Types and Applications of Sensors

Esam A. M. ALSUMAIT

Abstract: Sensors are the most important part of the robotics and the embedded system. we use the sensors to minimize the logic circuits and make the system more efficient. Beside advantages; recent advances, and cost reductions has stimulated interest in fiber optical sensing. Researchers has combined the product outgrowths of fiber optic telecommunications with optoelectronic devices to emerge fiber optic sensors. researches have been conducted in past decades using fiber optic sensors with different techniques. Intensity, phase, and wavelength based fiber optic sensors are the most widely used sensor types. In this paper, an overview of sensors and their applications are presented.

Index Terms: sensors types , Fiber optics, optical fiber sensing, fiber Bragg gratings (FBGs), interferometry, micro bending, smart structures , IR sensors, temperature sensors, Touch sensors, Proximity sensors, UV sensors and advanced sensor technology.

I. INTRODUCTION

The laser had been invented in 1960's and a great interest in optical systems for data communications began. The invention of laser, motivated researchers to study the potential of fiber optics for data communications, sensing, and other applications. Laser systems could send a much larger amount of data than microwave, and other electrical systems. The first experiment with the laser involved the free transmission of the laser beam in the air. Researchers also conducted experiments by transmitting the laser beam through different types of waveguides. Glass fibers soon became the preferred medium for transmission of light. Initially, the existence of large losses in optical fibers prevented coaxial cables from being replaced by optical fibers. Early fibers had losses around 1000 dB/km making them impractical for communications use.

Recent advances in fiber optic technology have significantly changed the telecommunications industry. The ability to carry gigabits of information at the speed of light increased the research potential in optical fibers. Simultaneous improvements and cost reductions in optoelectronic components led to similar emergence of new product areas. Last revolution emerged as designers to combine the product outgrowths of fiber optic telecommunications with optoelectronic devices to create fiber optic sensors. Soon it was discovered that, with material loss almost disappearing, and the sensitivity for detection of the losses increasing, one could sense changes in phase, intensity, and wavelength from outside perturbations on the fiber itself. Hence fiber optic sensing was born of the components associated with these industries were often developed for fiber optic sensor applications.

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Fiber optic sensor technology in turn has often been driven by the development and subsequent mass production of components to support these industries. As component prices have decreased and quality improvements have been made, the ability of fiber optic sensors to replace traditional sensors have also increased. Fiber optic sensors are excellent candidates for monitoring environmental changes and they offer many advantages over conventional electronic sensors as listed below:

Easy integration into a wide variety of structures, including composite materials, with little interference due to their small size and cylindrical geometry. Inability to conduct electric current. Immune to electromagnetic interference and radio frequency interference. Lightweight. Robust, more resistant to harsh environments. High sensitivity. Multiplexing capability to form sensing networks. Remote sensing capability. Multifunctional sensing capabilities such as strain, pressure, corrosion, temperature and acoustic signals.

To date, fiber optic sensors have been widely used to monitor a wide range of environmental parameters such as position, vibration, strain, temperature, humidity, viscosity, chemicals, pressure, current, electric field and several other environmental factors.

Sensors used to detect and respond to electrical or optical signals. A Sensor converts the physical parameter (for example: temperature, blood pressure, humidity, speed, etc.) into a signal which can be measured electrically. Let‟s explain the example of temperature. The mercury in the glass thermometer expands and contracts the liquid to convert the measured temperature which can be read by a viewer on the calibrated glass tube.

II. CHOOSING THE SENSORS

There are proper features which have to be considered when we choose a sensor. They are as given below:
Accuracy: Environmental condition - usually has limits for temperature. Humidity: Range, Measurement limit of sensor
Calibration - Essential for most of the measuring devices as the readings changes with time
Resolution - Smallest increment detected by the sensor
Cost: Repeatability - The reading that varies is repeatedly measured under the same environment.

A. Sensors Classification

The sensors are classified into the following:
Primary Input quantity (Measured)
Transduction principles (Using physical and chemical effects)
Material and Technology
Property
Application

III. CLASSIFICATION

Temperature - Thermistors, thermocouples, RTD‟s, IC and many more.
Image Sensors - These are based on the CMOS technology. They are used in consumer
Motion Detectors - These are based on the Infra-Red, Ultrasonic, and Microwave / radar technology. They are used in videogames and simulations, light activation and security detection.
Pressure - Fibre optic, vacuum, elastic liquid based manometers, LVDT, electronic.
Flow - Electromagnetic, differential pressure, positional displacement, thermal mass, etc.
Level Sensors - Differential pressure, ultrasonic radio frequency, radar, thermal displacement, etc.
Proximity and displacement - LVDT, photoelectric, capacitive, magnetic, ultrasonic.
Biosensors - Resonant mirror, electrochemical, surface Plasmon resonance, Light addressable potentio- metric.
Image - Charge coupled devices, CMOS
Gas and chemical - Semiconductor, Infrared, Conductance, Electrochemical.
Acceleration - Gyroscopes, Accelerometers.
Others - Moisture, humidity sensor, Speed sensor, mass, Tilt sensor, force, viscosity.

Surface Plasmon resonance and Light addressable potentio-metric from the Bio-sensors group are the new optical technology based sensors. CMOS Image sensors have low resolution as compared to charge coupled devices. CMOS has the advantages of small size, cheap, less power consumption and hence are better substitutes for Charge coupled devices. Accelerometers are independently grouped because of their vital role in future applications like aircraft, automobiles, etc. and in fields of videogames, toys, etc. Magnetometers are those sensors which measure magnetic flux intensity B (in units of Tesla or As/m2).

A. Classification based on Application:

Industrial process control, measurement and automation
Non-industrial use –Aircraft, Medical products, Automobiles, Consumer electronics, other type of sensors.

Sensors can be classified based on power or energy supply requirement of the sensors:
Active Sensor - Sensors that require power supply are called as Active Sensors. Example: LIDAR (Light detection and ranging), photoconductive cell.
Passive Sensor - Sensors that do not require power supply are called as Passive Sensors. Example: Radiometers, film photography.

