strands that have to be bunched together in order to make a sizeable light carrier, PMMA, and polycarbonate in sizes from 0,25 to 3mm and solid core fibers made from special polymers in a Teflon sheath from 3mm to over one-inch thick. Other types of fibers such as liquid core, colored fibers, fluorescent, and scintillating are little used and for specialized applications.

4. . Are there di fferent qual i t ies of f iber opt ics?

Definitely yes. The raw materials used in the manufacture of fibers may be similar in some instances but the process to make finished optics can vary greatly from one manufacturer to another.

The greatest differences arise from the level of purity and refinement with which the raw materials are pro- duced, the degree of impurities, contamination and the very technology of the process.

Optical properties such as numerical aperture, attenuation and selective spectral absorption

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are widely diffe- rent from one fiber to other. This means that some fibers may be suitable for one task and useless for others.

5. . What is a l ight guide?

When a number of single fibers are grouped together to make a larger diameter light conductor the resulting structure is called a light guide. Sometimes large diameter solid core fibers are also termed light guide.

Light guides can come in many forms and finished, clad with a number of different polymers, articulated ana- conda type flexible metal coverings, rigid tubes, heat shrink tubes, etc.

6. . What are bare f ibers?

The term is used mainly with PMMA fibers and refers to the optics that have no external protection sheath.

7. . What are sheathed f ibers?

The optics that have an external cladding whether opaque or transparent in order to afford a mechanical protection to the optics.

8. . Is the sheath color important?

This is a particularly slippery subject and the cause of heated debate. Some scientists affirm that an opaque white or light colored cladding, especially in single core fibers improve, marginally, the transmission properties of the optics. Others say that this is nonsense. In any case, the difference if it exists, must surely be minimal.

9. . What is a harness?

The term applied in the industry to describe a group of fibers or light guides, individually terminated and with a common end. Generally, each harness must have its own illuminator.

10. . Do f ibers have losses?

All things in the universe are inefficient. This means that when a measured amount of something enters a system, less comes out than originally went in. If you pour a liter of water into one end of a pipe, you will always get less than a liter out of the other end. If you apply a voltage to the extreme of one wire, no matter how you do it, you will get a lesser value at the other end.

Fiber optics are no exception, the light entering one end encounters all kinds of obstacles and flaws, resul- ting in losses; from 2 to 10% for every running meter.

11. . Why do some f ibers change the color of the l ight?

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In fact, all fibers change the color of the light in one way or another. Due to the physical characteristics of the conductor some frequencies travel with less impediment than others and it is impossible to produce a fiber that would have the same attenuation on the whole of the visible spectrum. To expect a light conductor to transport millions of different wavelengths along with exactly the same attenuation in every one would be quite unreasonable.

Some fibers absorb a little more blue than red and less green than yellow and others just the opposite. Consequently, the hue and tone of the light varies from meter to meter, in some cases very apparently. This phenomenon is referred to as selective spectral absorption.

12. . Is low attenuat ion a sign of good qual i ty f iber?

Generally yes, but in lighting fiber optics the manufacturer's attenuation figures are frequently meaningless. (In order to be reasonable this is the only figure they can quote)

Attenuation is measured using a laser, a light emitting diode or a collimated light source. In all three cases the light used is monochromatic, meaning that only one wavelength or a very narrow set of wave- lengths is used.

The figures issued by manufacturers, per example: 150dB/Km refer to that single wavelength and corres- ponding color which could be yellow or yellow/green. The same fiber may have an attenuation of 750dB/Km on the blue end of the spectrum and 400dB/Km on the red side.

To calculate the average attenuation for white light would involve firstly analyzing the light of the lamp in the illuminator to determine its composition that could vary enormously, even for two identical lamps. Then one would have to measure attenuation in all individual wavelengths taking into account the amount of each present on the lamp's emission. Finally, we would have to compute to obtain a result which would only hold true for that lamp/fiber combination.

To be honest a close average can be worked out with a few instruments but lamp deterioration due to aging, dust in the system and coloring of the common end due to solvent migration from the potting compounds, if used, soon make nonsense of averaged figures.

13. . What are the advantages of glass f iber opt ics?

Glass fiber optics are very resilient and ideally suited for working in places where the actual conductor will be subject to extreme temperatures or/and radiation, are little affected by most solvents and oils and the spectral transmission is good.

14. . And the disadvantages?

It must be borne in mind that the actual nature of the conductor, in lighting systems, represents only one of the elements responsible for system performance. Glass light guides are always sheathed in a poly- mer tube and the common end encapsulated with epoxy

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compounds.

The actual element in contact with the environment is the polymer tube. In fact, the characteristics of this element will, for all purposes, determine the resilience of the system. This little considered point makes nonsense of some critics of polymer fiber who complain of the plastic contents. The fact is that if we take a 2mm-polymer fiber and a glass fiber with the same optical diameter we will find out that the latter contains more plastic than the former. Naturally we are talking about a bare PMMA fiber, this is to say without cladding. PMMA fibers can be used bare, glass fibers cannot; must always be cladded. At the common end, the epoxy compounds make up to 17% of the total optical area to receive the light from the lamp. It is a well known fact that these potting adhesives behave erratically in the presence of high temperatures and steep radiation gra- dients, such as the ones present at the screen or focus of the lamp in the generator, light source or illumina- tor. This epoxy tends to age very quickly, darken, absorb more radiation, heat up and contribute to the pre- mature failure or deterioration of the system. On the other hand, glass fibers are very brittle. Studies show that vibration affects adversely glass fibers up to the point where shatter may occur. If the external sheath or tube becomes also hard and lose flexibility because of environmental factors then the light guide becomes extremely fragile.

15. . What are the advantages of polymer f iber opt ics?

The spectral transmission of PMMA fibers is difficult to improve upon, the quality of the light transmitted over distances longer than four or five meters is considerable better that the standard glass fibers. Cost is another factor; polymer fibers have a lower cost per optical area unit than glass, in part due to the easier manufacturing process. High quality PMMA systems rely on a fusion process to construct the common end, hence dispensing with the use of epoxy potting compounds. In all instances where the use of many fibers or light points is prescribed polymer systems are a much better option. Another point to bear in mind is the weight factor: glass fibers are heavier than polymer, a fact that may be critical in some applications, such as automotive and aircraft uses.

