Intrusion Detection using FBG Sensors

B.E. Project Report-B

Submitted in partial fulfillment of the requirements

For the degree of

Bachelor of Engineering

(Electronics Engineering)

by

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Certificate

This is to certify that, the project report-B titled

"Intrusion Detection using FBG Sensors "

is a bonafide work done by

Aniket More (16EE1035)
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and is submitted in the partial fulfillment of the requirement for the degree of

Bachelor of Engineering

(Electronics Engineering)

to the

University of Mumbai.

Examiner 1	Examiner 2	Supervisor
Project Coordinator	Head of Department	Principal

Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Abstract

Fiber Bragg Grating optical fiber is widely used to detect strain and temperature. Immunity to Electromagnetic Interference improves the precision of the result and enables its application into different areas. Optisystem is used to observe strain and temperature parameters of FBG Sensor. SingleMode FBG sensor having 1550μm wavelength is implemented for usage due to high immunization to EMI and lowered attenuation rate.The shift in wavelength when strain is experienced by FBG has also been analysed. The level of accuracy and delivery mode are taken into consideration.The results exemplify full capability to acquire strain and temperature parameters exclusively. A rational linear relationship between wavelength shift of optical fiber and strain applied over it shows the sensitivity of FBG for strain. This property of FBG can be used for intrusion detection in remote areas.

Keywords:
FBG, Optical fiber,Strain variation, Temperature Variation

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Abbreviations

FBG	fiber Bragg grating
SMF	single-mode fibers
UV	ultraviolet
WDM	Wavelength-division multiplexing
I/O	Inputs and Outputs
OSNR	Optical Signal to Noise Ratio
CIDF	Component Iteration Data Flow
QAM	Quadrature amplitude modulation
PWM	Pulse Width Modulation
EDFA	Erbium-doped fiber amplifier
OSA	optical spectrum analyzer

Chapter 1

Introduction

Fiber Bragg Grating sensors are widely used in remote locations because of it can work in harsh environment. This technology is very promising it provides high accuracy results. It reflects light and its wavelength is linearly proportional to the strain applied to it. As the strain on the FBG gets increased the distance between in the fiber gratings also increases. This changes the reflected bragg wavelength which can be analysed using digital spectrometer. SingleMode FBG sensor having 1550 Nm wavelength is im-plemented for usage due to high immunization to EMI and lowered attenuation rate.The shift in wavelength when strain is experienced by FBG has also been analysed. The level of accuracy and delivery mode are taken into consideration.The results exemplify full capability to acquire strain and temperature parameters exclusively. A rational linear relationship between wavelength shift of optical fiber and strain applied over it shows the sensitivity of FBG for strain. This property of FBG can be used for intrusion detection in remote areas.

1.1 Motivation

We are inspired by the problem faced in security where intrusion detection at a certain point is not easy in large surveillance systems. Expensive systems cause budget problems and lack of accuracy causes creation of half developed systems. The wavelength shift plays a major role in usage of FBG sensors in security based intrusion detection systems . FBG sensors are highly effective and are resistant to external electromagnetic interference.

1.2 Objective

Optical fibers have various applications and sensing is one of them. Thus,this project aims at exploring the wider usage of a fiber-optic type which can be used as a sensor.This project aims at integrating the properties of FBG sensors into the application of intrusion detection systems. The wavelength shifting phenomenon of an FBG can be used to study varying strain and temperature parameters.

1.3 Problem Definition

FBG Sensors having the property of wavelength shifting, they can be used to detect occurence of strain and varying parameters affiliated to it along with temperature sensing. Thus we can amalgamate the properties of Bragg Grating Wavelength to be applied into the broader systems of intrusion detection.Therefore, this can be done using the simulation software by Optiwave known as Optisystem.

1.4 Organization of Report

Chapter 2 includes the literature survey, Chapter 3 discusses optical fiber as a concept. Chapter 4 deals with Fiber Bragg Grating Sensors. Chapter 5 explores the tools and resources of Optisystem. Chapter 6 shows the result of the conducted simulation. chapter 7 focuses on conclusion and future work.

Chapter 2

Literature Survey

We got to know the application of FBG in monitoring the movement to detect strain in “FBG in PVC foils formonitoring the knee joint movement during the rehabilitation process” by R. P. Rocha, A. F. Silva, J. P. Carmo, and J. H. Correia [1].It presents a sensing electro-void wearable answer for observing the body kinematics. The estimating of the knee developments, flexion and augmentation, with the relating joint going about as the turn pivot is appeared as working rule. We studied methods developed to measure intervertebral disc pressure using optical fibre-Bragg gratings (FBGs) from A minimally invasivein-fiber Bragg grating sensor for intervertebral disc pressure measurements” by C. R. Dennison, P. M. Wild, D. R. Wilson, and P. A. Cripton [2] .

We studied Fiber Optic Sensors from book by Gupta B.D Fiber Optic Sensors; New India Publishing Agency (NIPA) [3] .Simulation and Analysis of the Fiber Bragg Gratting Sensor from Journal of Optical Technology by K.S.Khaled, M.Zafrullah, S.M.Bilal,M.A.Merza [4].

The working of FBG sensors was understood through the essential information provided in Yu, F.T.S.; Yin, S. Fiber Optic Sensors; [6]. and ”What is Sensor and What are Different Types of Sensors” from Engineersgarage.com [7]. Optiwave OptiSystem software is widely used in the fiber optic field. It is used to perform simulation of the fiber optic sensors. Documentation of the Optiwave helped us to perform simulation of intrution detection system using FBG [8].Optical Fibre Bragg Gratings for Acoustic Sensors by G. Wild and S. Hinckley has explained in detail about the sensitivity of the fiber bragg grating sensors and how it can be used for the acoustic sensing [25].

The various methods to develop fringes in the fiber optic cable explained in Niay, P.; Bernage, P.; Legoubin, S.; Douay, M.; Xie, W. X.; Bayon, J. F.; Georges,T.; Monerie, M.; Poumellec, B. (1994). ”Behaviour of Spectral Transmissions of BraggGratings Written in Germania-Doped Fibers - Writing and Erasing Experiments UsingPulsed or CW UV Exposure”[11]. Bhowmik, K.; Peng, G.D.; Luo, Y.; Ambikairajah, E.; Lovric, V.; Walsh, W.R.; Ra-jan, G. High Intrinsic Sensitivity Etched Polymer Fiber Bragg Grating Pair for Simul-taneous Strain and Temperature Measurements. IEEE Sens. J. 2016, 16, 2453–2459 [12]. Qingmin, H.; Wenling, J.; Shuhui, Z.; Liang, R.; Ziguang, J. Natural Gas PipelineLeakage Detection Based on FBG Strain Sensor. The change in the temperature due to the pipeline leakage can be detected with the help of the FBG sensor is shown [13].

Allwood, G.; Wild, G.; Hinckley, S. Fiber Bragg Grating Sensors for MainstreamIndustrial Processes various applications of FBG in automation industry [14].

Recent advances and applications in the fiber optic domain from Sante, R.D. Fibre Optic Sensors for Structural Health Monitoring of Aircraft Com-posite Structures [15]: Zhang, W.; Huang, W.; Li, L.; Liu, W.; Li, F. High resolution FBG sensor and itsapplications in Geophysics Recent advances and applications in the GeoPhysics [16].A. M. Abobaker, I. Eldbib, A. H. Daw , P. R. Babu, "Testing a real timemoni-toring system for passive optical networks using an array of fibre Bragg gratings",International Journal of New Compute [17].

Therefore, with the intrinsic information provided by the highly accomplished researchers who possess immense knowledge of the given area of study, we were able to understand and gain insight about the further application of the mentioned areas, while learning to utilize resourceful virtual tools for their implementation. Thus, Fiber Bragg Grating Sensor has property of wavelength shifting and this property of wavelength shifting is used to detect the occurance of intrusion along with temperature sensing simulated on the software Optisystem.

Chapter 3

Optical Fiber

A fibre-optic is a adjustable, transparent fibre composed of silica or plastic to breadth somewhat bigger than human hair. Fibers are used frequently as a mode to send light from one end to another of the bargain and find wide use in fiber optic communication, where they allow transsmission over seprations and at higher infomation rates than electrical connects.[3]

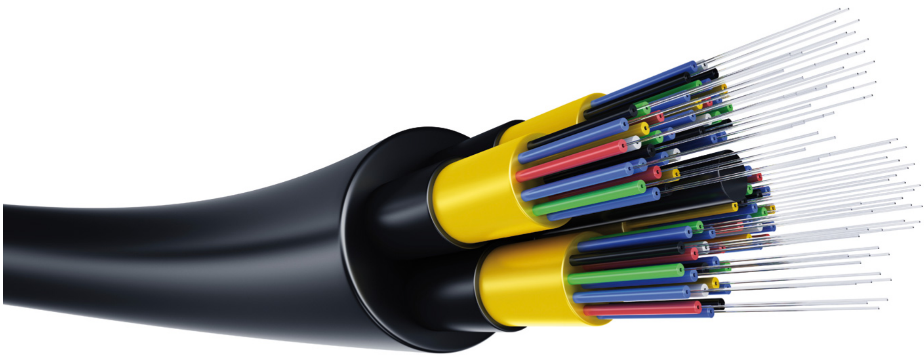

Figure 3.1: Optical Fiber [5]

3.1 Principle

As we can see in the Figure 3.1, it shows a basic structure of how a fiber optic cable appears. The basic principle of Fiber Optic Cables are based on the following parameters:

1. Refractive Index: The process of determining the pace of light movement in a substane is referred to as the refractve index.Light traverses fastly in vacuum. The RI off vacuum is 1. A cladding made of pure silica of 1550 n m and a silica-doped core exists in a normal singgle-mode fibre.Light goes as slow as the large nature of the refraction file.