In the current and future applications, sensors can be classified into groups as follows:
Accelerometers - These are based on the Micro Electro Mechanical sensor technology. They are used for patient monitoring which includes pace makers and vehicle dynamic systems.
Biosensors - These are based on the electrochemical technology. They are used for food testing, medical care device, water testing, and biological warfare agent detection.

IV. BASICS OF OPTICAL FIBER

An optical fiber is composed of three parts; the core, the cladding, and the coating or buffer. The basic structure is shown in Figure 1. The core is a cylindrical rod of dielectric material and is generally made of glass. Light propagates mainly along the core of the fiber.

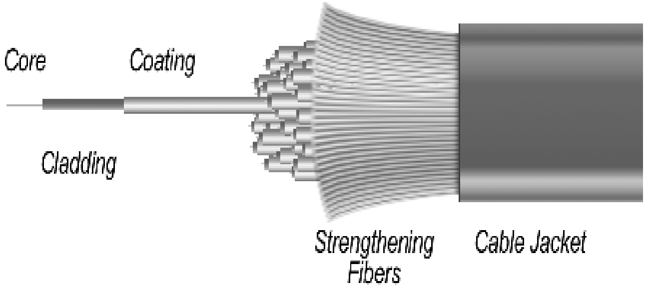

Fig 1. Structure of an optical fiber.

The cladding layer is made of a dielectric material with an index of refraction. The index of refraction of the cladding material is less than that of the core material. The cladding is generally made of glass or plastic. The cladding executes such functions as decreasing loss of light from core into the surrounding air, decreasing scattering loss at the surface of the core, protecting the fiber from absorbing the surface contaminants and adding mechanical strength [1]. The coating or buffer is a layer of material used to protect an optical fiber from physical damage. The material used for a buffer is a type of plastic. The buffer is elastic in nature and prevents abrasions [1]. The light-guiding principle along the fiber is based on the “total internal reflection”. The angle at which total internal reflection occurs is called the critical angle of incidence. At any angle of incidence, greater than the critical angle, light is totally reflected back into the glass medium (see Figure 2). The critical angle of incidence is determined by using Snell's Law. Optical fiber is an example of electromagnetic surface waveguide

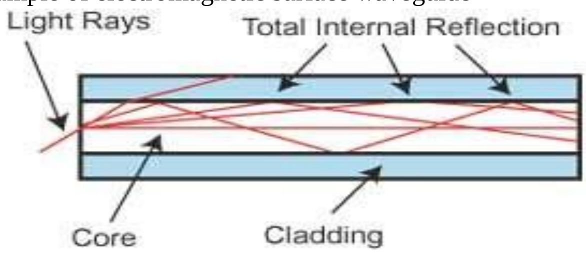

Fig 2.Total internal reflection in an optical fiber.

Optical fibers are divided into two groups called single mode and multimode. In classifying the index of refraction profile, we differentiate between step index and gradient index. Step index fibers have a constant index profile over the whole cross section. Gradient index fibers have a nonlinear, rotationally symmetric index profile, which falls off from the center of the fiber outwards the below Figure shows the different types of fibers.

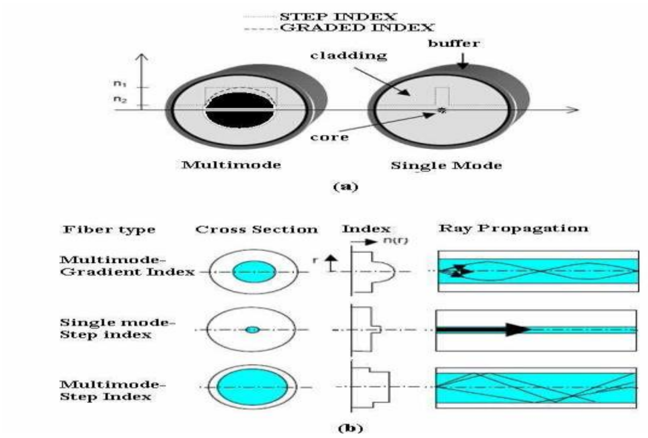

Fig 3. Different types of optical fibers.

-Fiber Optic Sensor Principles

The general structure of an optical fiber sensor system is shown in Figure 4. It consists of an optical source (Laser, LED, Laser diode etc), optical fiber, sensing or modulator element (which transduces the measurand to an optical signal), an optical detector and processing electronics (oscilloscope, optical spectrum analyzer etc).

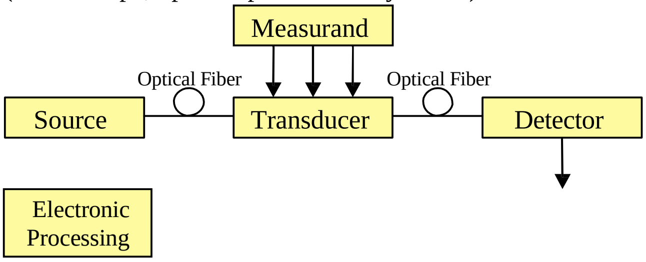

Figure 4. Basic components of an optical fiber sensor system.

Fiber optic sensors can be classified under three categories: The sensing location, the operating principle, and the application. Based on the sensing location, a fiber optic sensor can be classified as extrinsic or intrinsic. In an extrinsic fiber optic sensor, the fiber is simply used to carry light to and from an external optical device where the sensing takes place. In this cases, the fiber just acts as a means of getting the light to the sensing location.

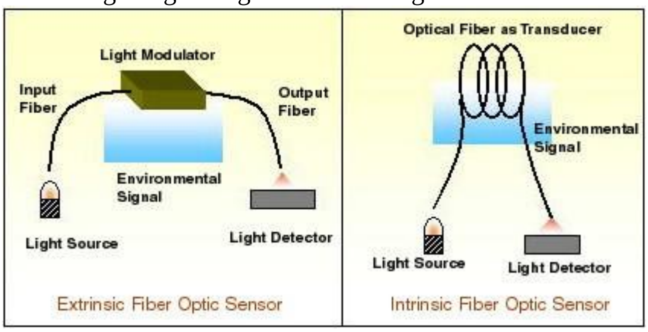

Fig 5. Extrinsic and intrinsic types of fiber optic sensors.

