PERFORMANCE ANALYSIS OF ALL OPTICAL DATA AND CLOCK RECOVERY SYSTEM USING FIBER BRAGG GRATING IN SENSING APPLICATIONS

B. Arun Vijayakumar[1], Dr.A.Swarnalatha[2], L.Kanagadurga[3]

[1]Assitant professor, Department of ECE, Jeppiaar Engineering College

[2]Professor, Department of ECE, St. Joseph's College of Engineering

[3]Assitant Professor, Department of ECE, St. Joseph's Institute of Technology

[1]bjarunvijayakumar@gmail.com

Abstract-*This paper presents chirp, apodization functions and temperature variations effects on the optical data and clock recovery system using fiber Bragg Grating sensors (FBGs). The performance of then system is also intended for sensing effect using different profile of fiber Bragg by inferring the transmitted and reflected signal power can be at different ambient temperatures. FBGS operation performance efficiency can be enhanced with the employment of user defined chirp function with user defined apodization function at room temperature in the presence of suitable value of Tanh parameter. It is observed that user defined apodization function has presented the highest FBGS power and the lowest reflected signal power in compared with other apodization functions at different types of chirp functions. It is found that the dramatic negative effects of increasing ambient temperature on FGBS power, reflected signal power, signal quality factor and bit error rate (BER) measurements.*

Keywords-*Apodization function, Chirp function, Fiber Bragg Grating temperature sensor, Reflected signal power.*

I. Introduction

Ref. [1] has presented the different types of Grating based sensors such as titled fiber Bragg Grating sensors, long period Grating sensors, and fiber Bragg Grating sensors. the mathematical relation is discussed and simulated to study the variations of Bragg wavelength with respect to strain, pressure, and ambient temperature variations. As well as the study of the Bragg wavelength shift under the static/dynamic pressure sensitivity is experimented with the mathematical analysis based fiber Bragg Grating sensors [2]. The study of optical fiber temperature sensors is analyzed and discussed based on interference of selective high order modes. Experimental results of the variations of Bragg wavelength shift against high temperature variations from 200 °C to 800 °C are reported using multi mode optical fiber in the presence of high order modes [3]. As well as the experimental results are also reported with the complete analysis and discussions to show the Bragg wavelength shift and relative output power versus both the temperature variations over the dynamic range from 30 °C to 1000 °C and applied dynamic pressure [4, 5].

Output power intensity and Bragg wavelength shift of fiber Bragg Grating sensors are measured experimentally with the complete analysis and discussions over the dynamic temperature range variations from 25 ºC to 85 °C taking into account, the cost criteria for the fabrication of the sensor device. Moreover, it is observed that the temperature sensitivity of fiber Bragg Grating sensors is about 1 pm/0.1 ºC [6, 7]. In addition to the fiber Bragg Grating temperature sensor implementation and spectral characterization are studied to show the high resolution detection of Bragg wavelength shift and phase shift induced by temperature degrees over temperature range of 10-70 °C. The study indicated that the wavelength sensitivity is about 1-6 pm/ 0.1 ºC and the relation between shifted Bragg wavelength and ambient temperature degrees was linear relation [8].

The paper is organized as follows. Section II presents the system simulation model description. The simulation results and performance evaluation of fiber Bragg Grating temperature sensors under apodization and chirp functions variations are studied in section III. The conclusion of the results is presented in section IV.

II. Experimental Simulation Description

BUPT

Fiber Bragg Grating temperature sensor is analyzed, and discussed through the basic schematic view of experimental simulation set up in Fig. 1. The circuit system consists of a pseudo random binary sequence generator is a binary sequence that, while generated with a deterministic algorithm and exhibits statistical behavior similar to a truly-random sequence. Non return to zero which is responsible for the creation a sequence of non-return to zero pulses coded by an input digital signal which is directed to vertical cavity surface emitting laser (VCSEL) is a type of semiconductor laser diode with laser beam emission perpendicular from the top surface which its function to generate a sufficient gain in order to pump the signal into fiber cable and then the signal is directed to fiber Bragg Grating which reflects a wavelength of light that shifts in response to variations in temperature and/or strain according to its application.