2. Total Internal Reflection:When the light enters into a glass fiber from one end, most of it propagates along the length of fiber and comes out from the far end. A small portion of the incident light escapes through the side walls of fiber.The light

is guided from one end to another and stays inside the fiber due to total internal reflection.

3. Light Scattering:The transmission of light through the center of an optical fiber depends on total internal reflection of the lightwave. Harsh and unpredictable surfaces, even at the sub-atomic level, can make light beams be reflected in irregular ways. This is called diffuse reflection or dispersing, and it is ordinarily described by wide assortment of reflection angles [9].

Having the alternative to get optical strands together with lower attenuation is critical in optical communication. This is more perplexing than connecting electric wire or connect and incorporates wary partitioning of the fibers, careful course of action of the fiber habitats, and the coupling of these balanced focuses. In application which demands an unending affiliation a blend unite is typical. In this technique, an electric bend is used to disintegrate the pieces of the deals together. Another normal strategy is a mechanical join, where the pieces of the deals are held in contact by mechanical force. Temporary or semi-never-ending affiliations are made by strategies for explicit optical fiber bridges.

3.2 Evolution and History

In the late nineteenth and mid twentieth hundreds of years, light was guided through twisted glass bars to enlighten body cavities[19]. Picture transmission through cylinders was exhibited independently by Clarence Hansell and the John Logie Baird during the 20s. During the 30s, Heinrich Lam demonstrated that images could be sent via a group of unclad optical filaments and utilized it for inward clinical assessments, yet his work was to a great extent forgotten. In 1953, Dutch researcher Bram van Heel first exhibited picture transmission through groups of optical filaments with a straightforward cladding.That equivalent year, Harold Hopkins and Narinder Singh Kapany at Imperial College in London prevailing with regards to making picture transmitting packs with more than 10,000 strands, and hence accomplished picture transmission through a 75 cm long group which joined a few thousand fibers.The primary functional fiber optic semi-adaptable gastroscope was licensed by Basil Hirschowitz, C. Wilbur Peters, and Lawrence E. Curtiss, analysts at the University of Michigan, in 1956. During the time spent building up the gastroscope, Curtiss delivered the main glass-clad filaments; past optical fibers had depended on air or unrealistic oils and waxes as the low-file cladding material.

In filaments accessible at the time was brought about by contaminations that could be evacuated, as opposed to by crucial physical impacts, for example, dissipating and methodicallly guessed the light-misfortune properties for optical fiber, and brought up the correct material to use for such filaments—silica glass.The significant weakening restriction of 20 dB/km was first accomplished in 1970 by analysts Robert D. Maurer, Donald Keck, Peter C. Schultz, and Frank Zimar working for American glass creator Corning Glass Works. They showed a fiber with 17 dB/km constriction by doping silica glass with titanium.

A couple of years after the fact they created a fiber with just 4 dB/km constriction utilizing germanium dioxide as the center dopant. In 1981, General Electric created combined quartz ingots that could be brought into strands 25 miles (40 km) long.At first, top notch optical filaments must be fabricated at 2 meters for every second. Compound designer Thomas Mensah joined Corning in 1983 and sped up assembling to more than 50 meters for every second, making optical fiber links less expensive than conventional copper ones. These developments introduced the period of optical fiber media transmission. Constriction in present day optical links is far not exactly in electrical copper links, prompting long stretch fiber associations with repeater separations of 70–150 kilometers (43–93 mi). The erbium-doped fiber intensifier, which diminished the expense of significant distance fiber frameworks by decreasing or disposing of optical-electrical-optical repeaters, was co-created by groups drove by David N. Payne of the University of Southampton and Emmanuel Desurvire at Bell Labs in 1986.

3.3 Basic Structure

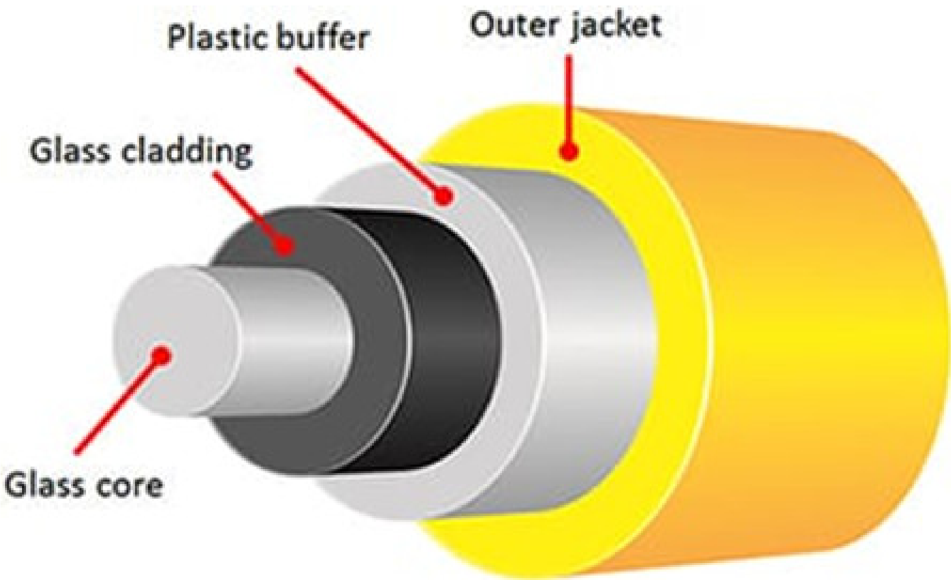

Figure 3.2: Basic Structure [10]

Figure 3.2 illustrates the basic structure of an optical fiber. Optical fibers commonly incorporate:

1. An innermost core layer: The innermost layer in an optical fiber cable is the glass core. The light rays travel through the innermost core.

2. Cladding Layer: The glass core is covered by the cladding layer. This layer is also made up of glass but the refractive index of this layer is lesser than that of the core. The thickness of the cladding layer is adjusted two times higher than the wavelength to be guided along the fiber.

3. Protective Jacket Layer: The outermost layer is the protective jacket layer. This layer provides mechanical strength to the optical cable. A Kevlar layer is often added to give additional support.

A core[10] encompassed by a transparent cladding material with a lower refraction index. Light is kept in the center by the occurrence of absolute internal reflection which makes the fiber act about as a waveguide. Fibers that help numerous engendering ways or transverse modes are called multi-mode fibers, while those that help a solitary mode are called single-mode fibers (SMF). Multi-mode fibers for the most part have a more extensive core diameters and are utilized for short-separation correspondence joins and for applications where high force must be transmitted.Single-mode fibers are utilized for most correspondence connects longer than 1,000 meters (3,300 ft)

3.4 Manufacturing Material

Glass optical fibers [19] are quite often produced using silica, yet some different materials, for example, fluorozirconate, fluoroaluminate, and chalcogenide glasses just as crystalline materials like sapphire, are utilized for longer-frequency infrared or other particular applications. Silica and fluoride glasses typically have refractive files of about 1.5, yet a few materials, for example, the chalcogenides can have files as high as 3. Normally the index difference among center and cladding is a little short of one percent.

3.4.1 Silica

Silica displays genuinely great optical transmission over a wide scope of frequencies. In the near-infrared (close to IR) segment of the range, especially around 1.5 m, silica can have very low retention and dissipating misfortunes of the request for 0.2 dB/km. Such astoundingly low losses are possible simply because ultra-pure silicon is accessible, it being fundamental for assembling incorporated circuits and discrete transistors. A high transparency in the 1.4-m area is accomplished by keeping up a low concentration of hydroxyl groups (OH). On the other hand, a high OH concentration is better for transmission in the ultraviolet (UV) region.

3.4.2 Fluoride Glass

Fluoride glass is a class of non-oxide optical quality glasses made out of fluorides of different metals. As a result of their low thickness, it is exceptionally hard to totally maintain a strategic distance from crystallization while handling it through the glass progress (or drawing the fiber from the liquefy).