On the other hand, in an intrinsic fiber optic sensor one or more of the physical properties of the fiber undergo a change (see Figure 5). Perturbations act on the fiber and the fiber in turn changes some characteristic of the light inside the fiber.

Based on the operating principle or modulation and demodulation process, a fiber optic sensor can be classified as an intensity, a phase, a frequency, or a polarization sensor. All these parameters may be subject to change due to external perturbations. Thus, by detecting these parameters and their changes, the external perturbations can be sensed [10].

Based on the application, a fiber optic sensor can be classified as follows:

Physical sensors: Used to measure physical properties like temperature, stress, etc.

Chemical sensors: Used for pH measurement, gas analysis, spectroscopic studies, etc.

Bio-medical sensors: Used in bio-medical applications like measurement of blood flow, glucose content etc.

- **Fiber Optic Sensor Types**

Intensity Based Fiber Optic Sensors

Intensity-based fiber optic sensors rely on signal undergoing some loss. They are made by using an apparatus to convert what is being measured into a force that bends the fiber and causes attenuation of the signal. Other ways to attenuate the signal is through absorption or scattering of a target. The intensity-based sensor requires more light and therefore usually uses multimode large core fibers. There are a variety of mechanisms such as micro bending loss, attenuation, and evanescent fields that can produce a measurand-induced change in the optical intensity propagated by an optical fiber. The advantages of these sensors are: Simplicity of implementation, low cost, possibility of being multiplexed, and ability to perform as real distributed sensors. The drawbacks are: Relative measurements and variations in the intensity of the light source may lead to false readings, unless a referencing system is used .

One of the intensity-based sensors is the microbend sensor, which is based on the principle that mechanical periodic micro bends can cause the energy of the guided modes to be coupled to the radiation modes and consequently resulting in attenuation of the transmitted light. As seen in Figure 6, the sensor is comprised of two grooved plates and between them an optical fiber passes.

The upper plate can move in response to pressure. When the bend radius of the fiber exceeds the critical angle necessary to confine the light to the core area, light starts leaking into the cladding resulting in an intensity modulation .

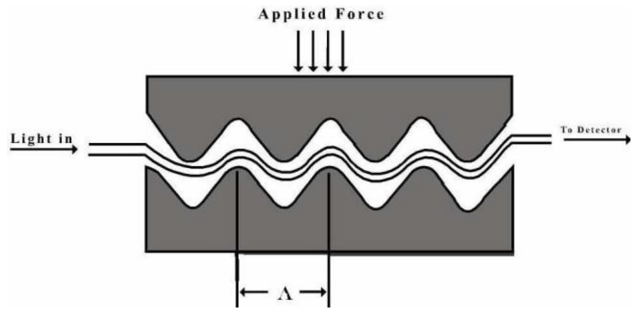

Fig 6. Intrinsic fiber optic sensor.

Another type of intensity based fiber optic sensor is the evanescent wave sensor (see Figure 7) that utilizes the light energy which leaks from the core into the cladding. These sensors are widely used as chemical sensors. The sensing is accomplished by stripping the cladding from a section of the fiber and using a light source having a wavelength that can be absorbed by the chemical that is to be detected.

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The resulting change in light intensity is a measure of the chemical concentration. Measurements can also be performed in a similar method by replacing the cladding with a material such as an organic dye whose optical properties can be changed by the chemical under investigation.

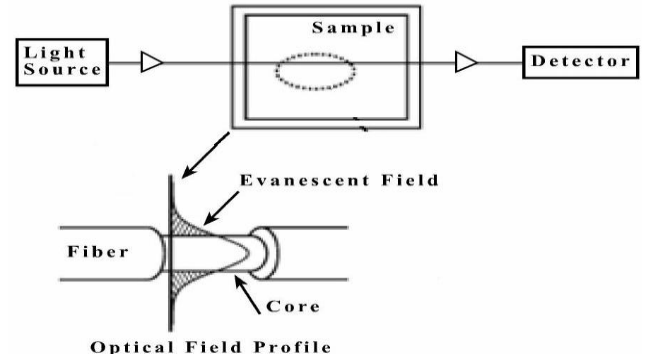


Fig 7. Evanescent wave fiber optic chemical sensor.

Wavelength Modulated Fiber Optic Sensors

Wavelength modulated sensors use changes in the wavelength of light for detection. Fluorescence sensors, black body sensors, and the Bragg grating sensor are examples of wavelength-modulated sensors. Fluorescent based fiber sensors are being widely used for medical applications, chemical sensing and physical parameter measurements such as temperature, viscosity and humidity. Different configurations are used for these sensors where two of the most common ones are shown in Figure 8. In the case of the end tip sensor, light propagates down the fiber to a probe of fluorescent material. The resultant fluorescent signal is captured by the same fiber and directed back to an output demodulator.

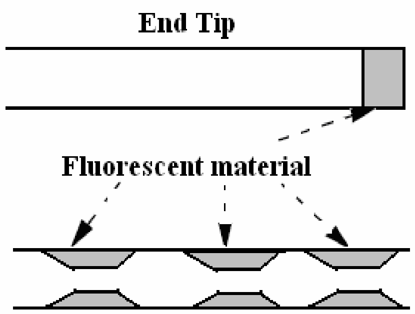


Fig 8. Fluorescent fiber optic sensor probe.

One of the simplest wavelength based sensor is the blackbody sensor as shown below. A blackbody cavity is placed at the end of an optical fiber. When the cavity rises in temperature it starts to glow and act as a light source. Detectors in combination with narrow band filters are then used to determine the profile of the blackbody curve. This type of sensor has been successfully commercialized and has been used to measure temperature to within a few degrees centigrade under intense RF fields.