16. . And the disadvantages?

The ends of polymer fibers cannot operate with high temperatures. Light sources or illuminators are needed with a screen temperature lower than 60ºC. Although some polymers can work with 100ºC and over, the fact is that these constant high temperatures cause changes on the polymer chains, especially at the common end. This results on a hardening and blushing or blooming of the material, causing a deterioration of the system. The use of very powerful and hot illuminators with polymer fibers, in most cases is sheer madness. Although there is very little data on polymer aging, some manufacturers offer a 20-year guarantee on their systems, which is more than adequate in most instances.

Radius of curvature is a delicate mater with large diameter solid core fibers and has to be

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handled with great care in order not to alter the internal architecture of the fibers, which will result in losses. Bare or unsheathed fibers are very delicate and the external cladding becomes rapidly damaged due to abrasions and scratches.

17. . Can I l ight a house wi th f iber opt ics?

A house can be lit with anything, from candles and gas lamps to fiber optics. There is the question, however, of the efficiency of the system. One should never forget that a light source, such as an electric lamp, delivers its maximum output hanging free in mid air, and that any thing added, such as a coffer, a louver or an optical system of lenses or reflectors diminishes the performance.

Truth is that in most cases light issuing from a lamp in a spherical fashion is of little use because we want the light pointing towards a given direction, in order to perform a task. Nevertheless, is also true that anything around or in front of a lamp rests light to the general output of the system.

With fiber optics, this is no exception. The lamp enclosed in the illuminator would give a greater quantity of light if taken out and hung from a ceiling than pushing the light through fibers.

There is a common misconception amongst the public that if we have a 100 Lm lamp in one place and we run ten fibers to different rooms we would have a 100 Lm light in each room. This sounds very much like the parable of the bread and the fishes and clashes with the laws of thermodynamics, as we know them.

If you have a 100 Lm lamp in a box and run ten fibers out, the total combined output of the fibers will always be considerably less than 100 Lm, now and in the future.

18. . Are f iber opt ics eff icient as a means to transport l ight?

The straight answer is no. If we take any other means of light re-direction or distribution we will find out that are far more efficient.

19. . What can just i fy the use of f iber opt ics?

In the great majority of tasks, using traditional means, the amount of light used is far in excess to the quantity really needed. Most light goes to illuminate areas that do not need light at all.

With fiber optics, we can distribute minute quantities of light exactly where needed, an impossible feat with conventional lighting because light sources are too large.

The distinct possibilities to put the lamp within easy reach whilst the light is distributed in zones with difficult access is another advantage of fiber optics. The main reasons for the use of fiber optics in lighting are safety, control, miniaturization, cost and ease of maintenance.

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20. . Are f ibers safe?

Fiber optics are passive elements, therefore do not use power to generate light, as is the case with lamps. As light conductors only carry light from one point to another, never electricity.

Fiber optics can be put under, or in direct contact with water, can be cut, handled, broken or hammered and can never be anything but totally safe lighting conductors, with the exception of power conversion.

Because standard lighting fiber optics have a very restricted transmission window most radiation which could be harmful to beings or things is not transmitted. In fact the amount of infrared and ultraviolet issuing from a fiber optic is, in most instances, negligible.

The use of fiber optics in the lighting of museum pieces or radiation sensitive material is one of the main appli- cations of these light conductors.

There is, however, the phenomenon of power to light conversion on the extremes of the fibers: a very high temperature may be present, with the use of high powered illuminators, very close to the tip. If a light guide is cut, abraded or damaged in anyway along its length a very hot spot may ensue which can destroy the fiber and the surrounds. When using systems with high power densities additional precautions should be obser- ved to maintain safety in the system.

21. . Who makes f iber opt ics?

Glass manufacturers mainly make Glass fibers. Chemical companies fabricate PMMA fibers. Compa- nies, both public and private, manufacture other types of fiber optics, especially solid core polymer and gene- rally with their own proprietary process.

22. . How are f iber opt ics made?

The actual process varies considerably from one manufacturer to another. In essence, a large cylinder of core is made off high purity material, an element called preform. The preform is later heated or treated and drawn into a filament, which is then coated with the external layer with a different refractive index.

Other systems include co-extrusion, continuous casting, direct co-polymerization, injection, wet drawing and soft extrusion with mercury formers.

These later techniques, and others under research, try to attain a better alignment of polymer chains in order to improve transmission and reduce attenuation. In fact, the fiber stretching and tensioning after drawing to promote molecular alignment is one of the industry secrets.

23. . Are opt ical f ibers fragi le?

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Glass fibers are very brittle, in fact in any glass light guide there is a percentage of fibers broken during the manufacturing process, on the other hand, because these light guides are sheathed, once installed are very resistant to external influences.

Bare PMMA fibers are extremely delicate during manufacture and manipulation, requiring great handling care. Once sheathed are practically impervious to external damage.

Other solid core fibers are very tough because of an external Teflon cladding and can be installed without any problem. The only drawback with this type of optics is the hardening with age, which makes these conductors brittle and prone to shatter.

24. . Can f ibers be bent at r ight angles?

No. All fibers must be bent with a radius, which will not alter the internal architecture of the fiber. For every type and size of fiber, there is a minimum radius of curvature, specified and recommended by the manufacturer. Bending fiber optics at right angles will cause the conductor to shatter in the case of glass, and be permanently damaged in all other types

25. . Can l ight ing f iber opt ics be spl iced or joined?

All fibers can be spliced with more or less success and difficulty. The problem is the losses resulting from such a joint.

Fiber splicing is a common practice in the telecommunications industry where is done with sophisticated alignment apparatus and a considerable dose of skill.

Nowadays there are splicing systems for polymer light guides using special fittings and a refraction index equalizing gel capable of low price splices with minimal losses. In glass fibers where one would have to indi- vidually splice hundreds or even thousands of single fibers, splicing is not resolved yet.