In this way, although substantial metal fluoride glasses show exceptionally low optical attenuation, they are hard to make, however are very delicate, and have poor protection from dampness and other environmental effects. Their best characteristic is that they do not have the absorption band related with the hydroxyl (OH) gathering (3,200–3,600 cm1; i.e., 2,777–3,125 nm or 2.78–3.13 m), which is available in about all oxide-based glasses.

3.4.3 Phosphate Glass

Phosphate glass comrises a class of optical glasses made out of metaphosphates of different metals. Rather than the SiO4 tetrahedra saw in silicate glasses, the structure hinder for this glass previous is phosphorus pentoxide (P2O5), which takes shape in any event four unique structures. The most recognizable polymorph includes atoms of P4O10.

3.5 Uses

3.5.1 Communication

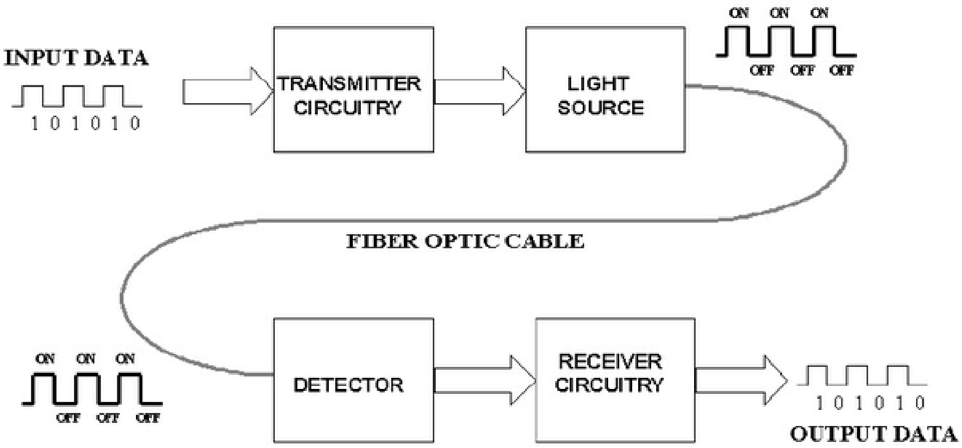

Figure 3.3: Uses in Communication [11]

Figure 3.3 illustrates the entire flow circuitry of communication systems and the implementation of Fiber-Optic cables along with it. Optical fiber is utilized as a mechanism for media transmission and computer networking on the grounds that it is adaptable and can be packaged as links. A transmitter circuitry is multiplexed upon by a light source where the detector detects the transmitted signal at the receiver circuitry and the corresponding output is obtained. It is particularly invaluable for significant distance interchanges, since infrared light spreads through the fiber with much lower attenuation contrasted with electrical links. This permits significant distances to be traversed with barely any repeaters.

Optical Fiber is additionally immune to electrical impedance; there is no cross-talk between signals in various links and no pickup of environmental noise. Non-armoured fiber links don't direct power, which makes fiber an optimal solution for securing communication hardware in high voltage conditions, for example, power age offices, or metal correspondence structures inclined to lightning strikes, and furthermore forestalling issues with ground circles. They can likewise be utilized in situations where hazardous fumes are available, without risk of ignition. Wiretapping (for this situation, fiber tapping) is progressively troublesome contrasted with electrical associations, and there are concentric double main elements that are said to be tap-proof.

3.5.2 Sensors

Fibers have numerous utilizations in remote sensing. In certain applications, the sensor is itself an optical fiber. In different cases, fiber is utilized to associate a non-fiberoptic sensor to an estimation framework. Contingent upon the application, fiber might be utilized due to its small size, or the way that no electrical force is required at the remote area, or in light of the fact that numerous sensors can be multiplexed along the length of a fiber by utilizing various frequencies of light for every sensor, or by detecting the time delay as light goes along the fiber through every sensor. Time postponement can be resolved utilizing a gadget, for example, an optical time-domain reflectometer.

3.5.3 Power Transmission

Fiber-optics are utilized to trasfer power utilizing a photo-voltaic cell to convert the photons into electric components.As this strategy for transmission of power isn't that proficient as customary one, it is particularly helpful in circumstances where alluring not to have a metallic conveyor as on account of utilization close to MRI machines, that provide solid attractive fields. Alternate models are for controlling gadgets in powerful recieving wire components and estimation gadgets utilized in high-voltage transmission hardware.

3.5.4 Other

Fiber-optic can likewise be utilized in strategic monitoring of health. Thus kind of sensor can recognize stresses that may lastingly affect structures. It depends on the guideline of estimating analog attenuation.

Chapter 4

Fiber Bragg Grating Based Sensors

The first in-fiber Bragg grinding was shown by Ken Hill in 1978. Initially, the gratings were manufactured utilizing a noticeable laser spreading along the fiber center. In 1989, Gerald Meltz and associates showed the substantially more adaptable transverse holographic engraving procedure where the laser light originated from the side of the fiber. This strategy utilizes the obstruction example of bright laser light to make the occasional structure of the fiber Bragg grinding [9].

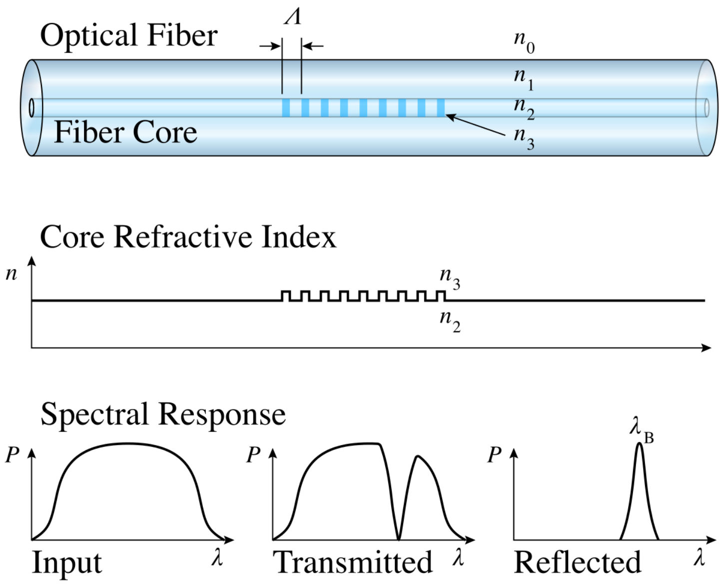

Figure 4.1: Fiber Bragg Grating Simplified Structure [19]

4.1 Principle and Setup

From the Figure 4.1, it can inferred that the internal reflection of light takes place in the fibre core.Fiber Bragg grating (FBG) pressure sensors are not simplest a totally nicely-set up studies location,but they're moreover acquiring a bigger marketplace percentage due to their sensitivity. In this project we assessment FBG stress sensors with excessive consciousness on the underlying bodily requirements, the interrogation, and the observe-out techniques. Particular emphasis is given to modern advances in quite-performing, unmarried head FBG, a class FBG stress sensors belong to. Different sensing schemes are defined, collectively with FBG stress sensors primarily based totally on mode splitting. Their operation principle and performance are stated and compared with the conventional architectures. In stop, a few superior packages and key sectors the worldwide fiber-optic pressure sensors marketplace are envisaged, in addition to the maximum critical marketplace players enthusiasts performing in this challenge.

The fiber optics correspondence industry has altered the media transmission industry through giving increasingly solid media transmission joins, better, and continually diminishing data transmission cost. The mechanical advancement of fiber optic correspondence has animated the advancement of the fiber optic sensors. Fiber-optic sensors offer favorable circumstances over other existing detecting advances, for example, expanded affectability and structure factor adaptability. The utilitarian idiosyncrasies of fiber optic sensors have been misused to supplant customary sensors in a wide scope of applications including strain, vibration, electric, acoustic and attractive fields, quickening, pressure, temperature, direct and rakish position, moistness, consistency, concoction estimations, what's more, numerous others. Because of their dielectric property, fiber-optic sensors can be utilized in unforgiving situations for example, high temperature, high voltage, or within the sight of destructive materials; likewise, these sensors are good with correspondence frameworks and can perform remote detecting. A rearranged design of fiber optic sensor is accounted for in Figure. It comprises of an optical source that energizes the transducer (i.e., the touchy optical component) through a fiber optic link (FO). Because of avariety of the measurand, the transducer changes over the underlying sign of the optical source in anothersignal having various highlights. The modificed signal is recognized from an indicator and, at that point, handled by the incitation circuity. The incitation hardware infers the informations about the measurand through a correlation between the underlying sign, for the most part called reference signal, and the sign changed by the transducer [10].

Clarify that the reason for the strain is the pressure. Uniquely in contrast to the strain, the pressure communicates the inner powers that particles apply on one another in a persistent material, while the strain is the outcome of these powers. On the off chance that the pressure surpasses a specific quality restriction of the material, it will be for all time distorted or it will change its gem structure and concoction organization, in any case the pressure is reversible. The pressure is characterized as the normal power per unit zone that a few molecule of the item applies on the contiguous one, over a nonexistent surface that isolates them. For example, for the strain, the pressure can be delegated ordinary pressure whether identified with pressure furthermore, pressure, and shear pressure whether identified with pressure corresponding to the surface. The pressure unit is than of weight.After quickly covering the ideas of strain and stress, the fundamental classes of fiber optics strain sensors are introduced in the accompanying area, where the FBGs are underscored for their crucial job as single-point sensors in which the detecting head is gotten through an occasional regulation of the refractive file.

