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Optical Pressure Sensing Using Fp Etalon

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ABSTRACT

One of the most vital application technology needed in various industries is to calibrate the pressure. This project helps to acquire the measure of pressure by intensity of light using Fabry Perot Interferometer. Attaining exact pressure measurements in the tough environments has always braved the obtainable measurement technologies. In Demodulation of Fabry Perot pressure sensor, light is sent through it to measure the pressure, where the light entering the Fabry Perot Etalon and reflects back and forth in the reflecting planes. This project is done to reduce the errors while acquiring the measurement of the pressure as optical pressure sensors are used instead of conventional sensors which can work in any type of harsh environment. The Demodulation of the Fabry Perot Pressure sensor is done by OPTISYSTEM software.

Keywords: Optisystem, FP Etalon, pressure.

1. INTRODUCTION

Pressure is defined as force per unit area. A pressure sensor usually acts as a transducer.

The methods for pressure measurement are

- Differential
- Gauge
- Absolute

Absolute pressure is the pressure in vacuum whereas gauge and differential pressure are the ambient pressure in atmosphere. Gauge and differential measurement methods are relative to some other dynamic pressure.

2. FIBER OPTIC PRESSURE SENSORS

FOP Sensor devices can measure parameters which are defined in terms of light. The distinctive features and favourable abilities of these sensors are more promising than other types of conventional sensors which make them highlighted in the photonics technology. Also the sensing is quick and the response is accurate in measuring the physical and chemical quantities (Ge et al., 2008).

2.1. Classification of FOPs

Based on the modulation type the FOPs are classified as

i. Polarization modulated FOP
ii. Intensity modulated FOP
iii. Wavelength modulated FOP
iv. Phase modulated based FOP

2.1.1 Intensity Modulated FOPS

These types of FOPs are easy, simple and cheap because by just varying the intensity of the light transmitted we can detect it at the output. This technology is more suitable for multimode fibres.

2.1.2 Wavelength Modulated FOPS

The sensor in which the fibre Bragg grating is modulated is Wavelength modulated FOPs. This is used to measure stain, pressure in terms of wavelength.

2.1.3 Phase Modulated FOPS

To sense and measure physical parameters such as temperature, humidity, strain, pressure using refractive index we use Sagnac interferometer which has propagating beams introducing phase shift in a ring path with an optical fibre, Mach–Zehnder interferometer with two separate beam splitters to split and recombine the beams and has two outputs. The outputs depend on the precise difference in optical arm lengths and on the wavelength, Michelson interferometer which has a single beam splitter, the optical feedback is unwanted and access to the second output is required, the recombination of beams can occur at a somewhat different location on the beam splitter. These FOPs are not suitable for many applications because of its temperature instability and polarization fading.

3. FABRY PEROT INTERFEROMETER SENSOR

A Fabry-Perot interferometer (FPI) is generally composed of two parallel reflecting surfaces separated by a certain distance. Sometimes it is called an etalon. Interference occurs due to the multiple super positions of both reflected and transmitted beams at two parallel surfaces. For the fibre optic cases, the FPI can be simply formed by intentionally building up reflectors inside or outside of fibres. The Fabry-Perot interferometer is a very useful tool for high precision measurement, optical spectrum analysis, optical wavelength filtering and construction of lasers. It is a high resolution, high throughput optical spectrometer that works on the principle of constructive interference.

According to the different behaviours of the incident light, fibre optic Fabry-Perot sensors can be classified into two types:

i. Extrinsic Fabry-Perot Interferometric Sensor
ii. Intrinsic Fabry-Perot Interferometric Sensor

In intrinsic sensors, the light can continue within the fibre and be modulated. In Extrinsic sensors, light can be allowed to exit the fibre and be modulated in a separate zone before being relaunched into either the same or a different fibre.

3.1. Fibre Optic Fabry-Perot Interferometric Pressure Sensor

EFPI sensor consists of one silica capillary tube and two single mode fibres. In EFPI sensor, two single mode fibres are adjusted in a silica capillary tube using thermal bonding adhesive in such a manner that determines the gauge length and a certain length of an air cavity. A fibre can either be a single mode or multimode fibre called as reflector fibre and opposite of it is a single mode fibre called a detector fibre or source fibre is simply connectorized with a Ferrule Connector (FC) on this other end. The faces of both the fibres placed in the silica capillary tube opened in air cavity act as partial mirrors. These mirrors respond Fresnel Reflection of light beam and Air cavity called Fabry-Perot cavity. This responds Fabry Perot Interference between two beams of infrared light having 830nm wavelength occurred on the face of the detector due to the phase difference or change in optical path length. The source fibre is connected with IR source and detector using 3dB coupler.

Optical fibre EFPI sensor works on the two fundamental principles; Fresnel Reflection and Fabry Perot Interferometer by interconnecting single mode fibre within the silica capillary which represents Fabry-Perot cavity as sensing elements.