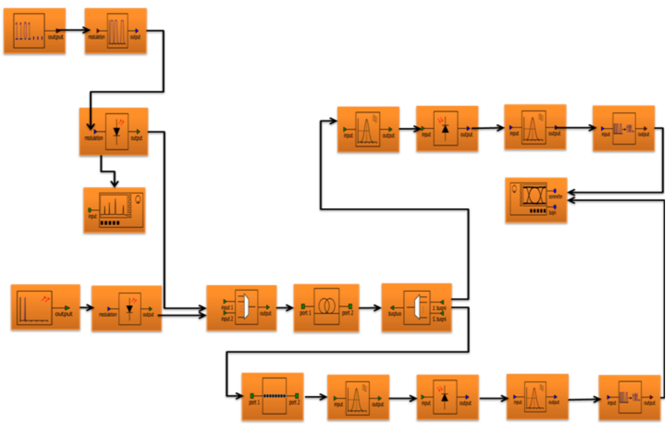

Fig. 1. Schematic view of experimental system simulation set up.

Optical spectrum analyzer is designed to measure and display the distribution of power of an optical source in the vertical scale over a specified wavelength span in the horizontal scale. As well as optical power meter is designed to measure the numerical values of fiber Bragg Grating sensor power and reflected signal power. The signal is directed to Bessel optical filter (BOF) whose its function is to optical signal processing from the noise and then routed to avalanche photo detector (APD) receiver whose is function is to convert the light signal system unit to electrical signal system unit. In addition to the converted signal is pass through band pass Bessel filter (BPBF) in order to remove the ripples from the signal. The processing signal is directed to 3R regenerator whose its function is regeneration, retiming, reshaping the signal and then the generated signal is measured its quality through BER analyzer.

III. Simulation Results and Performance Analysis

Fiber Bragg Grating power, reflected signal power, maximum signal quality facto, and minimum bit error rate are simulated, analyzed and discussed based on the variations of apodization, chirp functions, Tanh, Gauss parameters and ambient temperatures. Clarified simulation results based on the simulation operating parameters are listed in Table 1.

Table 1: Proposed simulation parameters used in this study [9].

NRZ pulse generator	
Parameter	Value
Amplitude	1 a.u.
Rectangle shape	exponential
Rise time	0.05 bit
Fall time	0.05 bit
VCSEL laser	
Frequency	193.1 THz
Temperature	25 ºC-125 ºC
Bias current	10 mA
Modulation peak current	20 mA
Operating power	6.6 mW
Bit rate	5 Gb/s
Optical Fiber	
Length	1 Km
Attenuation	0.2 dB/Km
Reference wavelength	1550 nm
Fiber Bragg Grating	
Frequency	193.1 THz
Refractive index	1.45
FBG length	2 mm
Apodization functions	Uniform, Gaussian, Tanh, and user defined
Chirp functions	Linear, quadratic, square root, cubic root, and user defined
Gauss parameter	0.1-1
Tanh parameter	0.1-1
Bessel optical filter	
Frequency	193.1 THz
Insertion loss	0 dB
Bandwidth	10 GHz

BUPT

Order	14
APD photodetector	
Gain	3
Responsivity	1 A/W
Ionization ratio	0.9
Dark current	10 nA
Band pass Bessel filter	
Insertion loss	0 dB
Frequency	10 GHz
Order	1

Based on the system simulation setup and list of simulation parameters used in Table 1. The following results are indicated as shown in the series of Figs. (2-15):

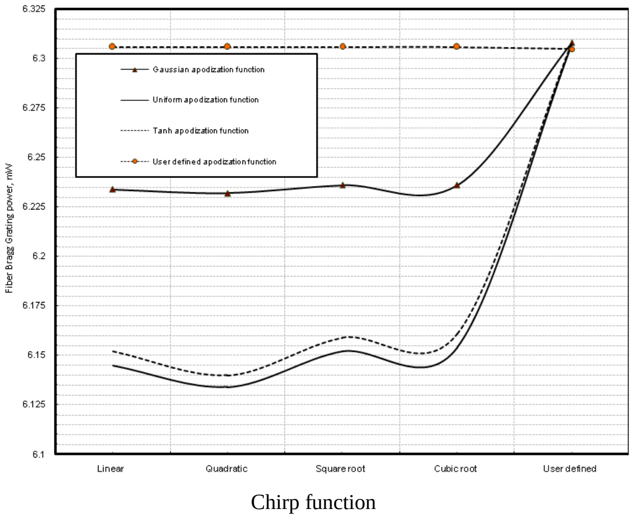

Fig. 2. Fiber Bragg Grating power versus both different chirp and apodization functions at room temperature.