4.2 Manufacturing of Fiber Bragg Grating Sensors

The illustration of the entire process of phase masking of FBG in writing schematic is done in the Figure 4.2. Manufacture of FBGs profits by the way that the center of most optical strands is doped with germanium (to expand the refractive record), which makes it photosensitive in the bright (UV). In particular, photosensitivity implies that presentation to UV light will prompt a perpetual refractive-record change. Now and again, photosensitivity is made or further expanded by hydrogen stacking[11]. The most

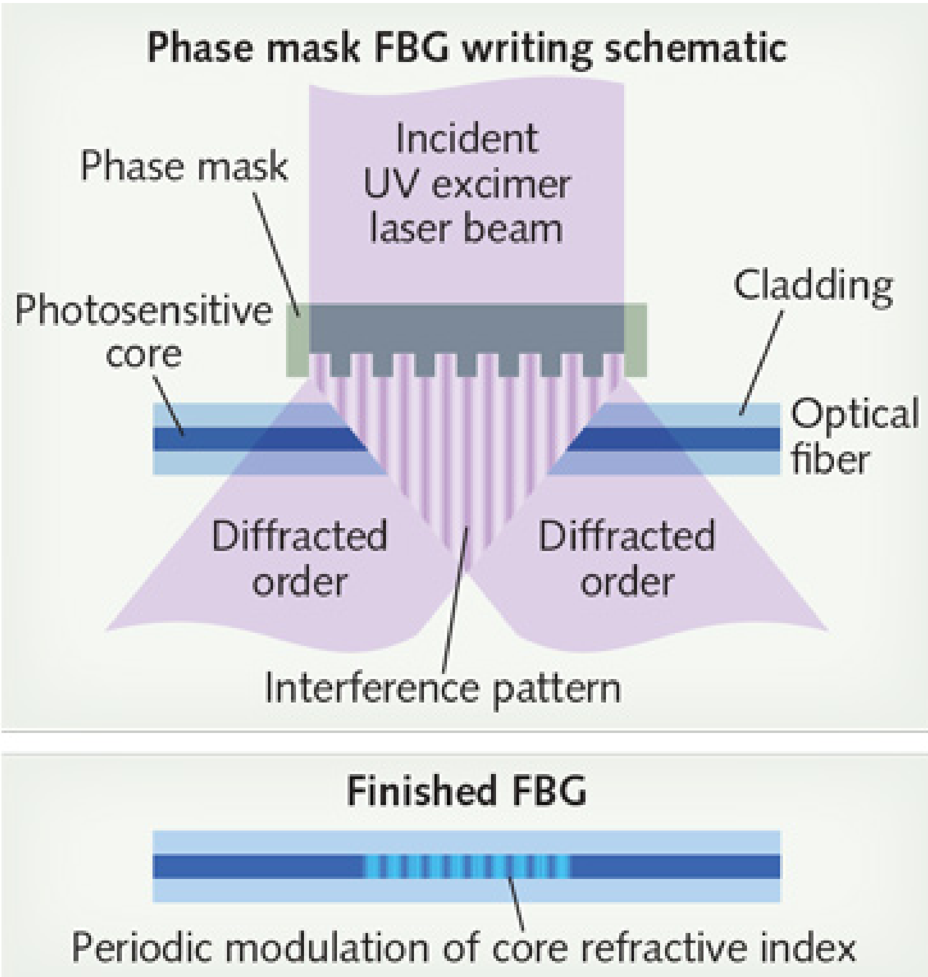

Figure 4.2: Manufacturing of Fiber Bragg Grating Sensors [20]

well-known strategy for FBG creation is to uncover a photosensitive fiber to an impedance periphery design in UV light. This is generally practiced by coordinating the yield of an excimer laser through a stage veil (basically a diffraction grinding; see Figure. The stage cover diffracts the occurrence laser light into different requests, which cover and optically meddle with one another in the veil region. This obstruction makes fixed, rotating zones of high and low laser force whose dividing is either equivalent to the stage cover period or half of this worth, contingent on the specific introduction geometry.

4.3 Types of gratings

1. Type 1 gratings: Written in both hydrogenated and non-hydrogenated fiber of different sorts, type I gratings are ordinarily known as standard gratings and are made in fibers of various sorts under all hydrogenation conditions. Normally, the reflection spectra of a sort I pounding is identical to 1-T where T is the transmission spectra.

   This infers the reflection and transmission spectra are relating and there is unimportant loss of light by reflection into the cladding or by ingestion. Type I gratings are the most normally used of each and every crushing sort, and the primary sorts of pounding open off-the-rack at the hour of creating.

2. Type 2 gratings: Fiber gratings framed at low forces are by and large alluded to as Type I. Another kind of grinding is a harm grinding framed when the vitality of the composing shaft is expanded above around 30 mJ. Physical harm is caused in the fiber center on the composing shafts. The clear edge is joined by a huge change in the refractive file regulation. It is hence conceivable to compose high-reflectivity gratings with a solitary laser beat.

   Over 40–60 mJ, the refractive file adjustment soaks at around 3 103. Vitality of the request for 50–60 mJ can devastate the optical fiber. The unexpected development of the refractive record is joined by an enormous short-frequency misfortune because of the coupling of the guided mode to the radiation field [12].

Chapter 5

Optisystem

OptiSystem is an optical communication system simulation bundle for the plan, testing, and improvement of essentially any kind of optical connection in the physical layer of an expansive range of optical systems, from simple video broadcasting frameworks to intercontinental spines. A framework level test system dependent on the sensible demonstrating of fiber-optic correspondence frameworks, OptiSystem has an amazing reproduction condition and a genuinely progressive meaning of parts and frameworks. Its capacities can be effectively extended with the expansion of client parts and consistent interfaces to a scope of broadly utilized apparatuses [24].

Figure 5.1: Optiwave Optisystem [21]

As we can see in Figure 5.1, Optisystem is a software provided by Optiwave Systems Inc. [21]. OptiSystem is an optical communication system simulation bundle for the plan, testing, and improvement of essentially any kind of optical connection in the physical layer of an expansive range of optical systems, from simple video broadcasting frameworks to intercontinental spines. A framework level test system dependent on the sensible demonstrating of fiber-optic correspondence frameworks, OptiSystem has an amazing reproduction condition and a genuinely progressive meaning of parts and frameworks. Its capacities can be effectively extended with the expansion of client parts and consistent interfaces to a scope of broadly utilized apparatuses.

Since its origin in 1994, Optiwave's product has been authorized to in excess of 1000 industry-driving partnerships and colleges in more than 70 nations around the world. Today, Optiwave's front line photonic structure computerization programming and redid building configuration administrations offer its clients an unmistakable upper hand, by boundlessly shortening their opportunity to advertise while drastically improving quality, efficiency and cost-viability.

In an industry where cost viability and profitability are basic for progress, the honor winning OptiSystem can limit time necessities and reduction cost identified with the structure of optical frameworks, connections, and parts. OptiSystem is an imaginative, quickly advancing, and amazing programming configuration apparatus that empowers clients to plan, test, and reenact pretty much every sort of optical connection in the transmission layer of a wide range of optical systems from LAN, SAN, MAN to ultra-long stretch. It offers transmission layer optical correspondence framework structure and arranging from segment to framework level, and outwardly presents investigation and situations. Optisystem is Created to address the requirements of research researchers, photonic architects, educators and understudies; OptiSystem fulfills the interest of clients who are looking for an incredible yet simple to utilize photonics framework configuration apparatus[24].

5.1 Benefits

1. Provides global insight into system performance
2. Assesses parameter sensitivities aiding design tolerance specifications
3. Visually presents design options and scenarios to prospective customers
4. Delivers straightforward access to extensive sets of system characterization data
5. Provides automatic parameter sweep and optimization
6. Integrates with the family of Optiwave products

5.2 Key Functions

1. Component Library: The OptiSystem Component Library incorporates many parts that empower you to enter parameters that can be estimated from genuine gadgets. It coordinates with test and estimation gear from various merchants. Clients can consolidate new parts dependent on subsystems and client characterized libraries, or use co-recreation with an outsider instrument, for example, MATLAB or SPICE.
2. Quality and performance algorithms: So as to foresee the framework execution, OptiSystem figures parameters, for example, BER and Q-Factor utilizing numerical investigation or semi-logical procedures for frameworks constrained by between image impedance and commotion.

3. Advanced visualization tools: Propelled perception apparatuses produce OSA Spectra, signal trill, eye charts, polarization state, group of stars graphs and substantially more. Likewise included are WDM examination instruments posting signal force, gain, clamor figure, and OSNR per channel.