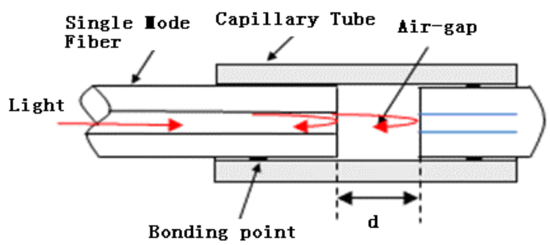

Figure 3.1 Fibre-optic extrinsic Fabry-Perot interferometer

4. DEMODULATION SYSYEM

Light from the source say laser is sent to tunable laser which is constructed by a Fabry-Perot tunable optical filter and EDFA (Erbium Doped Fibre Amplifier). This EDFA excites the photons in the light and the isolator which is connected to it removes the unwanted feedback. The laser output is parted into three ways with the help of the coupler where one part is fed into the Fabry-Perot etalon to calibrate the wavelength. Here, the light source entered into the interferometer reflects back and forth in the reflecting plates placed which amplifies the output light from the tunable laser (Junfeng Jiang et al.,2010).

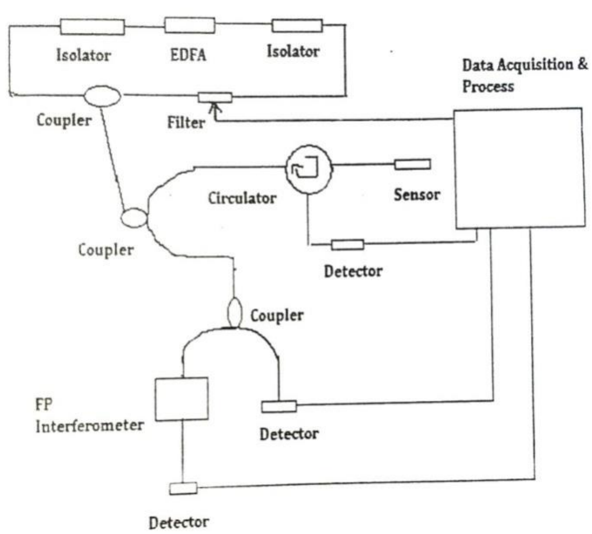

Figure 4.1 Demodulation system

The system consists of

ISOLATOR
To avoid the damages in the laser system due to optical feedback Isolators are used.

EDFA
An erbium-doped fibre amplifier or EDFA, is an optical or IR repeater that amplifies a modulated laser beam directly, without opto-electronic and electro-optical conversion

COUPLER
A fibre optic coupler is a device used in optical fibre systems with one or more input fibres and one or several output fibres.

FABRY-PEROT TUNABLE FILTER
Tunable Fabry-Perot filter supported on a substrate is transparent. It has two reflectors and there is a gap between which can be adjusted with the support of the body to modulate a wavelength of light output by the filter.

CIRCULATORS
An Optical Circulator is a non-reciprocal device allowing for the routing of light from one fibre to another based upon the direction of the light propagation. It enables the routing of light from one optical fibre to another based upon the direction of light propagation

DETECTOR
Detectors convert optical signals back into electrical impulses that are used by the receiving end of the fibre optic data, video, or audio link.

5.1. Simulation of demodulation system in optisystem

The demodulation block is designed using OPTISYSTEM software. The tools are imported from the component library to the main layout. The blocks are connected to form the demodulation circuit. The block construction is shown in the Fig.5.1

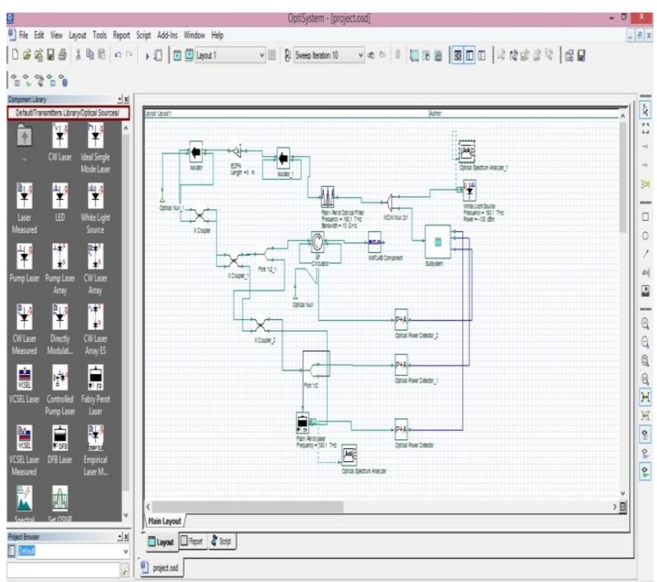

Figure 5.1 Construction of Blocks in OPTISYSTEM

Run the simulation by clicking Ctrl+F5 button or File menu ・Calculate.
The successful completion of the calculation is shown in the Fig 5.2

