CHAPTER 09

FIBER OPTIC SENSORS

INTRODUCTION: After the invention of LASER in 1960 a new branch in fiber optics developed in parallel with the communication which is also a well known and interesting topic in the field of research known as 'FIBER OPTIC SENSORS'. With the advancement in communication system via using fiber optics there was a great demand to measure and sense the rate of data transmission, change in phase, intensity, and wavelength and in the case of incentive conditions as noise, unstable environmental conditions, high vibration and extreme heat etc. These are the basic reasons for the birth of fiber optic sensors. Due to its small size, low cost and ease of fabrication leading it to replace traditional sensors which were used frequently before the birth of fiber optic sensors. Further there are many points why fiber optic sensors are used in place of traditional sensors which are listed below:

- Due to ease in fabrication in the form of different structures, including composite materials with least interference due to small size and cylindrical geometry.
- Due to its light weight.
- Due to its high sensitivity.
- Due to incapability to conduct electrical current the sensor is unaffected by electrical noise and the heat resistant type fiber units enables to detecting high temperature.
- Due to its free nature towards electromagnetic interference and radio frequency interference.
- Due to its ability towards remote sensing.
- It has also multiplexing capability to build up sensing network such as a fiber optic amplifier allows more than 100 types of special fiber units.
- It has flexibility also which enables easy installation in limited space such as space between machines.
- Extremely compact sensor head allows for easy detection of extremely small targets.
- It has a wide dynamic range.
- Due to its reliable operation.
- Due to its compact nature.
- Due to its capability to monitor a wide range of physical and chemical parameters.
- Due to its chemically inert nature.

FIBER OPTIC SENSOR PRINCIPLES: Fiber optic sensors consist of an optical source (LEDs, Lasers, Laser diodes etc.) optical fiber, sensing element (transducer), optical detector and electronic processing unit (Optical spectrum analyzer, wave analyzer, oscilloscope etc). A block diagram of fiber optic sensor system is shown in below figure

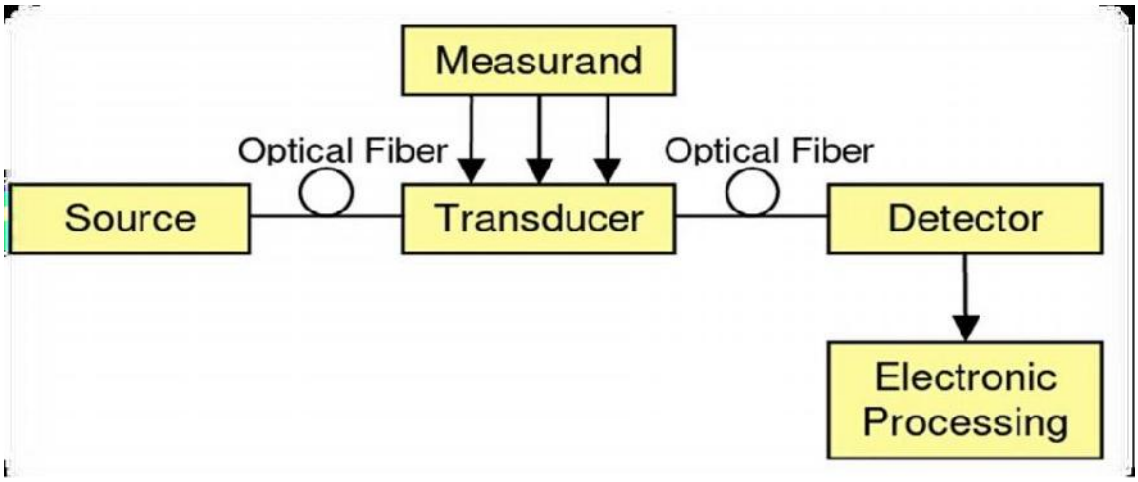


Fig: Block diagram of fiber optic sensor.

CLASSIFICATION OF FIBER OPTIC SENSORS:

Fiber optic sensors can be classified under three categories. On the basis of their

1) Sensing location.
2) Operating principle.
3) Application.

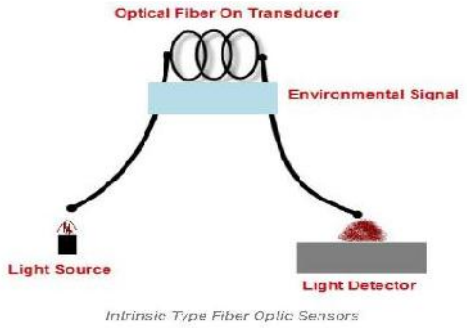
These three classes are further sub divided as following;

1) On the basis of sensing location-
(a) Intrinsic
(b) Extrinsic
2) On the basis operating principle-
(a) Based on intensity
(b) Based on phase
(c) Based on wavelength
(d) Based on polarisation
3) On the basis of their application –
(a) Physical sensor s
(b) Chemical sensors
(c) Bio-medical sensors
4) On the basis of response to the measurement point-
(a) Point to point sensors
(b) Multiplex sensors 5

(c) Distributed sensors

Each of these above mentioned classes of fibers in turns has many subclasses that consist of large number of fiber optic sensors.