4. Multiple layouts: You can make numerous structures utilizing a similar task document, which permits you to make and alter your plans rapidly and productively. Each OptiSystem venture record can contain many structure adaptations. Structure renditions are determined and changed autonomously, however count results can be joined across various adaptations, taking into account examination of the plans.

Chapter 6

Simulation and Results

We conducted the simulation using the Optisystem software by Optiwave. Following is presentation of obtained results. The visualiser permits a client for computing and showing optic signals within recurrence space. After you run a cycle, the visualizers in the task produce diagrams and results dependent on the sign information.

6.1 Block Diagram

Fig 6.1 represents the Block Diagram of the proposed layout.

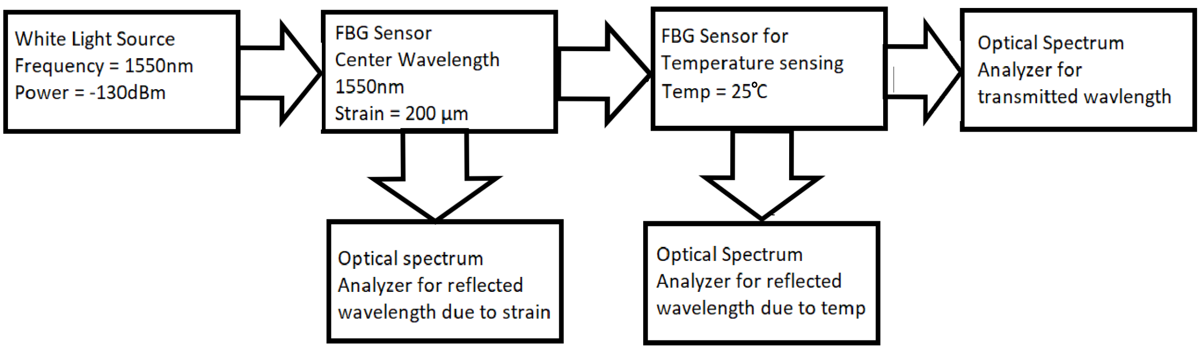

Figure 6.1: Block Diagram

- White light source has wide optical Bandwidth. It contains all the wavelength of the visible spectrum.

  1. Sometimes, a light source truly transmits noticeable white light. To produce white light having wide optical bandwidth we can use tungsten lamp. Xenon lamp can be used for this application.
  2. In different cases, a broadband light source is implied, which doesn't really transmit in the obvious ghostly area. Such sources can be superluminescent sources, for example superluminescent diodes, and ordinarily display a high spatial lucidness, while the is low as indicated by the enormous bandwidth.

Average uses of this sort of white light sources are white light interferometry, portrayal of optical parts, spectroscopy, and so forth.

- FBG Sensors: This component permits clients to plan the FBG that is utilized to sense temperature,strain. Transmission and reflection ghostly attribute of the FBG will shift with any adjustment in these natural conditions permitting clients to screen these changes. The fibre Brag gratting is capable of being utilized like temperature strain sensor. Grating community frequency shifts with changing the natural condition encompassing it. The client can mimic the conduct of business FBG sensors by entering their parameters into the FBG Sensor segment in OptiSystem and compute their unearthly attributes under various natural conditions. Likewise, clients can combine the grating parameters by coordinating test results with reproduced results got by fluctuating the FBG plan parameters. It delineates a square outline arrangement used to portray the presentation of the FBG Sensor segment when the temperature is changed from 30 °C to 50°C

- Optical-Visual Analyzer : You can get to the diagrams and results from the Project Browser, from the Component Viewer, or by double tapping a visualizer in the Main Layout.

6.2 Schematic and Simulation

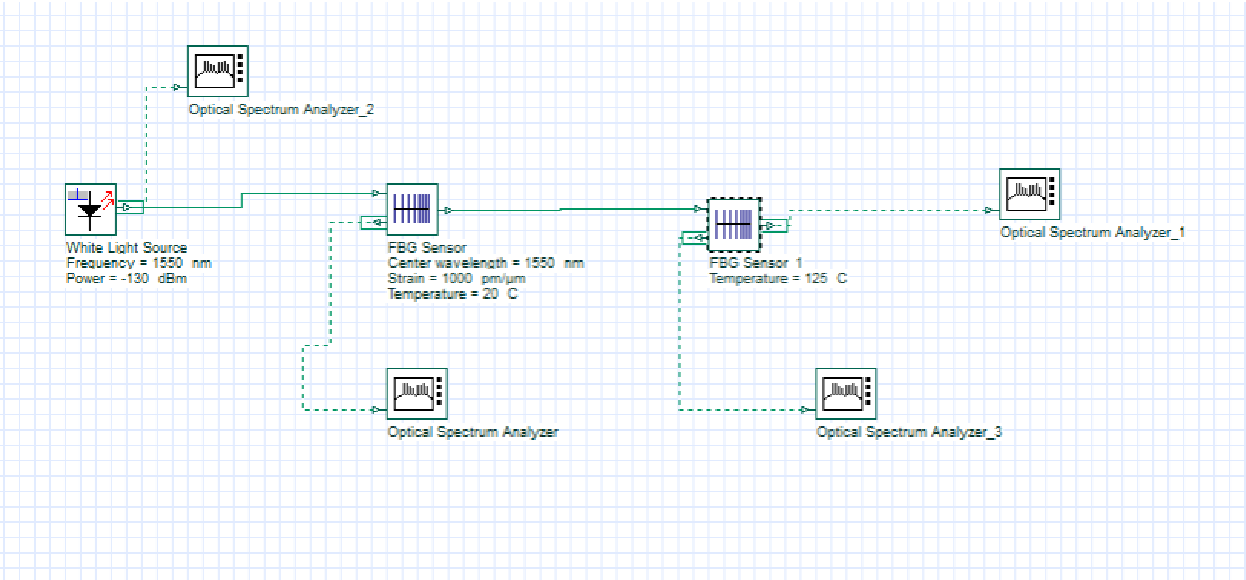

Figure 6.2: Schematic

- Fig. 6.2 illustrates the simulation schematic that has been simulated using the software Optisystem.
- The following simulation was done using the Optisystem software and its resourceful tools that come along with it.
- The design contains one white light source with wavelength of 1550μm.
- 1st FBG is centered at 1549 μm and 2nd FBG is centered at 1551 μm, 2 FBG sensors and 2 optical-spectrum analyzer.
- For the Fiber Bragg sensor, sensor I will sense strain while sensor II is for measuring temperature only. using default setting.
- In FBG 1 temperature is constant at 25°C and strain will vary after operation on FBG 1.
- Optical analyzer is used to see the reflected wavelength and output of FBG 1 is transmitted to the input of FBG 2.
- In FBG 2 Temperature will vary from 25 to 350 and strain will be zero.
- Again an Optical analyzer is placed to check the Reflected Wavelength for FBG 2 and also another optical analyzer is used to Check the final transmitted wavelength from both the FBG sensors.

6.2.1 FBG sensor strain performance analysis

- Fig. 6.3 shows that the strain applied is 200 μm and the corresponding reflected wavelength is 1.549μm. The applied strain has a direct impact on the reflected wavelength.

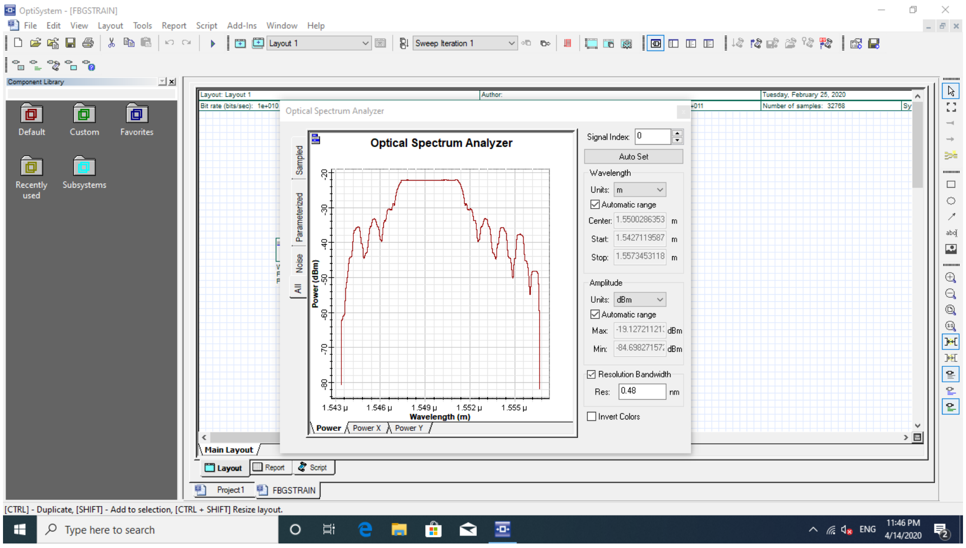

Figure 6.3: Strain Applied 200 μm

- Fig. 6.4 shows that the strain applied is 600 μm and the corresponding reflected wavelength is 1.549μm. The gradual shift in wavelength can be observed.