Solid core fibers can be joined with greater ease but the losses are massive; up to 25% of the available light.

26. . Wi ll l ight go any length along a f iber?

All conductors have losses, and in the case of fiber optics, these are sizeable.

Light losses in the industry average 2 to 5% per meter or over. If we start with, say 100 units of light at the common end we will lose 25% at the end of five meters and over 40% after ten. In fact, most systems have losses greater than 50% over a ten-meter length.

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27. . How many sizes are there of l ight ing f iber opt ics?

Literally hundreds, from a few microns to over an inch in diameter, solid core and multicore, square shaped, ribbons, tapes and sheet.

28. . Can you put any amount of l ight into a f iber opt ic?

This is one of the standard fallacies of the industry. The system needed to put a sizeable amount of light into a fiber optic is very simple; a lamp, perhaps a lens and something to hold the fiber pointing at the light source. It follows that the bigger and more powerful the lamp the greater amount of light it will issue and the more light that will get into the fiber; at least this is the argument that most people think logical.

The problem is that optics is a subject far from simple. An optical fiber will accept a measure of light and no more, regardless of the power of the lamp: if a light source puts ten units of light through a fiber, another light source, twice as bright will not put double the light into the fiber.

There is one thing called power density acceptance which marks the limit to how much energy can circulate through a system, no matter how much more energy you try to force into it. A copper wire of a given thick- ness will be happy with five amps, get warm with ten, heat up with twenty and melt with forty.

29. . Do f iber opt ics transmit radiat ion?

Light is a radiation; therefore, the answer is yes. Some fibers, depending on the nature of the materials from which they are made, transmit one band of radiation more or less wide or restricted.

Generally, the fibers used for lighting transmit little or no ultraviolet, a very small amount of infrared and varia- ble quantities of the visible light frequencies.

Heat is a radiation on the infrared region and does not transmit well on standard lighting fibers. To put an example; the amount of heat that will build up inside a case with a volume of one cubic meter of air, is only one degree in 24 hours, from a 5mm diameter PMMA light guide powered by a 150W metal halide illumina- tor.

30. . Glass or polymer?

There is not an easy answer because it will always depend on the final use and working conditions of the system.

Generally speaking glass fibers are better suited for those environments where high temperatures are cons- tant and for data transmission. Glass fibers are very thin conductors only a few microns in diameter, therefo- re in order to construct a sizeable light conductor,

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hundreds or even thousands have to be bunched and she- athed together.

Bending radii are small and the performance is acceptable although glass fibers with comparable spectral characteristics to PMMA are considerably more expensive.

In essence both, glass and polymer systems have advantages and drawbacks, to be individually assessed in view of the actual application and working conditions. In recent times, however, there seems to be a general trend to abandon glass fiber optics in lighting applications in favor of PMMA.

31. . Can f ibers be made any size?

Theoretically, yes. There are, however, physical constraints because of the materials and utility. Very large fibers have proportional bending radii and are not very economical to produce. Under the all encom- passing classification of Remote Source Lighting, tubes made from special polymers and behaving like fiber optics are currently being manufactured, capable of being formed into light conductors over a foot in diame- ter.

32. . How long wi ll f iber opt ics last?

In the case of glass practically indefinitely due to the inert characteristics of the material. This refers to the actual fiber, and not to the polymer cladding. Also the common ends being an encapsulation of epoxy's will behave less predictably and perform erratically, depending of many factors, such as temperature of ope- ration and level of radiation exposure.

As far as polymer systems are concerned 20 years for the conductors is the standard guarantee in the industry. This also refers to the actual fiber, without reference to the common end whose average life depends on the same factors outlined before.

33. . Can several f ibers give the same amount of l ight?

No. If a number of fibers or light guides are coupled to the same illuminator, it is physically impossible that each receives the same amount of light and therefore transmit it. The spot or tack formed by a reflector lamp at the focus point or screen is not completely homogeneous, this is to say that it does not have the same quantity of light in each point of its surface. This problem is sometimes minimized by mixing the fibers at the common end (a process termed “randomizing”) but it can never be made totally even.

34. . What are side- emi tt ing f ibers?

There are no side-emitting fibers. All fiber optics receive the light at one end and transport it to the other. When light enters a fiber and travels through the core it encounters multitude of obstacles: microscopic cracks and fissures, impurities and other elements which

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obstruct the passage of some light and which, in turn, esca- pes through the outer cladding.

All fibers lose some light though the cladding because there are no perfect systems. This unavoidable effect is used to produce elements termed "side emitting fibers" which, in fact are normal fiber optics with a clear protective external cladding which permit to view the escaping light. In fact, some manufacturers induce stres- ses on the fibers, by means of torsion or bending to bruise the fibers and cause more light to escape along the way.

Some glass fibers are made side emitting, by the expedient method of cladding a bunch into a clear tube and breaking them at intervals. Clearly there comes a point along the tube when there are no more unbroken fibers to continue the process.

35. . Are there di fferent types of side emi tt ing f ibers?

Nowadays several types of side emitting fibers are marketed. The most common are: Solid core optics

Multistranded optics

Multistranded roped/coiled and woven/knitted optics.

36. . What are sol id core f ibers?

These optics are cylinders made of diverse polymers and encased on a transparent sheath or tube. As a standard are manufactured in different gauges or calibers from 3 to 25 or more millimeters in diameter.

37. . What are mul t istranded opt ics?

Multistranded optics are narrow walled tubes off transparent material, housing a number of smaller solid core fibers. The inner fibers are, generally 0,75mm in diameter and numbered from ten or less to seve- ral hundred, depending on the final use and diameter of the optic.

38. . What are coi led roped and woven/ kni tted opt ics?

Simply braided or woven ropes manufactured with thin solid core fiber optics, instead of hemp or nylon. Because of the strain produced on the individual fibers by means of the torsion, coiling or knitting, the fibers have greater losses along the length. This means that more light is available for side viewing purposes.

39. . Sol id core or mul t icore?

That will depend on the use to which the optic is put and the actual installation conditions. Solid core optics have generally, a larger bending radius to avoid important losses.