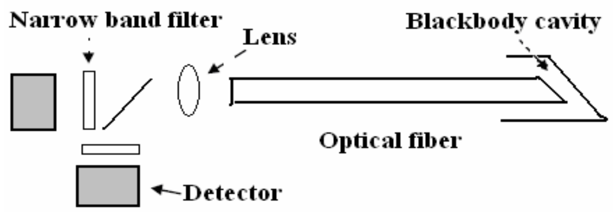


Fig 9. Blackbody fiber optic sensor.

The most widely used wavelength based sensor is the Bragg grating sensor. Fiber Bragg gratings (FBGs) are formed by constructing periodic changes in index of refraction in the core of a single mode optical fiber. This periodic change in index of refraction is normally created by exposing the fiber core to an intense interference pattern of UV energy. The variation in refractive index so produced, forms an interference pattern which acts as a grating.

The Bragg grating sensor operation is shown in Figure 10 where light from a broadband source (LED) whose center wavelength is close to the Bragg wavelength is launched into the fiber. The light propagates through the grating, and part of the signal is reflected at the Bragg wavelength. The complimentary part of the process shows a small sliver of signal removed from the total transmitted signal. This obviously shows the Bragg grating to be an effective optical filter.

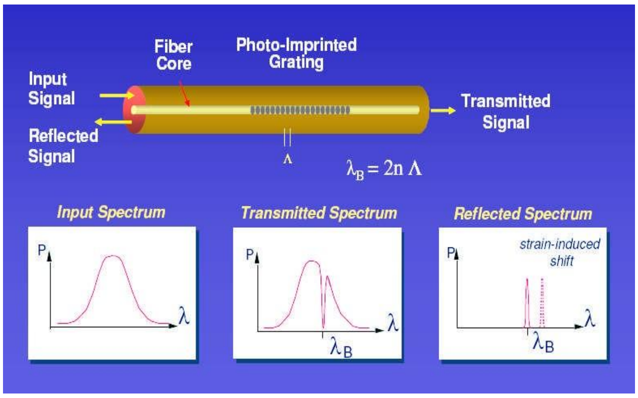
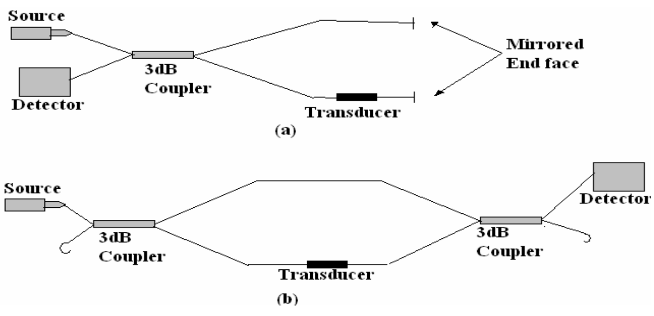


Fig 10. Bragg grating response.

Phase Modulated Fiber Optic Sensors:

Phase modulated sensors use changes in the phase of light for detection. The optical phase of the light passing through the fiber is modulated by the field to be detected. This phase modulation is then detected interferometerically, by comparing the phase of the light in the signal fiber to that in a reference fiber. In an interferometer, the light is split into two beams, where one beam is exposed to the sensing environment and undergoes a phase shift and the other is isolated from the sensing environment and is used for as a reference. Once the beams are recombined, they interfere with each other Mach-Zehnder, Michelson, Fabry-Perot, Sagnac, polarimetric, and grating interferometers are the most commonly used interferometers. The Michelson and Mach-Zehnder interferometers are shown in below:



There are similarities and differences between the Michelson and Mach–Zehnder interferometers.

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In terms of similarities, the Michelson is often considered to be folded Mach–Zehnder, and vice versa. Michelson configuration requires only one optical fiber coupler. Because the light passes both through the sensing and reference fibers twice, the optical phase shift per unit length of fiber is doubled. Thus, the Michelson can intrinsically have better sensitivity. Another clear advantage of the Michelson is that the sensor can be interrogated with only a single fiber between the source-detector module and the sensor. However, a good-quality reflection mirror is required for the Michelson interferometer.

Another commonly used interferometer based sensor is the Fabry-Perot interferometric sensor (FFPI) and is classified into two categories: Extrinsic Fabry-Perot interferometer (EFPI) sensor and intrinsic Fabry-Perot interferometer (IFPI) sensor. In an EFPI sensor, the Fabry- Perot cavity is outside the fiber. Fiber guides the incident light into to the FFPI sensor and then collects and the reflected light signal from the sensor. In an IFPI sensor, the mirrors are constructed within the fiber. The cavity between two mirrors acts both as sensing element and waveguide. In this case, the light never leaves the fiber.

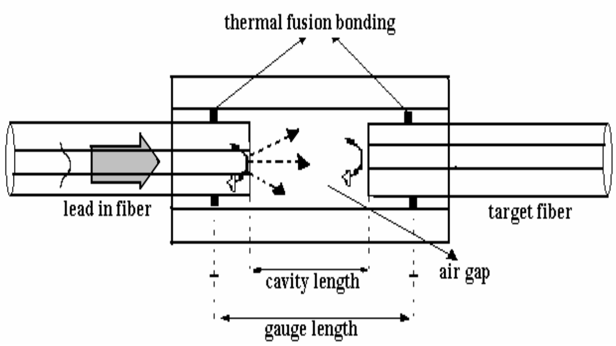

Fig 11. Capillary tube based EFPI sensor.

One cleaved fiber end (lead-in) is inserted into a glass capillary tube and another cleaved fiber end (target) is inserted into the tube from the other end. Both lead-in and target fibers are thermal fusion bonded with the tube. The cavity length between the two fibers is controlled using a precision optical positioner prior to the thermal fusion bonding. One of the advantages of this EFPI strain sensor is that its gauge length and cavity length can be different. The strain sensitivity is determined by the gauge length, while the temperature sensitivity is determined only by cavity length since the fiber and tube have the same thermal expansion coefficients. Hence, by making the gauge length much longer than the cavity length, the sensor temperature sensitivity becomes much less than the strain sensitivity. So, no temperature compensation is required.