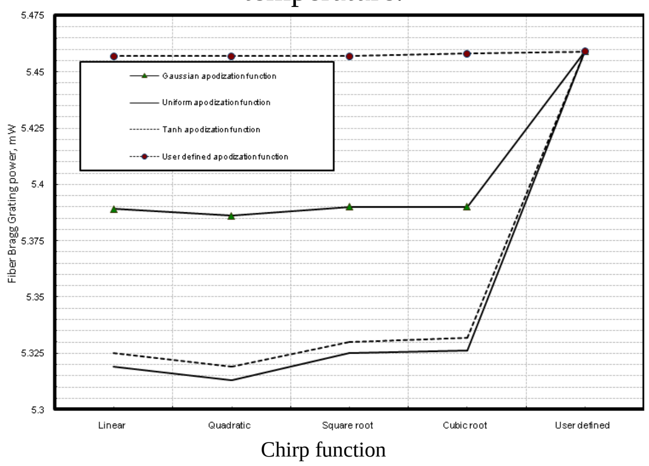

Fig. 3. Fiber Bragg Grating power in relation to both different chirp and apodization functions at ambient temperature (T=75 °C).

Figures (2-4) have demonstrated that fiber Bragg Grating sensor power has achieved its maximum value in used defined apodization function then Gaussian, then Tanh and finally uniform apodization functions for different shapes of chirp functions. It is found that fiber Bragg Grating power decreases with increasing ambient temperature.

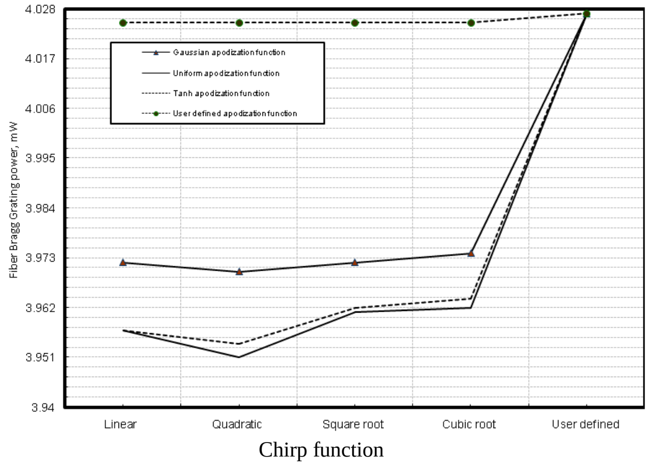

Fig. 4. Fiber Bragg Grating power in relation to both different chirp and apodization functions at ambient temperature (T=125 °C).

Figures (5-7) have assured that reflected signal power is decreased with the employment of user defined apodization function for different chirp functions in compared with other apodization functions. It is observed that reflected is increases with increasing ambient temperature, so the performance of fiber Bragg Grating temperature sensor degrades.

Figures (8, 9) have indicated that maximum signal quality factor decreases and bit error rate increases with increasing ambient temperature. Maximum Q-factor and minimum BER are achieved with Gaussian, and used defined apodization functions in compared with other apodization functions.

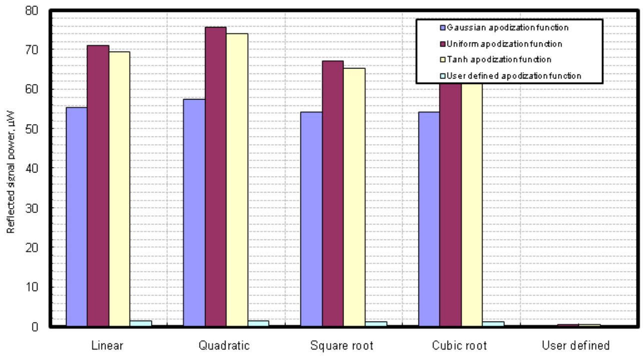

Fig. 5. Variations of reflected signal power against variations of both different chirp and apodization functions at room temperature.