INTRINSIC FIBER OPTIC SENSORS: In such type of sensors, sensing takes place within the fiber itself. These type of sensors have their dependency on the optical fiber properties itself to convert an environmental action into a modulation of the light beam passing through it. Virtually, any environmental effect can be converted to an optical signal to be interpreted .Each environmental effect may be measured by dozens of different fiber optic sensors approaches. It has been designed in such a way that it sensed only the environmental effects. • The most important characteristics of intrinsic fiber optic sensors is that it provides distributed sensing over long distances.



Intrinsic Type Fiber Optic Sensors

Some examples of intrinsic sensors are described below-

PRESSURE SENSOR:

In such type of sensors a fiber is sandwiched between a pair of toothed plates to induce micro bending .When pressure is applied to these toothed pairs, there is a redistribution of guided power between modes of fiber occurs, which changes the power at output end .Once we calibrate such change in optical power with applied pressure we can easily use such system as a pressure sensor. A schematic diagram of such type of sensor is shown below.

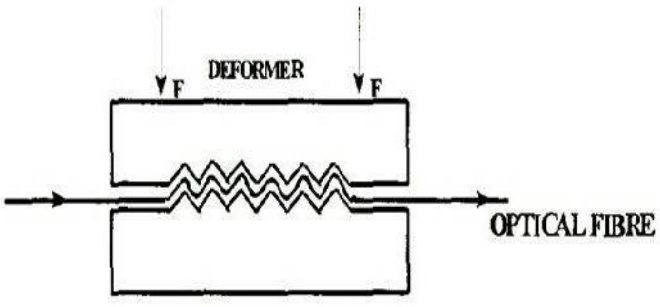
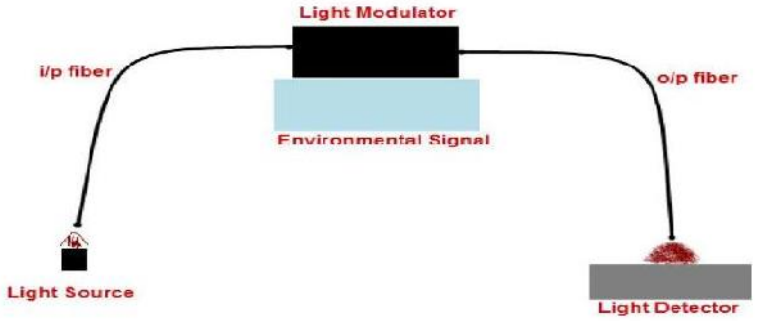


Fig: A schematic arrangement for pressure sensor

EXTRINSIC FIBER OPTIC SENSORS: In such type of sensors, sensing takes place in a region outside of the fiber and essentially fiber serves as a conduit for the to and fro transmission of light to the sensing region efficiently and in a desired form. These sensors may be used strictly as information carriers that lead up to a black box to impress information on a light beam that propagates to a remote receiver. The black box may contain mirrors, a gas or liquid cell ,a cantilevered arm or dozens of other mechanisms that may generate ,modulate or transform a light beam. The most important advantage of using these sensors is that their ability to reach places which seems to be unreachable.



Extrinsic Type Fiber optic Sensors

INTENSITY BASED FIBER OPTIC SENSORS: These type of sensors use multimode fibers having large core size. They require more light to gather into it.

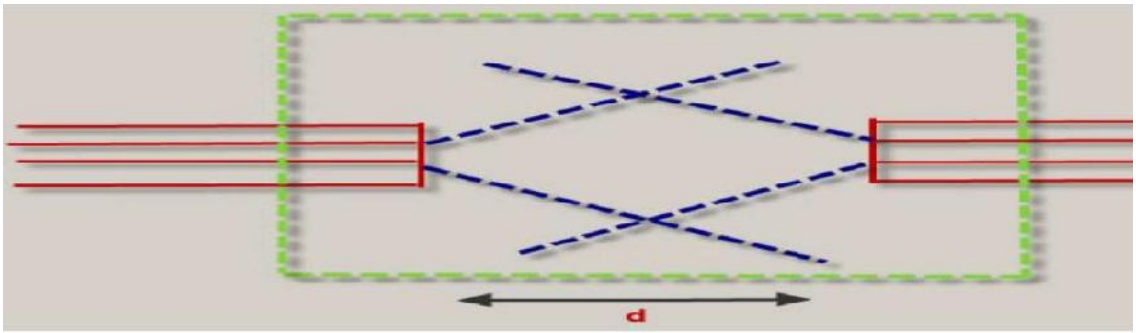


Fig: Vibration fiber optic sensor

Above fig. shows the vibration sensor that consists of two optical fibers held in close proximity to each other. When light is injected into one of the optical fiber, the light expand into a cone of light whose angle depends on their difference 'd'. These types of sensors faces many limitations regarding various losses such as losses due to connectors and splices, micro bending losses, macro bending losses and misalignment of light sources and detectors. To overcome these losses intensity based fiber optic sensors employ dual wavelength. One of the wavelengths is used for calibration of all the errors due to the undesired intensity variations by bypassing the sensing regions.