An IFPI sensor contains two mirrors separated by a distance within a fiber core. The earliest IFPI sensor probably is the spliced TiO2 thin film coated fiber IFPI sensor. In this sensor internal mirror is introduced in fiber by thin film deposition on the cleaved fiber end followed by fusion splicing as shown. Several other methods are also used to produce internal mirror, such as using vacuum deposition, magnetron sputtering, or e-beam evaporation [19].

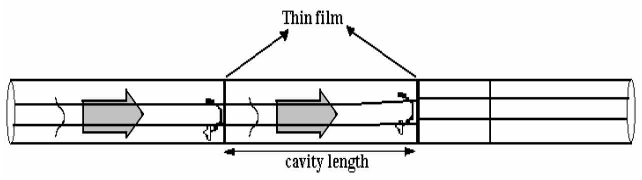

Fig 12. Thin film based IFPI sensor.

Sagnac interferometric sensors are based on fiber gyroscopes that can be used to sense angular velocity. Fiber gyroscopes are based on the principle that application of force changes the wavelength of light as it travels around a coil of optical fiber. It may also be occupied to measure time varying influences such as acoustics and vibration. Two types of fiber optic gyros have been developed: Open loop fiber optic gyro and closed loop fiber optic gyro.

The open loop fiber optic gyro is shown. A broadband light source is used to inject light into an input or output fiber coupler. The input light beam passes through a polarizer which is used to make certain the mutuality of the counter propagating light beams through the fiber coil. The second central coupler shares the two light beams into the fiber optic coil where they pass through a modulator. It is used to produce a time altering output signal indicative of rotation. The modulator is offset from the center of the coil for emphasizing a proportional phase difference between the counter propagating light beams. After light beams propagate from modulator, they rejoin and pass through the polarizer. Finally, light beams are guided onto the output detector.

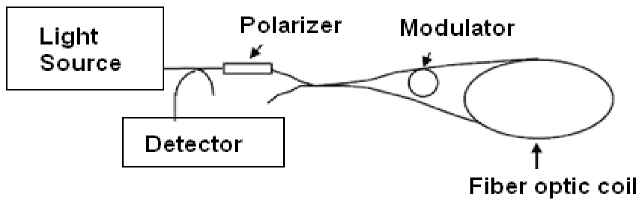

Fig 13. Open loop fiber optic gyro.

The second type is the closed loop fiber optic gyro that is primarily aimed at vacuum to high accuracy navigation applications. They have high turning rates and need high linearity and large dynamic ranges. In Figure 15, a closed loop fiber optic gyro is illustrated. This type of sensor is used as a modulator in the fiber optic coil to produce a phase shift at a certain rate. When the coil is rotated, a first harmonic signal is contributed with phase which depends on rotation rate. This manner is similar to open loop fiber optic gyro which is described before.

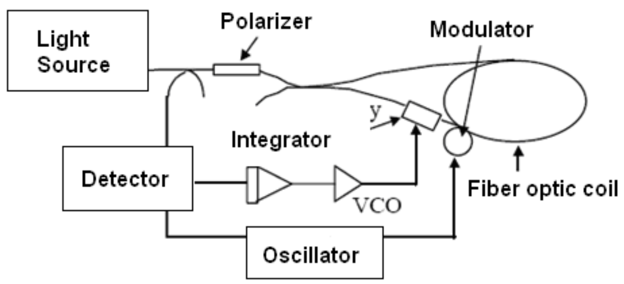

Fig 14. Closed loop fiber optic gyro.

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Polarization Modulated Fiber Optic Sensors
The direction of the electric field portion of the light field is defined as the polarization state of the light field. Different types of polarization states of the light field are linear, elliptical, and circular polarization states. For the linear polarization state, the direction of the electric field always keeps in the same line during the light propagation. For the elliptical polarization state, the direction of the electric field changes during the light propagation. The end of the electric field vector forms an elliptical shape; hence, it is called ‘‘elliptical polarized light”.

The refractive index of a fiber changes when it undergoes stress or strain. Thus, there is an induced phase difference between different polarization directions. This phenomenon is called photoelastic effect. Moreover, the refractive index of a fiber undergoing a certain stress or strain is called induced refractive index. The induced refractive index changes with the direction of applied stress or strain. Thus, there is an induced phase difference between different polarization directions. In other words, under the external perturbation, such as stress or strain, the optical fiber works like a linear retarder. Therefore, by detecting the change in the output polarization state, the external perturbation can be sensed [10]. Figure 16 shows the optical setup for the polarization- based fiber optic sensor. It is formed by polarizing the light from a light source via a polarizer that could be a length of polarization-preserving fiber. The polarized light is launched at 45 degrees to the preferred axes of a length of bi-refrigent polarization-preserving fiber. This section of fiber is served as sensing fiber. Under external perturbation such as stress or strain, the phase difference between two polarization states is changed. Then, the output polarization state is changed according to the perturbation. Hence, by analyzing the output polarization state at the exit end of the fiber, the external perturbation can be detected.

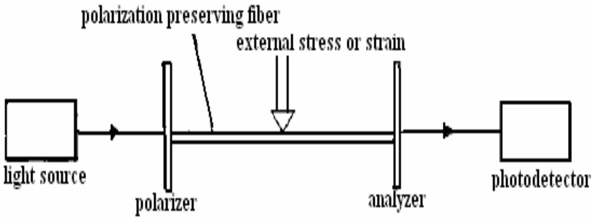


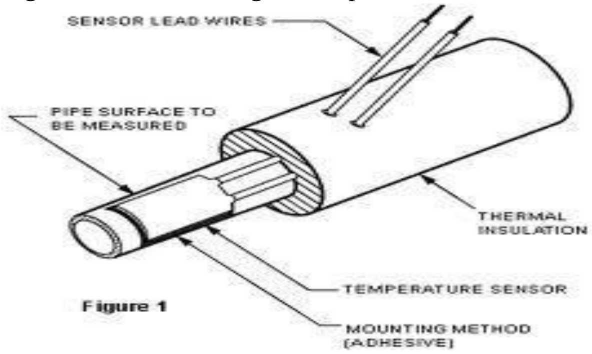
Fig 15. Polarization-based fiber optic sensor.