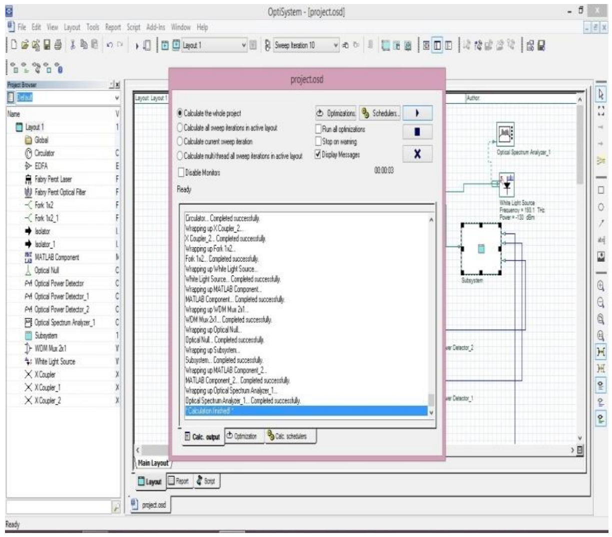

Figure 5.2 Callibrating the simulation

The parameter values can be changed by double-clicking the block.
This is shown as below in the Fig 5.3.

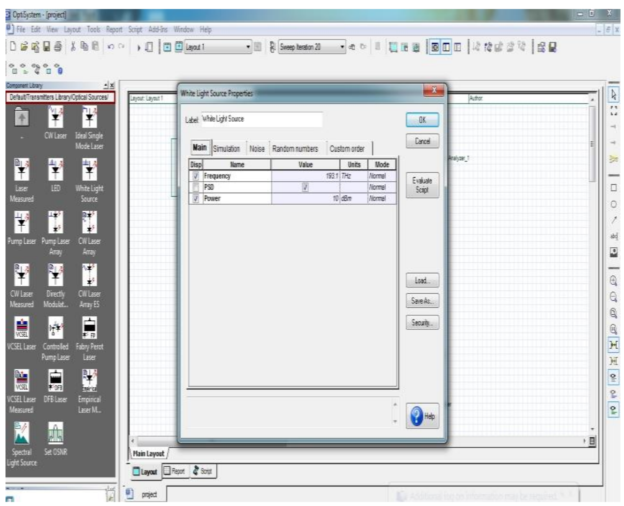

Figure 5.3 Applying changes to the parameter values

Then the input source from the laser can be analysed by the visualizer. The analysis can be obtained by double-clicking on the visualizer block and this is shown in the Fig 5.4.

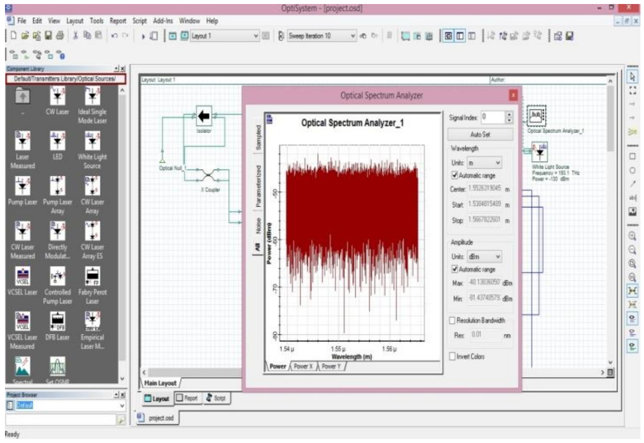

Figure 5.4 Visualising the light source from the laser

Another visualizer is connected to the Fabry-Perot Interferometer to analyse the output as shown in the Fig 5.5.

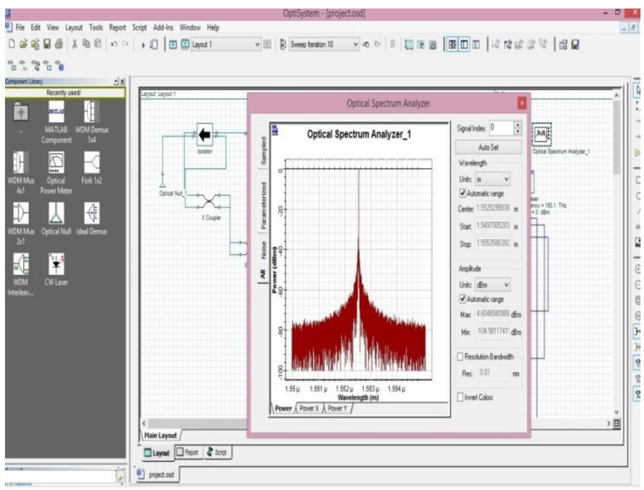

Figure 5.5 Output from the Fabry-Perot Interferometer

6. CONCLUSION

The Fabry Perot Interferometer used to measure the pressure for intensity of light. It challenged the available measurement technologies in these harsh environments for accurate pressure measurements. The Demodulation of the Fabry Perot Pressure sensor is demonstrated by OPTISYSTEM software. It is evolved to reduce the errors while acquiring the measurement of the pressure as optical pressure sensors are used instead of conventional sensors which can work in any type of harsh environment.

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