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Furthermore, because of the trans- parent quality of the core, unless the contrast with the background is adequate the appearance is that of infe- rior luminance.

Multicore optics, on the other hand, have a more flexible construction, especially in large diameters. Becau- se of the reduced transparency of the optic, the luminance appears greater.

Solid core fibers can operate in some types with higher screen temperatures and can be connected (at least in theory) to generators that are more powerful without damage to the core. It must be said, however, that the long-term effects, especially those related to the power density of the systems, are as yet undetermined.

40. . Can side emi tt ing opt ics be as br ight or br ighter than neon?

Fiber optics can be made to be brighter than neon but only for very short distances. We can think of a garden hose as an example: making tiny holes along the hose can cause a sizeable amount of water gus- hing out of the holes nearer the tap, and for a distance that will depend on the size of the holes. If we make the holes larger a greater amount of water will issue, but only for a shorter distance until it only trickles.

There is a limit to the quantity of water that can be made to pass through a hose, a limit given by the mate- rial of the pipe and the viscosity of water. We simply cannot increase pressure infinitely.

The limit on the quantity of light traveling through a fiber optic is also imposed by physics: the actual material of which the optic is made and the intrinsic qualities of light. There is a power density limit to each material. In some systems, especially with late generation purpose made metal halide illuminators, luminance values greater or equal to that of neon may be obtained for lengths up to few meters. The sizeable cost of these sys- tems when compared to neon makes the proposal impractical in most cases.

41. . Wi th all the l imi tat ions, what are the uses of side emi tt ing opt ics?

There is a common misconception about the quantity of light needed for a given task: more light is not necessarily better, and often is worse than the right amount with the correct characteristics.

In many instances, small quantities of light to demarcate, decorate or accent are much better than a glaring neon-like line.

A good example that comes to mind is the uses in theatres, cinemas and public buildings to line out corridors, aisles and emergency exits: in these instances the brightness of neon would simply not be acceptable. Cou- pled with the beauty of color change capabilities side emitting optics are a valuable tool in the hands of the designer for outlining buildings, both externally and internally, pools, spas, cornices, gardens, and all kinds of architectural details.

Another point not to be forgotten is the total safety of fiber optics. There is no electricity in them. This means that in all those instances where high voltage neon simply cannot be

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contemplated because of danger, main- tenance or fragility; side-emitting fibers can be the only sensible alternative.

42. . What are the design constraints to side emi tt ing opt ics?

The actual illuminance of side emitting optics is low, although the luminance is quite acceptable in most cases. This means that if the contrast values are correctly applied the visibility of the optics can be excellent. The actual quantity of ambient illuminance, the colors of backgrounds, distance and line of vision are para- meters to be carefully balanced, in order to obtain the best results.

43. . Could the l ight along a side emi tt ing opt ic be total ly homogeneous?

Despite the assurances of some manufacturers, this is a total impossibility because it would clash with the laws of physics, as we know them.

In order for an optic to display the same illuminance along a given length, it would have to be perfect: with no losses.

As soon as light is produced by an emitter starts to decay, in a similar fashion that a bullet starts to lose speed from the moment it issues from the muzzle of a gun.

The light is not the same inch by inch in an optic as it leaves the optical port of the illuminator: the farthest from the light source, less light, due to the attenuation of the optic.

44. . Wi ll we always see a di fference in br ightness along an opt ic?

Not necessarily so. The human vision system appreciates illuminance grades in a logarithmic fashion and if the transition was smooth would be very difficult to actually notice the difference.

If we observe an optic of, say 30 meters, from one end to the other along the optic it would not matter in which end is situated the illuminator: we would see the optic homogeneously lit, although we know that it is not pos- sible. If we were to look at the same optic sideways, from some distance, then we would notice the differen- ce in luminance, because we could compare both ends.

The judicious use of illuminators, daisy chaining the optics, restricting the length of the fibers to that recom- mended by manufacturers, the control of the contrast and the angle of vision, are the tools needed for a suc- cessful installation.

45. . Can l ight be made to move or chase along a side emi tt ing opt ic?

With roped or braided multicore fiber and a special process at the common end optics can be made to chase in both directions and display multiple colors at the same time.

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46. . Are the side- emi tt ing f ibers wi th ref lect ing core more luminous?

To answer this question honestly is very much like trying to determine the sex of the angels.

If a side emitting light guide has a center reflecting core it would appear that it would issue more light omni directionally, this is to say: if the light guide was suspended in mid-air and viewed from any angle.

The problem with that argument is that those optics are, normally attached to a support and viewed from fixed angles. The opaque centerpiece, in this case, would impede the passage of light from behind the core and hence the optic would have less light available to the viewer.

Side-emitting light guides are sheathed in a transparent cover and the viewer, by transparency, has the bene- fit of the light escaping not only from the individual fibers placed directly in front of his line of vision but also from the ones behind.

If we take a glass tube filled with a colored liquid and light it up from one end, we could view the whole of the mass as a lit-up cylinder. If we then place a concentric opaque core, from a given direction we would have less vision of the cylinder mass. The same would hold true with any transparent cylinder.

To prove this argument is a practical impossibility since it would require two optics, with and without core of the same size and optical properties, placed exactly on the same spot in an illuminator. In my opinion, no mat- ter the patents, the so-called center reflecting cores do not add more light to a guide and probably rests light to the viewer and the system as a whole.

47. . Is there any way to improve side- emi tt ing viewing?

A side emitting light guide is viewed optimally when the contrast between the optic and background is maximized. If the light guide is placed on a white track or against a tight opaque white back the light is more apparent.

This does not mean that the optic issues more light, only that the illuminance falling on the background impro- ves the overall luminance of the optic.

**I L L U M I N A T O R S**

48. . What is an i l luminator?

An illuminator, light source or generator is a box with a lamp inside, pointing towards an opening where fiber optics are secured. Naturally, this is an over-simplification, although in reality a large number of the illuminators available in the industry are little more than this.

49. . What makes a good i l luminator?

Illuminators must perform three separate tasks with a degree of efficiency. Firstly must

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house a lamp and its power source, transformer, ballast, igniter and wiring in a correct and safe manner.