V. TYPES OF SENSORS

A. *Temperature Sensors*

This device of sensor collects information about temperature from a source and converts into a form that is understandable by other device or person. The best illustration of a temperature sensor is mercury in glass thermometer. The mercury in the glass expands and contracts depending on the alterations in temperature. The outside temperature is the source element for the temperature measurement. The position of the mercury is observed by the viewer to measure the temperature. There are two basic types of temperature sensors:

Contact Sensors, This type of sensor requires direct physical contact with the object or media that is being sensed. They supervise the temperature of solids, liquids and gases over a wide range of temperatures.



Non contact Sensors – This type of sensor does not require any physical contact with the object or media that is being sensed. They supervise non-reflective solids and liquids but are not useful for gases due to natural transparency. These sensors use Plank‟s Law to measure temperature. This law deals with the heat radiated from the source of heat to measure the temperature.

Working of different types of Temperature Sensors along with examples.

Thermocouple – They are made of two wires (each of different homogeneous alloy or metal) which form a measuring junction by joining at one end. This measuring junction is open to the elements being measured. The other end of the wire is terminated to a measuring device where a reference junction is formed. The current flows through the circuit since the temperature of the two junctions are different. The resulted milli- voltage is measured to determine the temperature at the junction. The diagram of thermocouple is shown below.

Resistance Temperature Detectors (RTD) – These are types of thermal resistors that are fabricated to alter the electrical resistance with the alteration in temperature. They are very expensive than any other temperature detection devices. The diagram of Resistance Temperature Detectors is shown below.

Thermistors – They are another kind of thermal resistor where a large change in resistance is proportional to small change in temperature.

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- IR Sensor

This device emits and/or detects infrared radiation to sense a particular phase in the environment. Generally, thermal radiation is emitted by all the objects in the infrared spectrum. The infrared sensor detects this type of radiation which is not visible to human eye.

- Advantages

Easy for interfacing

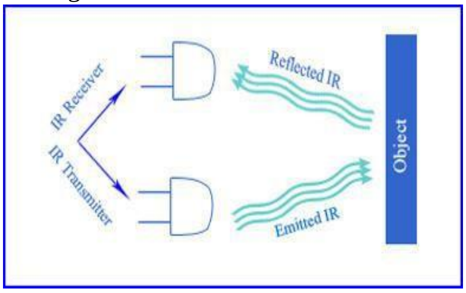
Readily available in market

- Disadvantages

Disturbed by noises in the surrounding such as radiations, ambient light etc.

- Working

The basic idea is to make use of IR LEDs to send the infrared waves to the object. Another IR diode of the same type is to be used to detect the reflected wave from the object. The diagram is shown below.



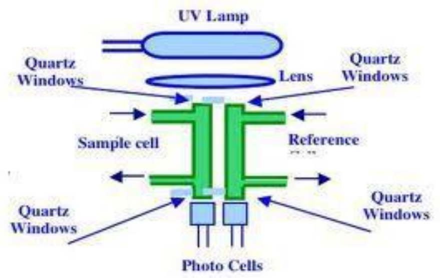
When IR receiver is subjected to infrared light, a voltage difference is produced across the leads. Less voltage which is produced can be hardly detected and hence operational amplifiers (Op-amps) are used to detect the low voltages accurately. Measuring the distance of the object from the receiver sensor: The electrical property of IR sensor components can be used to measure the distance of an object. The fact when IR receiver is subjected to light, a potential difference is produced across the leads.

- UV Sensor

These sensors measure the intensity or power of the incident ultraviolet radiation. This form of electromagnetic radiation has wavelengths longer than x-rays but is still shorter than visible radiation. An active material known as polycrystalline diamond is being used for reliable ultraviolet sensing. UV sensors can discover the exposure of environment to ultraviolet radiation.

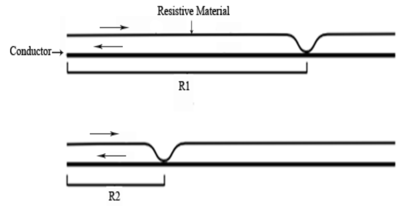
- Working

The UV sensor accepts one type of energy signal and transmits different type of energy signals. To observe and record these output signals they are directed to an electrical meter. To create graphs and reports, the output signals are transmitted to an analog-to-digital converter (ADC), and then to a computer with software.



- TOUCH SENSOR

A touch sensor acts as a variable resistor as per the location where it is touched. The figure is as shown below.

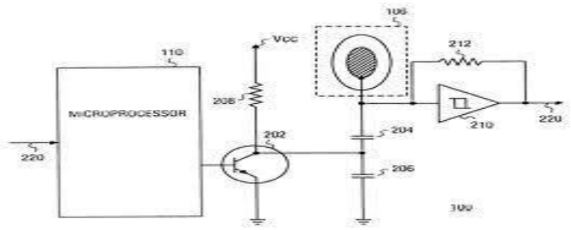


A touch sensor is made of: Fully conductive substance such as copper Insulated spacing material such as foam or plastic partially conductive material

- Principle and Working

The partially conductive material opposes the flow of current. The main principle of the linear position sensor is that the current flow is more opposed when the length of this material that must be travelled by the current is more. As a result, the resistance of the material is varied by changing the position at which it makes contact with the fully conductive material.

Generally, softwares are interfaced to the touch sensors. In such a case, a memory is being offered by the software. They can memorize the „last touched position" when the sensor is deactivated. They can memorize the „first touched position" once the sensor gets activated and understand all the values related to it. This act is similar to how one moves the mouse and locates it at the other end of mouse pad in order to move the cursor to the far side of the screen.



Ultrasonic waves differs due to shape and type of media. For example, ultrasonic waves move straight in a uniform medium, and are reflected and transmitted back at the boundary between differing media. A human body in air causes considerable reflection and can be easily detected.

The travelling of ultrasonic waves can be best explained by understanding the following:

- Multi-reflection

Multi-reflection takes place when waves are reflected more than once between the sensor and the detection object.

