UNIT II - INDUSTRIAL APPL . OF OPTICAL FIBRES

PART A

1.What are the properties that can be sensed using Fiber Optics?

The properties that can be sensed using Fiber Optics are,

•Acceleration

•Chemicals/Gases

•Color

•Displacement

•Flow

•Force

•Humidity

•Liquid Level

•Magnetic/Electric Fields

•Moisture

2.What is fiber optic gyroscope?

One of the more important fiber optic sensors is the fiber optic gyroscope, capable of measuring rotation rate. The principle of operation of the fiber optic gyroscope is based on the Sagnac effect.

3.What is a modulator?

Optical carrier waves can be modulated in Amplitude, Phase and Frequency in order to carry information. Modulators modulate the carrier wave by changing the material properties of attenuation 'a' and refractive index 'n.' In suitable materials a and n can be modulated at high frequencies by time dependent electrical fields (EO), magnetic fields (MO) or acoustic fields (AO). The external modulators produce much less chirp (dispersion) than eg. current-modulated SC-diode lasers.

4.What are the different types of modulators?

The different types of modulators are a)Electro optic modulators, b)Acousto optic modulators, c)Magneto optic modulators. d)Electro absorption modulators.

5. What is a acousto optic modulator?

An acousto-optic modulator (AOM) is a device which allows to control the power, frequency or spatial direction of a laser beam with an electrical drive signal. It is based on the acousto-optic effect, i.e., the modification of the refractive index by the oscillating mechanical pressure of a sound wave..

6. What are the important parameters of optical detectors?

i)Responsivity: Ratio of current output to light input. High responsivity equals high receiver sensitivity.

ii)Quantum Efficiency: Ratio of primary electron-hole pairs created by incident photons to the photons incident on the detector material.

iii)Capacitance: Dependent upon the active area of the device and the reverse voltage across the device.

iv)Response Time: Time needed for the photodiode to respond to optical inputs and produce and external current.

7. What is the principle of fiber optic sensor? In a fiber optic sensor, one or more of the following characteristics of a propagating lightware is altered and correlated to an externally-induced physical or

chemical parameter:
•Intensity
•Phase
•Frequency (color)
•Polarization state
•Time-of-flight
•Modal cross talk

8.What are the advantages of fiber optic sensor?
The advantages of fiber optic sensor are, a)freedom from EMI, b)Wide bandwidth, c)Compactness, d)geometric versatility and economy

9. What are laser diodes? Laser Diodes
are complex semiconductors that convert an electrical current into light. The conversion process is fairly efficient in that it generates little heat compared to incandescent lights. Five inherent properties make lasers attractive for use in fiber optics.
1. They are small.
2. They possess high radiance (i.e., They emit lots of light in a small area).
3. The emitting area is small, comparable to the dimensions of optical fibers.
4. They have a very long life, offering high reliability.
5. They can be modulated (turned off and on) at high speeds.

10. What is an LED?
LEDs are complex semiconductors that convert an electrical current into light. The conversion process is fairly efficient in that it generates little heat compared to incandescent lights. LEDs are of interest for fiber optics because of five inherent characteristics: 1. They are small.
2. They possess high radiance (i.e., They emit lots of light in a small area).
3. The emitting area is small, comparable to the dimensions of optical fibers.
4. They have a very long life, offering high reliability.
5. They can be modulated (turned off and on) at high speeds

11. What are the classification of fiber optic sensors?
i)Based on modulation and demodulation process: Sensor can be called as an intensity (amplitude), a phase, a frequency, or a polarization sensor
ii)Based on their applications: a)Physical sensors (e.g. measurement of temperature, stress, etc.); b)chemical sensors (e.g. measurement of pH content, gas analysis, spectroscopic studies, etc.); c)bio-medical sensors
iii) Extrinsic or intrinsic sensors

12. What is extrinsic and intrinsic sensors?
In the extrinsic sensor, sensing takes place in a region outside of the fiber and the fiber essentially serves as a conduit for the to-and-fro transmission of light to the sensing region efficiently and in a desired form. The fiber merely acts as a light delivery and collection system, i.e., the propagating light leaves the fiber, is altered in some way, and is collected by the same fiber. On the other hand, in an intrinsic sensor one or more of the physical properties of the fiber undergo a change as mentioned in above. The fiber

itself acts as the sensing medium, i.e., the propagating light never leaves the fiber and is altered in some way by an external phenomenon.

13.What is polarization?

Polarization is a phenomenon peculiar to transverse waves, i.e., waves that vibrate in a direction perpendicular to their direction of propagation. Light is a transverse electromagnetic wave . Thus a light wave traveling forward can vibrate up and down , from side to side , or in an intermediate direction. Ordinarily a ray of light consists of a mixture of waves vibrating in all the directions perpendicular to its line of propagation. If for some reason the vibration remains constant in direction, the light is said to be polarized.

14. What is a Fiber Optic Polarimeter?

The birefringence property arising from optical anisotropy is used in the study of photoelastic behaviour . The anisotropy may be due to naturally occuring crystalline properties or due to stress induced birefringence. It is the latter that is used in a photoelastic fiber optic strain gauge. In a simple setup two lead fibers are used to illuminate and collect light passing through a photoelastic specimen.

15. What is Pockels effect?

Pockels effect refers to the change of refractive index of the medium by the applied electric field. Due to phase shift or phase retardation is produced in the transmitted polarized light and hence there in a change in the intensity of the transmitted light.

16.What are the laser diode performance characteristics?

a)Peak wavelength b)Spectral width c)Emission pattern d)Power e)Linearity

17. What is Kerr effect?

Kerr effect change in the refractive index proportional to the square of the electric field. All materials display the Kerr effect, with varying magnitudes, but it is generally much weaker than the Pockels effect.