Secondly, it must focus the light of the lamp in the most efficient way to ensure an adequate performance. Thirdly, it must create a suitable environment to guarantee the long life of the common end, this being the union with the fiber optics. With this last task in mind, an illuminator must be designed to minimize the ther- mal load on the screen by all possible means, filters, forced ventilation, air ducting and deflectors.

50. . Is bigger better?

It is somehow surprising that manufacturers place great emphasis in the power consumption, stating that a machine is 50, 100 or 400 Watts, when in reality this has little bearing on the overall performance of the illuminator.

In the lighting industry, the performance of a lamp is measured in a number of ways, depending on the com- parison standards. The accepted data regarding a lamp's virtues are, usually, efficiency and light output, although the single must important element is the burner size.

Efficiency, determined in Lm/W, states the amount of light that a lamp produces for each unit of energy used. Is very low on incandescent lamps, where most of the energy is transformed in heat and very high in fluo- rescent and some types of discharge lamps, such as low-pressure sodium. Unfortunately, neither of these last lamps can be used sensibly with fiber optics.

The amount of light that a lamp makes is a useful piece of information when we try to light up a warehouse or an office table but useless when used to project and concentrate light on a given point. In this case the screen of the illuminator or the fiber common end.

The actual quantity and directionality of light reaching the screen, having little to do with the power con- sumption of the machine, is the only measure of performance in an illuminator.

Many lamps, specially the latest arrivals, have much improved light outputs, better beam control and preci- sion. Paradoxically a last generation 50W-halogen lamp with a dychroic reflector puts more light into a fiber than a 75W lamp with a similar construction and outdated technology.

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51. . How many types of i l luminators are there?

Since there are no standards in the industry, the term "type" is slightly confusing.

With regards to power usage, the lamp illuminators vary from as little as 5W to as much as a 1.000W and more.

As far as the type of lamp, illuminators are divided into two families: those using incandescent lamps, gene- rally halogen, and the ones equipped with gas discharge lamps.

Illuminators can also be typed by use. Some are mainly used for lighting and others to produce effects such as animations, color change or twinkles and sparkles.

52. . Halogen or gas discharge?

Again, it will depend on the use of the system. Gas discharge lamps, especially those with a very small plasma area are ideally suited for use with optical systems such as lenses or reflectors. Consequently, the quantity of light aimed in the right direction can be far superior to that of a halogen lamp. Lumen output of these lamps is, usually greater than their incandescent counterparts. Conventional means cannot be used to regulate the output of gas discharge lamps. This means that if regulation is required mechanical irises or com- plex high frequency oscillators have to be used.

Halogen lamps are smaller, less costly, and need simpler power supplies but give less overall light.

For lighting and side light applications, gas discharge is used universally, reserving the less powerful halogen light sources for effects and decoration.

It must be said, however, that if the correct halogen lamp, with the right projection angle is used, excellent results can be obtained with small diameter harnesses.

53. . Must all i l luminators have forced vent i lat ion?

Generally yes, the exception being those with a massive construction, which dissipate heat by radia- tion or transfer.

54. . How noisy is an i l luminator?

Very noisy, slightly so or totally silent, depending on the power source and the construction.

Heat dissipation is something that has to be done by one of two means: radiation or ventilation.

If radiation is the method chosen then the housing must have the mass and surface to ensure dissipation of the heat. In ventilated systems, the air is the agent for cooling and must be evacuated and renewed. The pro- blem is that some light sources are so hot that would need an oversized housing to dissipate all the heat build up, clearly not a very practical solution.

Silent illuminators use normally small halogen or gas discharge lamps, devoid of mechanical ventilation and relying on radiation to cool the housing and dissipate the heat. Generally,

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works well only if placed outdoors or in a volume where the ambiance temperature is considerable lower than that of the housing.

Forced air drought is used in most power illuminators and the noise can range from 20 or so dB to 70 or 80dB. Taking into account that noise in a forced air system is relative to duct size and air speed, in addition to ven- tilator speed, mounting, vibration and other related aspects is easy to suspect that design can vary the amount of noise that a illuminator produces. This can be brought down to a minimum that can only be further reduced by damping with noise suppression material.

55. . Are cert i f icat ions important?

That will depend on the type of certificate, what is certified and by who is granted. Many certifications refer to the inherent safety of a product, with regards to accidental electrical shock. In fact some certifications attest to the fact that the contraption will not kill you, but say nothing, or very little, as far as the performance of the product. The certificate on a washing machine says nothing to the effect that the thing will wash clothes; only that is unlikely that you will get an electrical shock.

Some other certifications refer to the performance, but unfortunately, these are not compulsory. In the fiber optics industry even these certificates are, very often meaningless because there is little or no control on the interface between illuminator and fiber. A laboratory report will say that a illuminator delivers so many screen lumens but cannot say how many will get into the fiber, because that will depend on a number of factors totally outside their scope.

56. . Are machines wi th the CE mark cert i f ied?

The CE mark was a good idea in its inception but it has been so much abused that has become prac- tically meaningless for the end user.

CE is not a certification or a quality mark, moreover is not granted by any official body or controlled in any way, distributors or end users have no right whatsoever to demand a CE certificate from the manufacturer, even if his products bear the stamp.

CE is a declaration from the manufacturer stating that the object complies with CE directives and regulations. Really is the equivalent to taking the words of a used car salesman as Gospel truth.

The market is awash with shoddy products of uncertain origin and parentage bearing the CE mark, products that, obviously, do not conform to any regulation whatsoever.

In a resume: the CE mark does not attest or imply any quality or fitness for use of the object bearing the stamp. It only says that the manufacturer declares that his product is built in accordance with the community directives, under his own responsibility and without effective control by an official body.

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57. . How then do I recognize a product ' s qual i ty?

There are a number of ways. The name and status of the company making the product is important and its geographical location. Some countries are famous for making good quality products and others just the opposite.

The stamp of approval of an internationally recognized testing organization is a sure way of knowing that the product has been tested and found built to very high standards. Generally, such institutes or laboratories have follow-up programs that control the manufacturing and quality processes of the manufacturer.