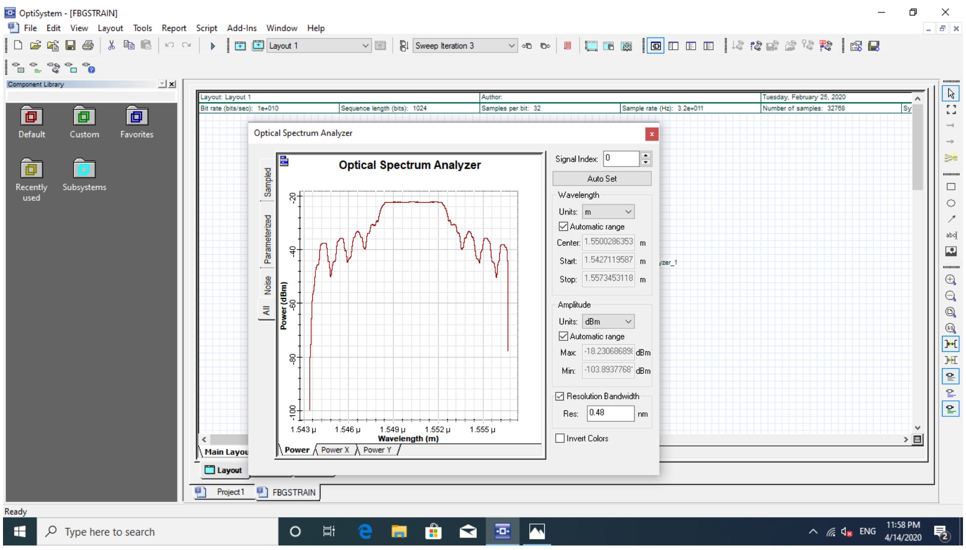

Figure 6.4: Strain Applied 600 μm

- Fig. 6.5 shows that the strain applied is 1000 μm and the corresponding reflected wavelength is 1.550μm.It is noticable that there is a gradual shift in the wavelength as the applied strain is incremented.

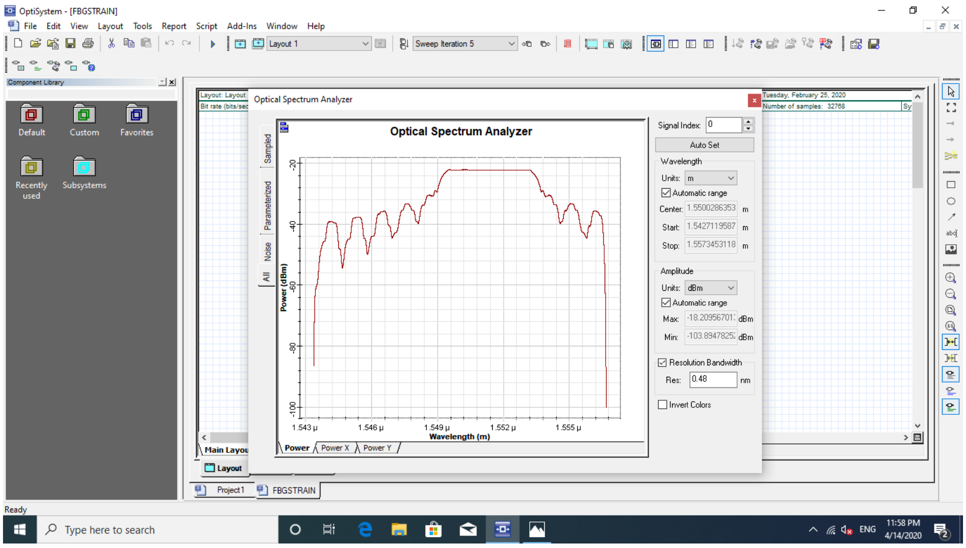

Figure 6.5: Strain Applied 1000 μm

- Fig. 6.6 shows that the strain applied is 1400 μm and the corresponding reflected wavelength is 1.551μm. A shift in corresponding wavelength by increasing the strain is observed.

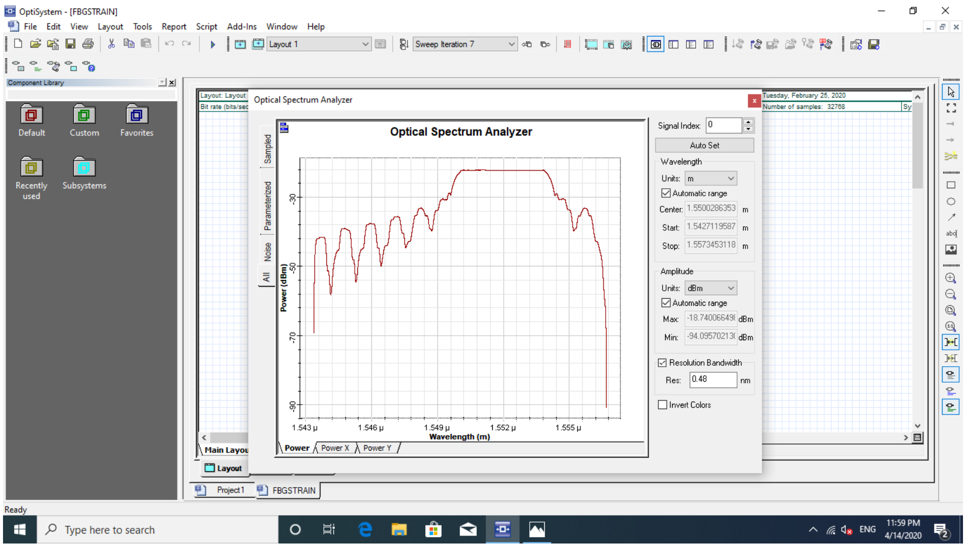

Figure 6.6: Strain Applied 1400 μm

- Fig. 6.7 shows that the strain applied is 1800 μm and the corresponding reflected wavelength is 1.553μm. The property of shifting of wavelength can be seen by the reflected wavelength.

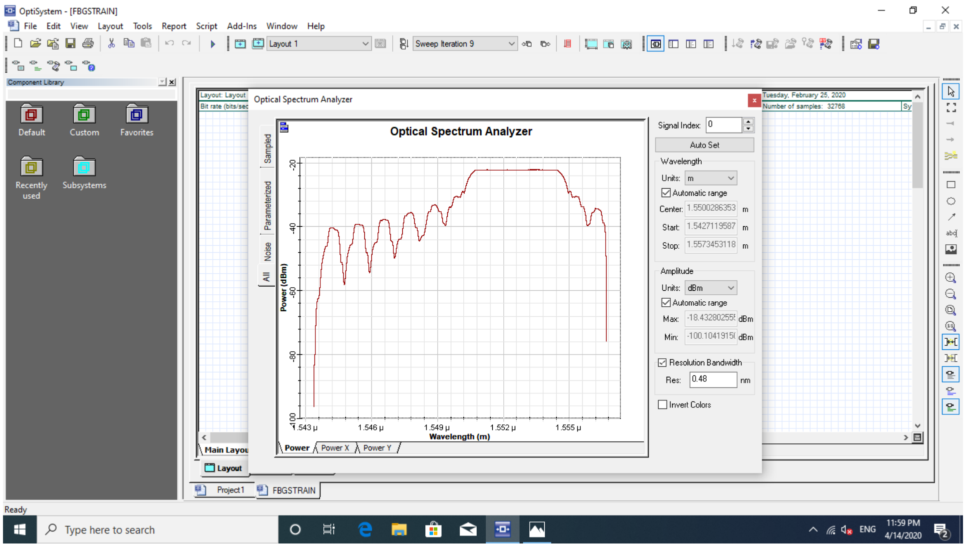

Figure 6.7: Strain Applied 1800 μm

- Fig. 6.8 shows that the strain applied is 2000 μm and the corresponding reflected wavelength is 1.554μm.Thus, it can be inferred that the applied strain and shift in wavelength are directly proportional.