- Limit zone

The minimum sensing distance and maximum sensing distance can be adjusted. This is called the limit zone.

- **Undetection zone**

The undetected zone is the interval between the surface of the sensor head and the minimum detection distance resulting from detection distance adjustment.

The Undetection zone is the area close to the sensor where detection is not possible due to the sensor head configuration and reverberations. Detection may occur in the uncertainty zone due to multi-reflection between the sensor and the object.

- **Advanced Sensor Technology**

Sensor technology is used in wide range in the field of Manufacturing. The advanced technologies are as follows:

Bar-code Identification - The products sold in the markets has a Universal Product Code (UPC) which is a 12 digit code. Five of the numbers signify the manufacturer and other five signify the product. The first six digits are represented by code as light and dark bars. The first digit signifies the type of number system and the second digit which is parity signifies the accuracy of the reading. The remaining six digits are represented by code as dark and light bars reversing the order of the first six digits. Bar code is shown in the figure given below.

09062001 02920

The bar code reader can manage different bar code standards even without having the knowledge of the standard code. The disadvantage with bar coding is that the bar scanner is unable to read if the bar code is concealed with grease or dirt.

Transponders - In the automobile section, Radio frequency device is used in many cases. The transponders are hidden inside the plastic head of the key which is not visible to anyone. The key is inserted in the ignition lock cylinder. As you turn the key, the computer transmits a radio signal to the transponder. The computer will not let the engine to ignite until the transponder responds to the signal. These transponders are energized by the radio signals. The figure of a transponder is as shown below:

Electromagnetic Identification of Manufactured Components - This is similar to the bar code technology where the data can be coded on magnetic stripe. With magnetic striping, the data can be read even if the code is concealed with grease or dirt.

Surface Acoustic Waves - This process is similar to the RF identification. Here, the part identification gets triggered by the radar type signals and is transmitted over long distances as compared to the RF systems.

Optical Character Recognition - This is a type of automatic identification technique which uses alphanumeric characters as the source of information. In United States, Optical character recognition is used in mail processing Centre‟s. They are also used in vision systems and voice recognition systems.

Applications of these sensors:

Temperature sensors:

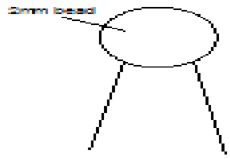
- **Thermistors**

Thermistors (thermally sensitive resistors) are available in two types:

- NTC (Negative Temperature Coefficient) resistance decreases with rising temperature
- PTC (Positive Temperature Coefficient) resistance increases with rising temperature

- **NTC**

The NTCs used by McLaren Electronics are polycrystalline metal oxide ceramic. These precision NTC elements have a very tight measuring tolerance in a small package, which results in a fast and accurate response.



Near room temperature, these devices offer the greatest sensitivity to temperature differences – an order of magnitude greater than PTCs or thermocouples. The nominal resistance of the NTC thermistors used in McLaren Electronics sensors is 5kohm at 25°C. However, the resistance decreases very rapidly with temperature, making them less suitable for accurate high temperature measurements. Furthermore, the low resistance at higher temperatures makes the sensors sensitive to the resistance of the harness and connector contacts.

Because of their high output, NTCs can interface with simple electronic interface circuits as used in mass market control systems. Our systems have high sensitivity inputs which do not need the high output of an NTC sensor. However, our systems can interface to NTC sensors, if required.

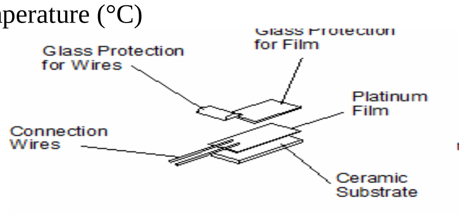
- **PTC**

Platinum (Pt.) thermistors are the most stable temperature sensors in common use today. They are constructed from a platinum film deposited onto a ceramic substrate. Platinum has been used to measure temperature for over 100 years. It offers high reliability, long term stability, and rapid response. It is also insensitive to vibration and thermal shock.

The resistance varies with temperature in a precise fashion. Between 0 and 600°C, this response can be expressed as an exact mathematical function. Pt. elements are normally supplied with a base resistance of either 100 ohm (Pt100) or 1000 ohm (Pt1000), measured at 0°C.

The Resistance-Temperature transfer function for Pt1000 sensors is defined as follows: Sensor Resistance (ohm) = 1000 * (1 + ((3.90802x10-3 * T) – (0.5802x10-6 * T2)))

T = Temperature (°C)



- **Application of NTCs and PTCs**

To measure resistance, an electric current has to flow through the element. This generates heat, resulting in errors.

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To minimize such errors, the measuring current needs to be kept low (typically less than 1mA). The wires joining the sensing element to the measuring device have their own resistance, which may vary in unpredictable ways, and so cause further errors. By selecting the sensor resistance to be as large as possible, both self-heating and lead wire resistance errors can be minimized.

Pt100s exhibit such a small resistance change with temperature that they tend to be overly sensitive to cable length and connector contact resistance changes. McLaren Electronics offers temperature sensors of all three types, i.e. NTC, Pt100 and Pt1000. We recommend the use of Pt1000 devices for highest accuracy and stability. All of our ECUs support Pt1000s as standard, but can be modified to support NTCs and Pt100s.

- **Sensor Design**

In automotive applications, the temperature of a gas (typically air) or a liquid (typically oil, water, fuel, etc.) needs to be measured. Gases and liquids have very different thermal characteristics, so each medium requires a different sensor design in order to make accurate temperature measurements.

Heat conducted into the sensor from the surrounding medium alters the temperature of the sensing tip. Because gases are poor heat conductors and have a very low thermal mass, air temperature sensors must also have a very low thermal mass. This minimizes errors in measurement and allows a rapid response to changes in air temperature.

McLaren Electronics air temperature sensors achieve this by exposing the sensor element tip directly to the air flow, without compromising ruggedness or reliability. Both screw-in and flange mount body styles are available. Sensors with a flange mount body can be aligned in the air stream to exploit the planar symmetry of the Pt. elements. This is most important for low velocity air flows, for example if the sensor is located at the end of a manifold pipe. With screw-in devices, the point at which the screw thread will tighten cannot be defined exactly. Any error due to misalignment of the element in the air flow is minimized by careful attention to the design of the sensor housing.