18. What is the principle of micro bending sensor?

Micro bending sensor is based on the production of micro bending in the fiber by the given variable and the measurement of intensity of the transmitted light through the fiber. The micro bending produces phase shift and coupling between different modes present in the transmitted light.

UNIT - II

INDUSTRIAL APPLICATION OF OPTICAL FIBRES.

1. Explain the working principle of different types of modulators with neat sketches.

* Internal modulators
  - placed in resonant cavity of laser diode

* External modulators.
  modulate the laser light outside the resonant cavity.
  ⇒ Electrooptic modulator.
  ⇒ Magnetooptic "
  ⇒ Acoustopetic "

* Electrooptic – kerr effect
$$\Delta n \propto E^2$$
$$\Delta n = K \lambda E^2$$

* Magnetooptic – Faraday's effect.
$$\theta = VBL.$$
$$\theta = \frac{2\pi}{\lambda} \Delta n L.$$

* Acoustoptic – photoelastic effect, $\Delta n \propto$ square root of acoustic power.
$$\theta = \sin^{-1}\left(\frac{\lambda c}{2\lambda s}\right) \qquad \zeta = \frac{2\pi \omega_s \Delta n}{\lambda e}.$$

2) What are the different types of fibre optic sensors? Explain them.

✓ Intrinsic (or) Active sensor – guided light in the fibre gets modulated.
* Intensity modulated sensors. – change in absorption beam of light.
* Phase modulated sensors – interference b/w s/l and reference in interferometer.
* Polarization modulated sensor – change in polarization state.
* Wavelength modulated sensor – Involve the spectral dependent variation of absorption

* Extrinsic (or) Passive Sensors - modulation take place outside the fibre.

  ⇒ Phase modulated sensor - to detect pressure, magnetic field.

* Temperature sensor. - Intensity modulated sensor.

  Phase modulated temperature sensor.

* Displacement sensor - used to measure the displacement

3. Describe in detail the principle of measurement of Pressure and temperature using fibre optic sensors.

Measurement of pressure - change in intensity is reflected (or) transmitted light

⇒ radius of curvature of diaphragm changed.

⇒ Pressure ↑, o/p vge ↓.

⇒ ↑ pressure, reflected light ↓.

Measurement of temperature - bimetallic strip - sensing element

⇒ Amount of reflected light - convert to voltage.

⇒ Phase modulated temperature sensor.

$$\Rightarrow \frac{\Delta \phi}{\Delta T} = \frac{2\pi L}{\lambda}\left[\frac{n \Delta L}{L \Delta T} + \frac{\Delta n}{\Delta T}\right]$$

4. Explain the fibre optic instrumentation system with neat diagram.

Fibre optic instrumentation system - Design the optical fibre link with an efficient waveguide structure

* fibre attenuation measurement used to determine maximum bit rate.

* Measurement of attenuation (by cutback method)

$$\Rightarrow \alpha(\lambda) = \frac{10}{L} \log \frac{P_r(\lambda)}{P_2(\lambda)} \text{ dB/km.}$$

Optical Domain Reflectometer.

* Used both in laboratory and field measurement for determining fibre attenuation, joint losses & detecting fault losses.

* Back Scatter method.

* Based on measurement & analysis of fraction of light

fibre scattering Loss measurement.

* He-Ne laser (or) Nd-YAG laser is used to provide sufficient i/p o/p power to the fibre.

$$\Rightarrow \alpha_{sc} = \frac{10}{l(km)} \log_{10} \left[\frac{P_{opt}}{P_{opt} - P_{sc}} \right] \text{ dB/km.}$$

5) Describe in detail the principle of measurement of Current, voltage and strain.

Measurement of Current - Linearised polarised laser from the negative laser is launched into fibre.

$$\Rightarrow K\theta_r = \frac{I_1 - I_2}{I_1 + I_2}.$$

Faraday's rotation effect.

$$I = H/2\pi r, \quad \theta_r = 2VBr.$$

Measurement of voltage : Variation of refractive index with respect to electric field 'E'.

$$\Rightarrow \frac{1}{n^2} = \frac{1}{n_0^2} + rE + RE^2$$

$$\Rightarrow \theta = \frac{2\pi n_0^3 r V_z}{\lambda}$$

Phase produced in linearized polarized wave is

$\propto$ applied electric field / voltage.

$$\Rightarrow I = \frac{I_0}{2}\left(1 + \sin {V}/{V_0}\right)$$

Measurement of strain :- Microbending losses are produced in fibre when the top block presses the fibre. to increase with ↑ in force applied.

6) Explain the working principle of fibre optic liquid level measurement.

* Measurement using total internal reflection -

⇒ Liquid level sensor consists of two fibres connected at the base of glass microprism.

⇒ tip - immersed, no o/p at the detector.

⇒ tip - above, o/p is got in the "

Liquid level sensor based on refractive index change.

⇒ fibre without cladding is made in form of 'U' configuration.

⇒ Loss of intensity $\propto$ liquid level (or depth of liquid).

7) Define (i) Moire fringes (ii) Modulators.

Moire fringes - Relatively thick lines produced when two
⇒ patterns of thin lines overlap.
⇒ Set of thick, sometimes coloured additional lines can be distracting.
⇒ Scanning - Slope increases very quickly.

Optical moire pattern - fringes produced when one fine grid (or) grating is illuminated.
⇒ Pattern consists of parallel lines.

Modulators - Internal - placed in resonant cavity of laser diode
External - outside the resonant cavity.

* Electrooptic modulators
  └ Kerr effect
* Magneto optic modulators.
  └ Faraday effect.
* Acoustooptic modulators - photoelastic effect.