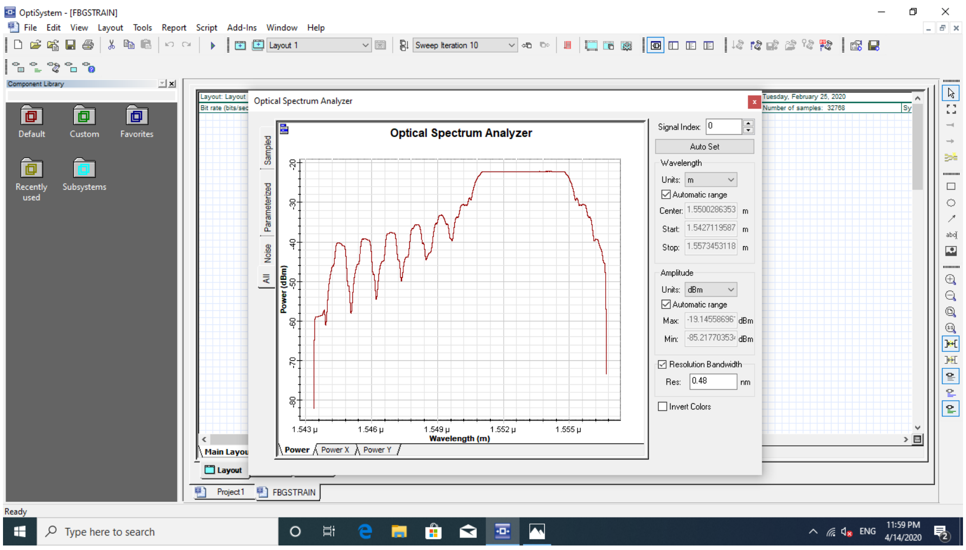

Figure 6.8: Strain Applied 2000 μm

Sr.No.	Strain Applied [μm]	Reflected wavelength[μm]
1	200	1.549
2	400	1.549
3	600	1.549
4	800	1.550
5	1000	1.550
6	1200	1.551
7	1400	1.551
8	1600	1.552
9	1800	1.553
10	2000	1.554

This is a tabular representation of the varying values of applied strain. The corresponding reflected wavelength has also represented in the table.The reflected wavelength proportionates according to the applied strain. Ten Values taken into consideration have been observed. The calculations were made with the formula of shifting of wavelenth for strain.

6.2.2 FBG sensor temperature performance analysis

- Fig. 6.9 shows that the temperature applied is 25 °C and the corresponding reflected wavelength is 1.550μm.

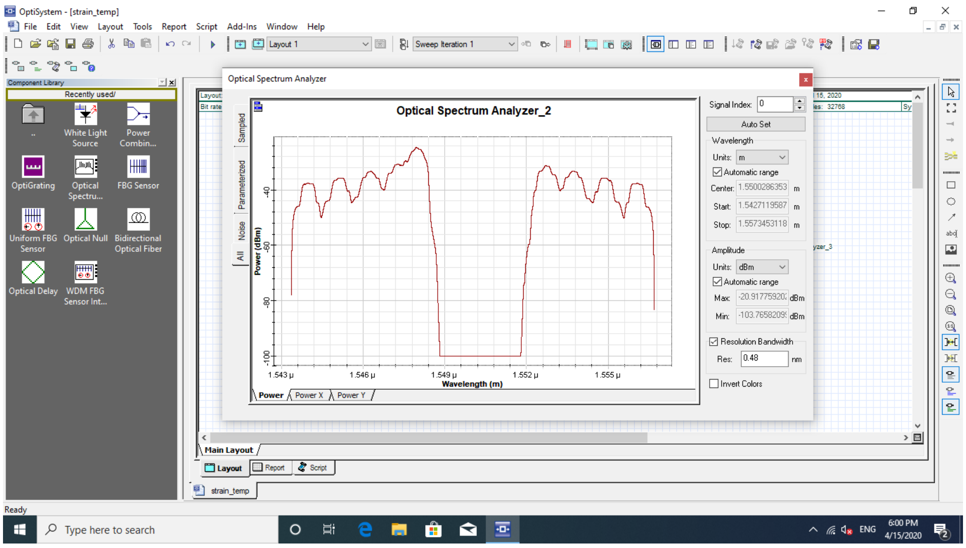

Figure 6.9: Temperature Applied 25°C

- Fig 6.10 that the temperature applied is 75 °C and the corresponding reflected wavelength is 1.552μm.

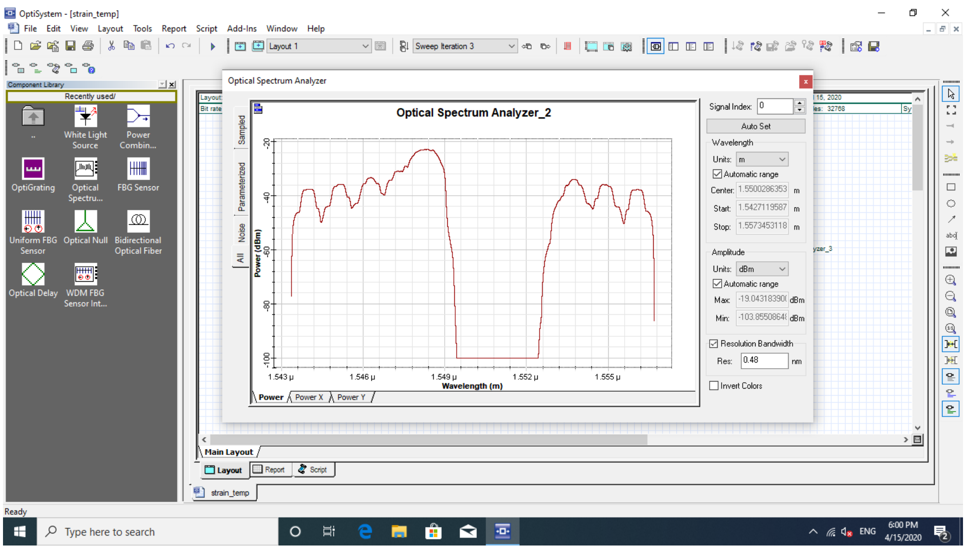

Figure 6.10: Temperature Applied 75°C

- Fig 6.11 shows that the temperature applied is 125°C and the corresponding reflected wavelength is 1.552μm.

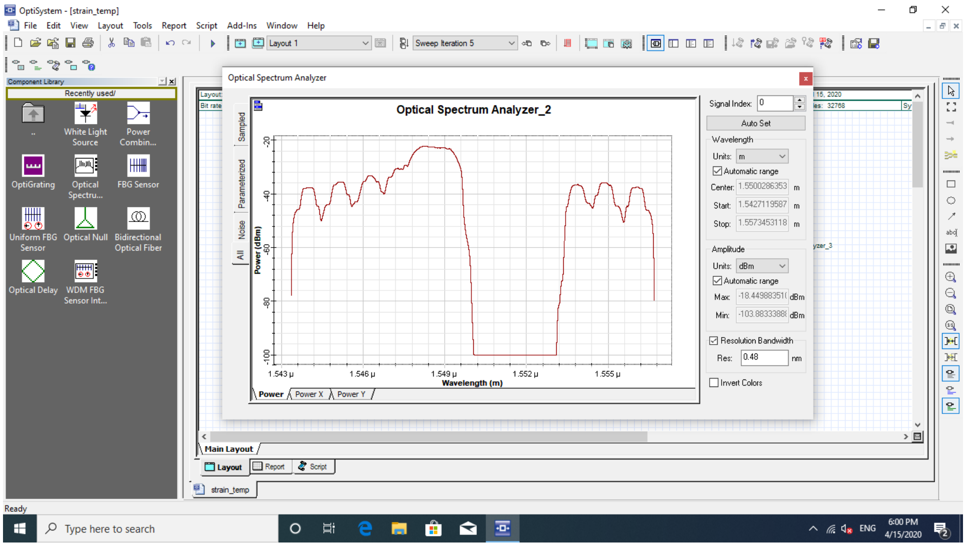

Figure 6.11: Temperature Applied 125°C

- Fig 6.12 that the temperature applied is 175 °C and the corresponding reflected wavelength is 1.553μm.

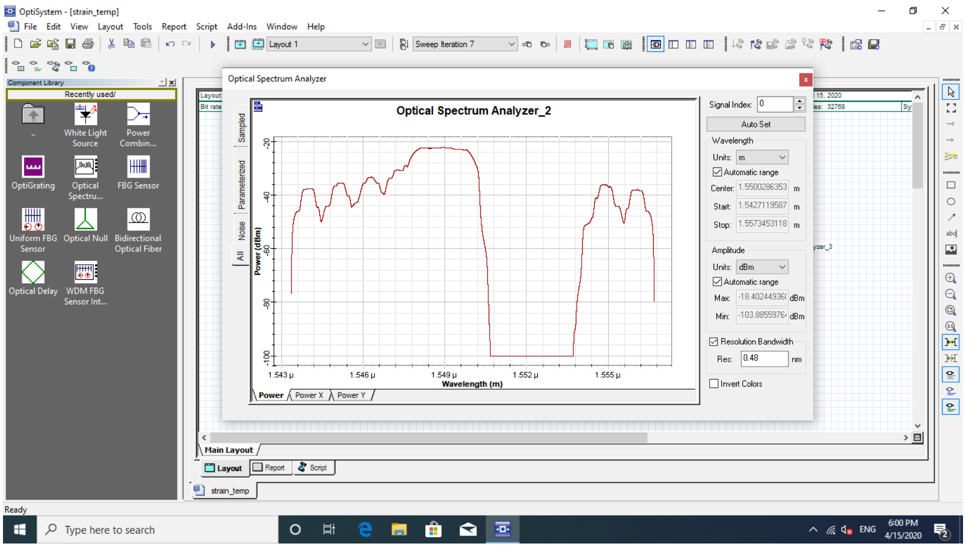

Figure 6.12: Temperature Applied 175°C

- Fig 6.13 shows that the temperature applied is 225°C and the corresponding reflected wavelength is 1.554μm.