It can be said, with a level of certainty, that a machine bearing one or several such stamps has a traceable pedigree and is well made.

58. . What about ISO 9000 ?

Again there seems to be confusion about the ISO 9000 series of certifications. The ISO in essence is not a guarantee of good quality and is not given to an object but to a company.

ISO 9000 is, in lays terms, a system that removes anarchy from management or production, making sure that things are made always the same and with the same quality, which is not a mean feat.

It does not guarantee that the products are good but with a constant in quality. If a manufacturer makes a good gizmo or widget, the ISO 9000 certificate guarantee that it will always be good. For the same token if someone makes a bad product the ISO will ensure that is always bad. A combination of ISO 9000 and labo- ratory certificates on a product is the surest way to ascertain that an object, an illuminator in this case, is good and will remain so.

59. . How does a color change works?

It consists generally of a small, geared motor with a disc. This can be made of glass, glass segments or a polymer material in a number of colors.

The motor causes the disc to revolve in from of the common end, altering the color of the issuing light. Lower priced systems use colored films or glass whilst most others make use of dychroic filters.

In animation illuminators instead of a disc, there is a turning drum of glass or polycarbonate with color films or varnishes applied in special patterns to create movement and rapid color changes.

60. . What is a dychroic f i l ter?

A thin flat piece of glass with a metal deposition in one of the surfaces applied in a high

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vacuum envi- ronment. The metal layer, only a few atoms thick causes interference in the

incoming light, letting some fre- quencies pass whilst stopping others.

This frequency separation has the effect of producing very saturated and vibrant colors.

Depending on the deposition type, all visible light can be allowed to pass through, whilst

stopping infrared or ultraviolet radiation. In fact, there is a dychroic or interference filter to

separate practically all frequencies in the spectrum.

61. . Are heat fuses necessary?

The working temperature range of the fiber optics common end is critical if the

performance of the sys- tem is to be maintained and the life guaranteed. A heat fuse of

thermostat must be installed in such a way as to disconnect the illuminator should there be a

heat build up.

Heat can accumulate rapidly for a number of reasons: a failed fan, obstructions on the air

passages or poor ventilation. A 50ºC thermostat should be the most adequate.

It must be borne in mind that the ambiance temperature in which illuminators must operate

seldom allow more than 25ºC, a very low temperature to maintain in most instances.

62. . Can mul t iple i l luminators change colors simul taneously?

Yes. Generally the standard disc rotating motors are of the synchronous type, very

reliable, and gea- red to the most adequate speed. The problem is that, although individually

these motors work fine, is difficult to make two or more act in perfect synchronization with

each other without additional mechanical or electro- nic gear.

A simple micro switch and an adequate wiring can make any number of synchronous motors

operate at the same time in perfect step.

Some manufacturers offer a variable speed synchronizer to control their illuminators with

special motors, zero settings and electronic control gear.

63. . Can i l luminators be computer control led?

Practically everything can be computer controlled and illuminators are not an

exception. Color discs, lamp voltage and mechanical shutters, in the case of gas discharge

lamps, can be programmed and contro- lled with a computer.

This is normally offered as an option on most illuminators, using step motors and DMX control.

64. . What is DMX?

A communications protocol between an electronic circuit and step motors and

actuators. A kind of lan- guage between elements so that different manufacturers can use

compatible components which will work happily understanding the same data.

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**E N D S , F I T T I N G S A N D T E R M I N A L S**

65. . What are end terminat ions?

Again, we find ourselves in an area where a lot of confusion and controversy are the

order of the day. Some American institutions have tried to set standards as to the correct

terminology to be applied in fiber optics specification. The problems is that not every

manufacturer is American and was not asked their opinion in the matter, hence many people

use different names referring to the same part or component.

With Illuminators happens the same as with ends, one can see reflected in manufacturer's

literature names such as: light engine, light source, generator, etc. All refers to the same box

with lamp inside.

End terminations suffer the same fate: single end, fiber end, single termination, emitting end,

tip, end, final, common end, bundle head, head, end ferrule, etc.

In order to set a common ground we will use the term single end and common end.

Terminations therefore are the extremes of a single fiber or a group of fibers.

66. . What are single ends?

The extreme of the fiber optics conductor farthest from the illuminator. The bit that emits

light or the end that lights up.

67. . Are there many types of single ends?

Single ends can be anything from a simple cut with snips or a cutter to a sophisticated

polished encap- sulation. The actual technique used depends not only on the type of fiber but

also on the application of the system.

68. . Is the f iber end important?

As far as the actual light output the fiber termination has little influence on the overall

light output. It is however, very important, when at the single end will be fixed some lens

system. Imperfections, scratches, dig and fractures at the single end termination will show as

darker patches on the resulting beam.

The mechanical connection between the single end and the finishing piece, being a board or

housing is also dependent on the actual finish and precision of the single end. Ferrules,

machined pieces and connectors have to be scrupulously free of adhesives and with even

diameters, to ensure a precise fitting.

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69. . How are glass f ibers ended?

Glass fibers are, generally potted or encapsulated at the single end with the help of an

epoxy adhesi- ve or compound. This results on a very hard element of fibers and adhesive

that, when hardened, is suitable for cutting flush and polishing or buffing.

This encapsulation is generally enclosed on a hollow brass tube, rivet or machined piece,

which then serves as a fixing, or positioning aid.

Glass fibers permit some sophisticated single end termination to support extreme

temperatures or working conditions. Special potting adhesives can be used and ends

processed to an operating temperature of 400ºC, indicated for oven and burner sensors and

controls. In these instances, special thermal bridges have to be built into the fiber to protect

the conductor.

Other terminations can be in the shape of wafers, rings, blocks or lines for machine vision,

instrument ligh- ting, microscopy and other highly specialized lighting applications.

70. . How are polymer f ibers terminated?

PMMA fiber single ends can be of several types always depending on the nature of the

conductor and the final application. A Simply cut fiber with cutters or snips is a standard for

decorative, display and sign uses. The same type of encapsulation as for glass fibers can be

used with multiple single conductors and for the same applications with the exception of high

temperature work.