BUPT

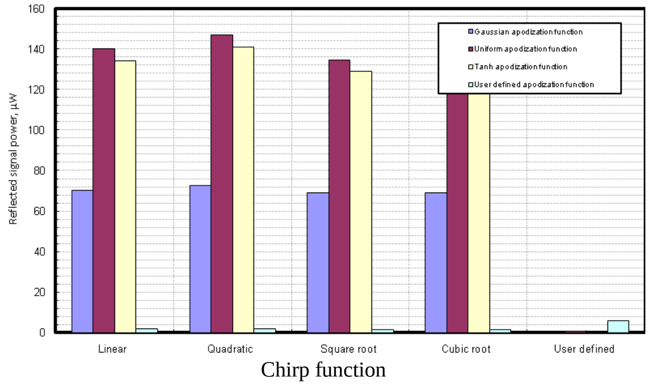

Fig. 6. Reflected signal power against variations of both different chirp and apodization functions at ambient temperature (T=75 °C).

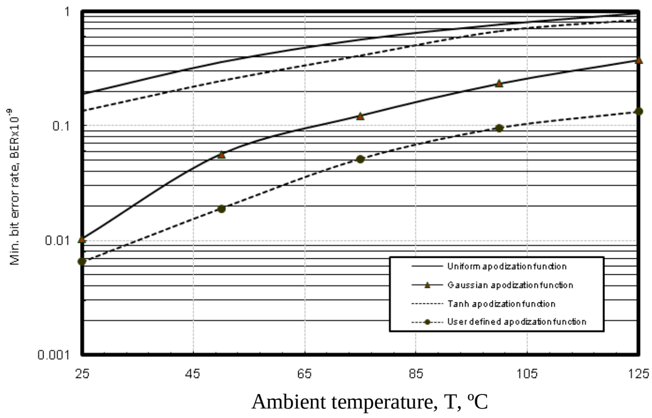

Fig. 9. Minimum bit error rate in relation to the variations of different ambient temperatures and apodization functions.

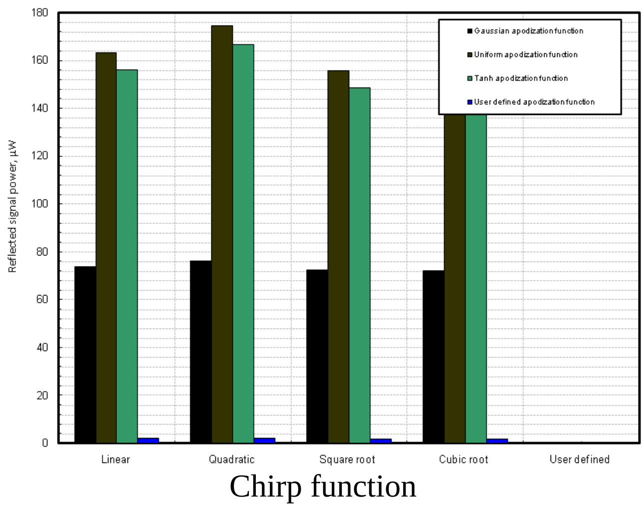

Fig. 7. Variation of reflected signal power versus both different chirp and apodization functions at ambient temperature (T=125 °C)

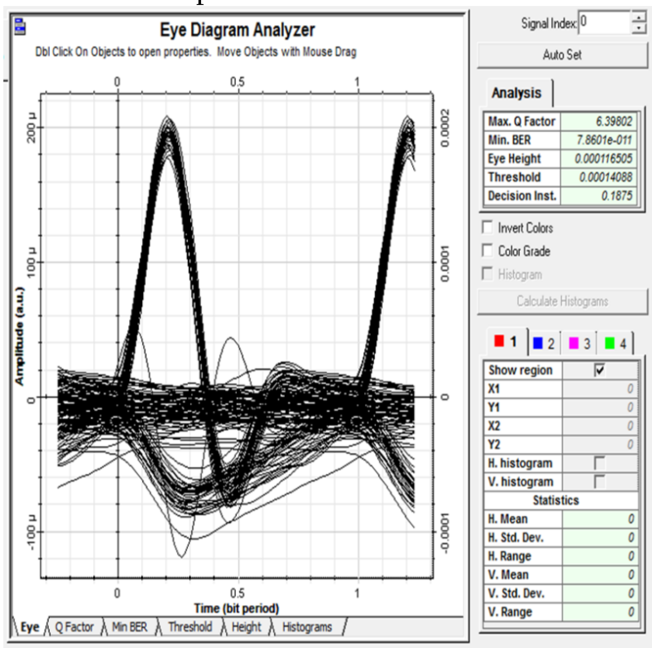

Fig. 10. Eye diagram analyzer with user defined apodization function at room temperature.