The fluids used in automotive applications are often aggressive and turbulent. The sensing element must be isolated from the medium, so the sensor element is encapsulated at the tip of a thermally conductive housing. This tip is made as small as possible to ensure minimal thermal mass – reducing error and response time. This package offers a very rugged and accurate method of measuring fluid temperature.

- **Interface Electronics**

The junction is the point of temperature measurement. The other end of each sensor wire needs to be connected to specialized electronics for reference cold junction compensation. Because the output voltage changes by just a few microvolts per degree, well designed and well filtered electronics are required, particularly if used close to an ignition system.

- **Sensor Design**

McLaren Electronics thermocouple sensors are mainly for the measurement of high temperature (up to approx. 1250°C). The element is surrounded by a stainless steel tube. The diameter of the steel tube has been selected as a compromise between mechanical robustness (particularly important when measuring exhaust gas temperature) and short response time. The steel tube is electrically isolated from the thermocouple as required by most cold junction compensation circuits.

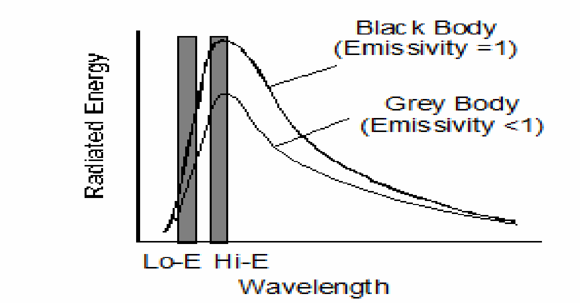
- **Infra-Red**

Infra-red sensors measure temperature by detecting the heat radiated from a target which may be some distance away. Such a MES Infra-red sensors obtain all their power from the energy radiated from the target so, in order to minimize errors, the leakage current drawn by the attached measuring device must not exceed 10nA.

- **Emissivity**

Different materials have a different emissivity, i.e. they radiate different amounts of energy even when held at the same temperature. Emissivity values are in the range 0 to 1. A perfectly reflecting surface has an emissivity of 0. Such a surface acts like a mirror in that it reflects an image of its surrounds rather than emitting its own radiation.

A perfect black body has an emissivity of 1. This kind of surface does not reflect at all, it emits energy in a characteristic way which depends entirely on its temperature.



All real objects have a lower emissivity than an ideal black body and therefore radiate less energy. Shiny metal surfaces have a low emissivity, in the region of 0.05 to 0.2, whilst non-metals, organic materials and coated metals typically have high emissivity, in the range of 0.8 to 0.95. McLaren Electronics offers Infra- red sensors suitable for the high emissivity range of 0.8 to 0.98. Emissivity is difficult to measure accurately and it can change with the temperature of the target surface. This affects the relationship between the temperature of the surface and the amount of energy it radiates. Unless the sensor reading is interpreted to take the emissivity into account, this appears as a measurement error. The sensors are sensitive to wavelengths which are much longer than those of visible light, so the color of the target has little effect. Please contact McLaren Electronics for assistance in determining the emissivity of your target medium.

VI. THE APPLICATIONS

Fiber optic sensors are used in several areas. Specifically:

Measurement of physical properties such as strain, displacement, temperature, pressure, velocity, and acceleration in structures of any shape or size.

Monitoring the physical health of structures in real time.

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Buildings and Bridges: Concrete monitoring during setting, crack (length, propagation speed) monitoring, prestressing monitoring, spatial displacement measurement, neutral axis evolution, long-term deformation (creep and shrinkage) monitoring, concrete-steel interaction, and post-seismic damage evaluation. Tunnels: Multipoint optical extensometers, convergence monitoring, shotcrete/ prefabricated vaults evaluation, and joints monitoring damage detection. Dams: Foundation monitoring, joint expansion monitoring, spatial displacement measurement, leakage monitoring, and distributed temperature monitoring.

Heritage structures: Displacement monitoring, crack opening analysis, post-seismic damage evaluation, restoration monitoring, and old-new interaction.

SPACE OPERATIONS – InfraTec is qualified by the European Space Agency for use on platforms for Earth limb detection for satellite orientation and will potentially see applications in LIDAR applications in the future. **UNDERGROUND SOLUTION –** The detection of Methane and other gases in mining operations is very critical to the safety of operations around the world. Many customers use our highly reliable devices to protect the lives of those that work long hours beneath our feet.

WATER and STEEL ANALYSIS – Clients use our devices to test gases emitted from water as it is boiled down to test for and identify impurities. In the production of steel, the same process can be used to test for correct mixture of elements by super-heating steel pellet samples and observing the level of known gases for quality and content. This gives controllers an opportunity to make corrections before molding or processing the molten metal.

- **UV sensors:**

The total photon flux of UV radiation from sunlight is close to 8.5 percent of the PPF in full sunlight. The photosynthetic photon flux at noon in full sunlight is about 2000 µmol m-2 s-1, thus the photon flux of UV radiation is about 170 µmol m-2 s-1. The SU ultraviolet sensor comes with a standard length of 5 meters of cable. The sensor is weather resistant. The ultraviolet meter comes in two versions, the MU-100 with a built-in sensor and the MU-200 with a remote sensor attached to the meter with 2 meters of cable.

VII. CONCLUSION

Here in this paper wa presented An overview of fiber optics sensors and their applications and The major types of sensors discussed included micro bending sensors, evanescent wave sensors, FBGs, optical fiber interferometers, and polarization modulated fiber optic sensors. and By knowing these types of sensors and their application we can be able to use them in a much specified manner. And also we can them in the various fields according to their principles and applications. The flexibility, fault tolerance, high sensing fidelity, low-cost and rapid deployment characteristics of sensor networks create many new and exciting application areas for remote sensing. In the future, this wide range of application areas will make sensor networks an integral part of our lives

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