For most decorative and lighting uses PMMA fibers are considerably more user friendly than

glass fibers. Very simple tools and little skill are, in most instances, sufficient to produce

stunning results on site, without having to result to factory custom made and cut components

which results in dramatic cost reductions.

PMMA fibers can also be polished to a mirror finish with buffing compounds and machines

without encapsu- lation for single fibers. Common ends must always be fused together,

without using adhesives. Some fiber manufacturers specifically render their guarantee void if

adhesives of any kind are used at the common end. Fusion produces a solid block , which can

the be polished to a very high optical finish.

71. . How are sol id core f ibers terminated?

The very architecture of solid core fibers makes the precise termination a difficult

operation, although it must be said that in most applications a precise end is academic.

Solid core fibers are considerably softer than PMMA or glass and hardness is a pre-condition

for precise polis- hing. Additionally if an attempt is made to polishing, the compounds,

(whether Cerium based or otherwise) are always in a wax or grease medium and seep in

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between the Teflon coating and the core, ruining the optic. Standard finishing techniques for

the single ends dispense with polishing and resolve to cutting with special tools where the

quality and sharpness of the blade determines the accuracy of the cut. Further polishing can

be accomplished with thermal treatment but only in factory installations.

Research is under way to polish solid core fibers using very low temperatures or else with

water jets and laser cutters with uncertain degree of success.

72. . How are coi led, twisted or roped f ibers terminated?

In general terms the same techniques as with PMMA apply, since these optics are no

more that 0,75mm diameter PMMA fibers bunched together.

In the case of coiled optics the sheath and the internal core (if existing) has to be removed

because of the different nature, melting point and physic characteristics with respect to the

fibers.

Wherever possible both extremes of a sidelight light guide should be fused and glass polished.

73. . What is a common end?

The fiber or fibers have to be connected to the illuminator. Especially in the case of a

number of fibers, these have to be bunched together and held securely. The common end is

the grouping, fusion or encapsu- lation where all of the fibers from a bundle come together

and are cut flush and even, polished or prepared to connect to the illuminator port.

74. . Is the common end important?

Although manufacturers place more attention on fibers and illuminators the common

end is a vital piece for the correct operation of an optical fiber system.

A properly engineered common end must pack the fibers tightey without adhesives and be

suitable for fine polishing.

Most failures on fiber optics are due to a bad common end design and construction.

The use of potting adhesives is the single cause most commonly found in harness failure, both

in glass and PMMA systems and should be avoided at all costs since it only reduces the overall

life expectancy of the sys- tem.

75. . What makes a good common end?

The capacity to hold the fibers ever and flush, lack of adhesives, optical polish and

absence of packing losses.

76. . How many types of common end are there?

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Basically two: adhesive encapsulated and state of the art fused, although some

manufactures dispen- se with both and simply fasten the fibers to the illuminator by means of

a pressure gland.

77. . What is a randomized common end?

When several light guides are bundled together into a single common end it becomes a

physical impos- sibility to attain the same level of light in each light guide because the lamp

emission is not totally even on the screen plane. In order to minimize the differences

individual fibers are mixed or "randomized" so that each light guide gathers its light from

different geometrical points within the screen. Light issuing from individual ends in a

randomized system is considerably more even but not perfectly so.

In polymer fiber systems state of the art optical randomizers can achieve greater evenness with little

loss.

78. . What are end f i tt ings?

Practically the only part of a fiber optic system that the public ever sees. End fittings are

the elements for fixing, aiming, supporting and finishing the fiber ends.

79. . How many types of end f i tt ings are there?

Literally thousands for every thought or dreamed up application. From small bullet

lenses to very large pavers, floor and pool lights. From simple rings and bezels to complex

optical trains with several lenses, besi- des hundreds of custom designed elements for specific

applications and uses.

80. . Fi tt ings or f ixtures?

In the industry, these terms are used indistinctly and often together. Some

manufacturers describe fittings as the fixing elements, such as connectors, ferrules, machined

ends, tubular rivets and bezel rings, reserving the term fixtures for large elements, swivel

rings, pool luminaries and the like.

Other manufacturers use the term fitting to describe anything at the end of the fibers.

81. . Who manufactures end f i tt ings?

Every system manufacturer produces a range of end fittings designed to be used with

their own fiber system.

82. . Are end f i tt ings standard?

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As a whole no. Each system manufacturer favors a kind of termination for his fibers with

pressure glands, threads, rivets or machined pieces as connectors for his own fittings. Due to

the absolute lack of stan- dards in the industry, it becomes impossible to use one

manufacturer's fittings with the fibers of other.

83. . What is an opt ical port?

In the fiber optics industry, optical port is the element that physically makes the

connection or interfa- ce between the illuminator and the harness. In its simplest form, an

optical port is made of male and female tubes fitting one inside the other with a retaining

screw or other fastener. More sophisticated optical ports include filter holders and various

devices to adjust, conform and cool the common end.

84. . Are there di fferent types of opt ical ports?

Optical ports can be divided in two types: potting and pressure. Potting optical ports are

little more than a hollow tube into which the fibers are introduced and encapsulated with

some adhesive, making a block to be later polished.

Pressure optical ports are more sophisticated and include seals to grip tightly, by means of a

tool, the har- ness of fibers.

Glass fibers are always prepared in potting optical ports whilst solid core fibers use pressure

optical ports. PMMA fibers can have the common end in either.

85. . Who manufactures opt ical ports?

All system integrator produce a particular type of optical port to connect to their choice of

illuminator.

86. . Are opt ical ports compat ible?

In general no. Illuminator manufacturers use a particular type of optical port to effect

the connection with the common end. As a whole, the harness made by a given manufacturer

will not fit into the illuminator made by another without retooling.

87. . What is a f iber opt ics system?

The term comprises all the necessary elements to install a working unit.

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**S Y S T E M S**

88. . What is a f iber opt ics systems integrator?

A fiber optics system integrator purchases the bulk fibers from a fiber optics

manufacturer, and ende- avor to manipulate, cut, polish, assemble, pack, produce and market a

final product.