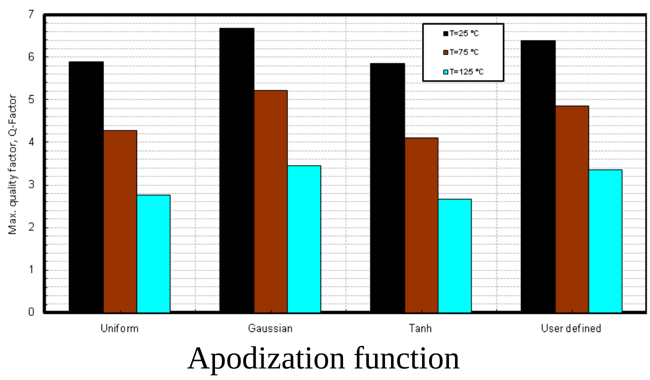

Fig. 8. Variations of maximum signal quality factor against variations of apodization function with different ambient temperatures.

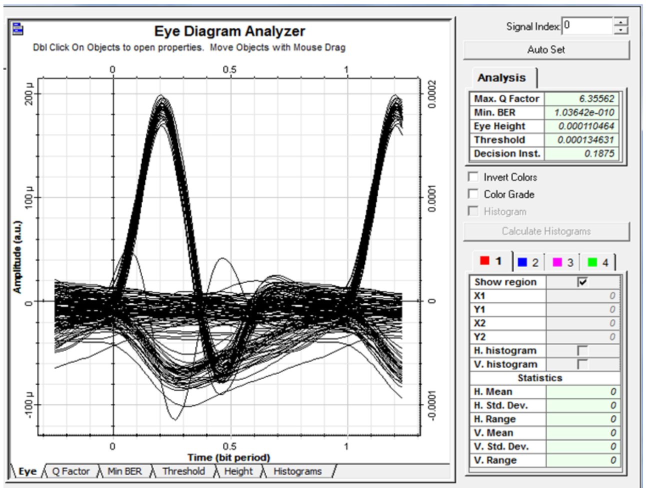

Fig. 11. Eye diagram analyzer with Gaussian apodization function at room temperature.

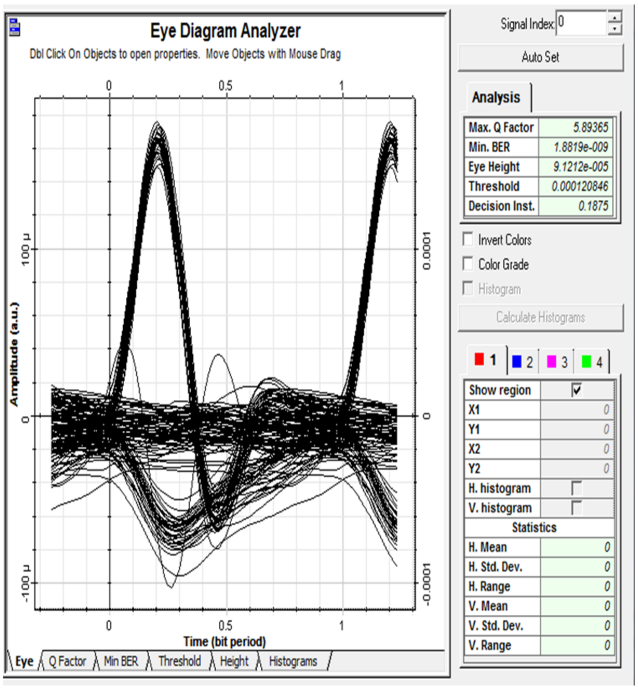

Fig. 12. Eye diagram analyzer with uniform apodization function at room temperature.