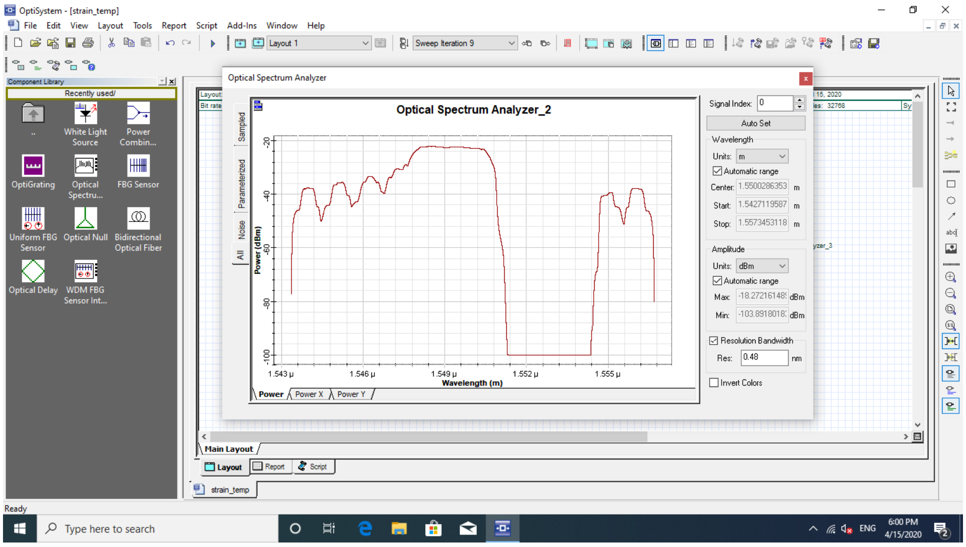

Figure 6.13: Temperature Applied 225°C

- Fig 6.14 shows that the temperature applied is 275 °C and the corresponding reflected wavelength is 1.554μm.

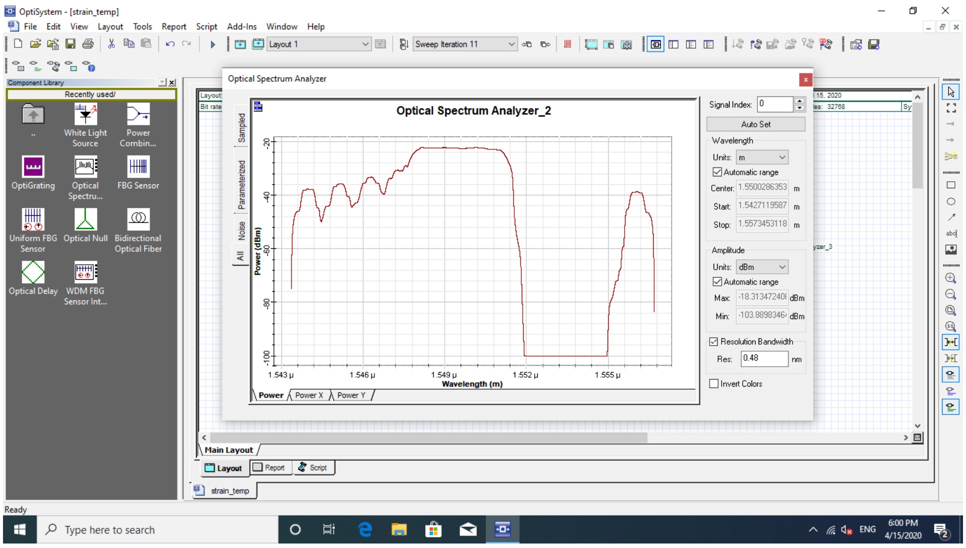

Figure 6.14: Temperature Applied 275°C

Sr.No.	Temperature °C	Reflected wavelength[μm]
1	25	1.550
2	50	1.551
3	75	1.552
4	100	1.552
5	125	1.552
6	150	1.553
7	175	1.553
8	200	1.553
9	225	1.554
10	250	1.554

This is a tabular representation of the varying values of temperature. The corresponding reflected wavelength has also represented in the table.The reflected wavelength proportionates according to the change in temperature. Ten Values taken into consideration have been observed. The calculations were made with the formula of shifting of wavelenth for temperature.

6.3 Results and Observation

- FBG sensors not being an extremely entrenched research area, be that as it may, they are additionally getting a greater piece of the pie because of their affectability with lower expenses.

- During this venture we audit strain sensorrs with greater spotlight over the basic standards, the cross examination, what's more, the read-out strategies.

- The activity standard execution are accounted for and contrasted and the ordinary designs. Optical fiber assumes critical roles in optical interchanges, optoelectronics, and sensors.

- The FBG sensors surpass other regular electric sensors in numerous viewpoints, for example, invulnerability to electromagnetic impedance, light weight, conservative size, soundness, adaptability, high temperature resilience, and impervious to brutal condition.

- This project gives the working rule, usage of a "without strain" FBG temperature sensors head and ghastly portrayal study. High-goals location of the frequency shifts instigated by temperature changes are accomplished utilizing optical range analyzer.

- Both uniform Fiber Bragg Grating (FBG) temperature sensors dependent on single mode fibers were executed and examined because of estimation of the Bragg frequency move.

- It has been appeared from the outcomes that the FBG is very delicate to varieties in temperature degrees over a temperature scope of (5–70) oC and the affectability was (1-6 pm/0.1C), likewise saw from the outcomes, the connection between the moved Bragg frequency and temperature degrees was direct.

- Thermal estimations using FBGs is an out and out estimation. There is continually a stand-out association among recurrence and temperature. FBG based temperature sensors are intrinsically uninvolved (no electrical power required) and henceforth can be arranged in high voltage and potentially delicate air regions.

Chapter 7

Conclusion and Future Work

It has been understood that optical fibers are effective mediums of communication and signal transmission and can parallely used as sensors too. They are composed of a core,cladding and an outer protective layer. Due to their high resistance to external noise and immunity to attenutation, the are more efficient than most communication mediums and cost more than the others. The glass core and the property of total internal reflection keeps the signal well within the boundaries of the internal transmission medium. The refractive index of the core is relatively lesser than that of the cladding. The precision in information transmission makes the overall complexity of setup a little higher as compared to other media of transmission.

Depending on the distance over which information has to be transmitted, there are two main types of fibers that are utilized which are commonly refered to as single-mode and multimode fibres. A Fiber Bragg Grating is a small element which can be placed in the core of a single-mode fiber optic cable. Its dimensions are usually in micrometers and the standard dimension is given by 1550μm. Multimode fibres offer transmission over larger distances and at higher speed with greater bandwidhts. Due to the micro nature of FBGs, they are usually placed in single-mode fibres.

We further explored the main property of an FBG : the ability to reflect a particular wavelength from a spectrum of wavelengths.Its sensitivity to strain and temperature makes it capable of being used as sensors. Spaced out around the core with alternating indices of refraction in high or low values, the gratings are placed with specific periods. The threshold wavelength at which a light source is reflected from a broadband of values,is commonly referred to as the Bragg Wavelength. The light rays meeting the minimum Bragg Wavelength values get reflected along the gratings spaced around the core.

It was observed that the strain incurred by the FBG based Sensor causes variations in parameters of the sensor. The direct impact begins from the change in grating period. The distance between spaced out gratings increases as a result of applied strain. There is also a corresponding shift in the Bragg wavelength which is determined by a strain co-efficient. The wavelength shift and distance increment is directly proportional to the intensity of applied strain. Thus,the reflected wavelenghts can be observed along with the respective fluctuations.

We could also infer that temperature-sensitivity is also another attribute of FBG based sensors and therefore, can be applied in systems incorporating thermal changes. The increment in temperature can be sensed by these type of sensors and the relative shift in grating period along with the bragg wavelength can be observed. Thus, as aligned with strain, temperature changes also are directly proportional to the shift in wavelenght. Due to these properties, FBG sensors are effective mediums to detect intrusion in security systems.

Optisystem is a virtual platform to perform optical experiments. It was understood that the tools and resources are highly useful in simulating real-life architectures and gain near optimal outputs. Parameters can be varied and fluctuated to obtain desired ouputs and corresponding waveforms can be generated to record observation and observe the shift in wavenlength graphically.

The wider area application of the proposed idea is novel and can create ideal systems employing and integrating cross-disciplinary concepts as a tool to creating real-time frameworks. Edge detecting along fences is one such application of the aformentioned layout. Floorboards can be used with sensors to create light switches. Surveillance Systems for securing borders can integrate the usage of such technologies to secure territories beyond the control of mankind. The project does propel a broad spectrum of diverse applications.

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Publication

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Date	Signature