89. . What is the di fference between a f iber opt ics manufacturer and a f iber

opt ics system manufacturer?

This is a question that would sound silly in other industries but not in this one. Many

firms hint, or even affirm in their brochures and catalogues to be fiber optics manufacturers

when this is simply not true. A Com- pany that manufactures fiber optics is the one that

transforms polymers, monomers or glass raw materials into rods and filaments, cladding

those with other elements to, finally create bulk fiber optics.

One can readily see the difference between a glass manufacturer, a glass merchant and a

window manufac- turer. The first takes sand and melts it into glass the second stores and

trades with glass and the third incor- porates glass into his final product: a window.

If one looks at the giant chemical and glass corporations it's a fair bet that they are fiber

optics manufactu- rers.

On the other hand, most fiber optics companies are System Integrators. This is to say that

they do not make fibers, just like the window producer does not make glass.

90. . Who are the best f iber opt ics manufacturers?

To single out a company would be grossly unfair because in this business the players

are, generally, respected industrial corporations with impeccable quality reputations.

State of the art fiber optics cannot be made in a garage shed and huge investments have to be

made in plant, equipment and human resources to produce optics of any kind.

The overall quality of fibers in the market is exceptionally high and it must be said that the

failures and disas- ters that may have happened have had nothing to do with the quality of the

fibers but with the handling and application of systems.

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91. . Who are the best systems integrators?

Being quite the opposite to fiber optics manufacturers, system producers

are usually small companies. In this case size has the opposite effect on the

final product because fiber optics system design require an inordinate amount

of ingenuity, talent and technical expertise even for tiny projects. The fast

responses, ins- tant drawings, quotations and studies normally demanded are

very hard to produce in a corporate environ- ment.

Naturally, this means that some system integrators are little more than a oneman

band and some operations are run on a shoestring with more enthusiasm

than resources.

On the other hand many system integrators have very little know-how and

soon get into trouble with the laws of physics.

Product certification, documentation, information and references are the

easiest way to ascertain the profes- sional reputation of a manufactures

In this industry when detailed and precise technical information is not

forthcoming and things are shrouded in a veil of secrecy, it usually means that

for the manufacturer the thing is also a mystery.

92. . How many parts does a f iber opt ics system have?

Depending on the final use the most common parts to account for in a

basic system are: illuminator, fiber bundle, bushing and end fittings.

Additional fittings, fixtures, controlling units and power sources may be used

harness, optical port.

93. . Are f iber opt ics systems expensive?

To determine whether a system is expensive one would have to

establish a comparison with an alter- native, which in most cases does not

exist.

To compare fiber optics with a standard off the shelf light fitting, lamp or

system is an unfair rule of thumb because fiber optics are unique.

Fiber optics systems can carry minute or large amounts of light to, practically

any place with precision, wit- hout heat or electricity and with the light source

far away.

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If the fiber optics system is to be used in applications where the above values

were of no consequence then one would have to say that there is no need for

it.

Fiber optics are not the universal solution to all lighting problems but a tool or

a technique to be used in cir- cumstances where other systems would be at a

disadvantage or even totally inadequate.

If one compares a one point of conventional light fixture with a one-point fiber

optics system then the price difference would weigh heavily in favor of the

standard fixture. If we compare several fixtures and one fiber optics system

with several light guides and one illuminator, taking into account the

maintenance advantages and power savings, then one would have to concede

that fiber optics are cheap.

94. . Wi ll f iber opt ics systems be cheaper in the future?

Lighting fiber optics is not a mass-market product and perhaps will never

be. Even today most systems are, at least in part, hand crafted or produced in

small batches of a few hundred units at most. Very few items are made in the

thousands, with the exception of injected parts, which have a very low unit

cost.

From a manufacturing point of view short series are very expensive to

produce, since the cost advantages of bulk purchase and manufacturing are

missing.

Fiber optics groups or harnesses could easily be mass-produced with very

important savings, which would reduce unit costs drastically. The problem is

that very seldom, harnesses are of the same size or have the same fiber

composition. Consequently, they have to be hand tailored, practically one by

one, which results on very high production costs.

Another reason for the high unit costs of systems is the technical backup that

system manufacturers have to provide. Nearly all of the installations have to

be individually assessed, studied and estimated in house, because of the lack

of widespread technical expertise elsewhere. This means that expensive

technical departments have to be kept in order to provide know-how on a

daily basis.

95. . Are f iber opt ics systems di ff icult to instal l?

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Again, it becomes important to establish a fair comparison with other

elements, in this case ordinary light fixtures.

Fiber optics systems, as a whole, are easier to install than electrical fittings.

Sometimes displays, panels, ceilings, effects or projects are made involving

thousands or even hundreds of thousands of single optical fiber ends which, to

be fair, are a challenge to install.

The problem in these cases is of sheer numbers, size and complexity. In any

case to install a point of fiber optics is considerably easier than to install an

electrical point.

96. . What is a starry sky?

Probably one of the most beautiful lighting effects that can be created,

which can be very simple or quite sophisticated.

In its simplest form, a starry sky effect is made with a number of small

diameter fibers coupled to a large solid core, which delivers the light from the

illuminator. This creates a number of static points of the same diame- ter,

which can be quite effective if a little flat.

More elaborate systems use several fiber caliber's, from 0,25mm to 3mm

diameter and run directly to the illu- minator. The several sizes of fiber make

for different intensities on the point light, giving the effect of distan- ce and

perspective creating great depth. Coupled with a twinkle effect wheel the

effect can be quite stunning.

97. . What is an effect wheel?

A disc of metal or polycarbonate revolving between the lamp and the

common end with holes, slits, colors or patterns.

98. . What is an animat ion harness?

A group of fiber optics arranged in a sequential fashion and numbered.

The fibers are then installed in the same order and, with the help of special

illuminators, movement can be added to lines or patterns.

99. . What are spat ial effects?

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Representations of comets, nebulas, shooting stars and others, made with

often thousands of indivi- dual fibers and animation illuminator.

100. . How would you descr ibe in one word f iber opt ics l ight ing systems?

Magic

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