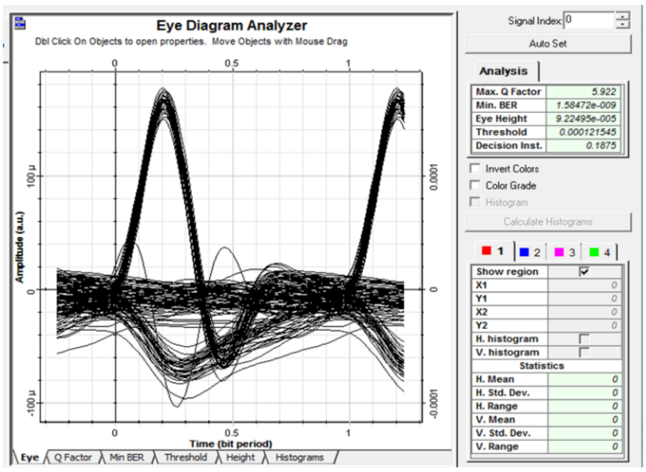

Fig. 13. Eye diagram analyzer with Tanh apodization function at room temperature.

Figures (10-13) show the maximum Q-factor and minimum BER measurements for different apodization functions at room temperature (optimum case) using eye diagram analyzer. It is numerically found that the enhancement of Q-factor and BER values with using both Gaussian, and used defined apodization functions in compared with other apodization functions.

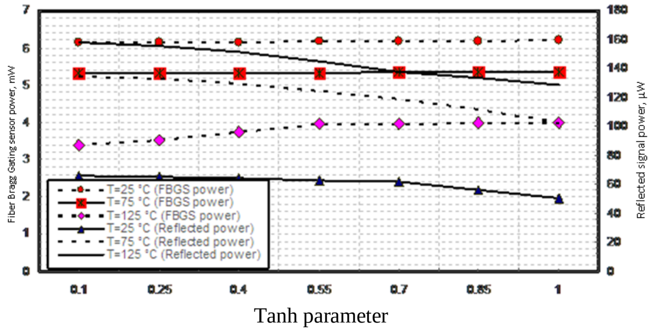

Fig. 14. Fiber Bragg Grating temperature sensor power and reflected signal power in relation to Tanh parameter and different ambient temperatures.

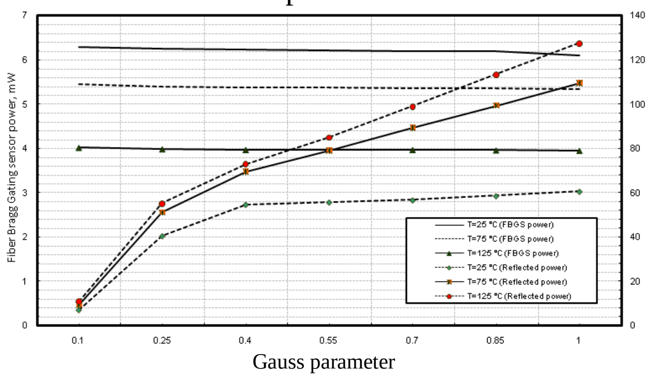

Fig. 15. Variations of fiber Bragg Grating temperature sensor and reflected signal power against variations of Gauss parameter and different ambient temperatures.

Figures (14, 15) show the effect of increasing either Tanh parameter or Gauss parameter on fiber Bragg Grating sensor power, and reflected signal power. It is indicated that the urgent need for either increasing Tanh parameter or decreasing Gauss parameter for increasing FBGS power and decreasing reflected signal power.

IV. Conclusions

In a summary, fiber Bragg Grating temperature sensors are deeply analyzed and simulated. Fiber Bragg Grating sensor power, reflected signal power, maximum signal quality factor, and minimum bit error rate are the major interesting parameters to measure FBGS operation performance efficiency under the effects of apodization, chirp functions and ambient temperatures variations. It is observed that the negative dramatic effects of increasing ambient temperature on the FBGS operation performance efficiency. It is indicated that the important employment of both user defined apodization function and user defined chirp function with room temperature in order to decrease reflected signal power and then to increase FBGS power with high signal quality factor. As well as it is found that the positive effect of increasing Tanh parameter and decreasing Gauss parameter for FGBS power enhancement and reflected signal power reduction. The future study will be expanded to include the pressure, and strain fiber Bragg Grating sensors under apodization and chirp functions variations.

References

[1] A. Zrelli, M. Bouyahi, and T. Ezzedline, "Control and Measurement of Presure, Temperature, and Strain Variation by Modeling Bragg Sensor," 3rd International Conference on Automation, Control, Engineering and Computer Science (ACECS 2016), Proceeding of Engineering & Technology, pp. 160-165, 2016.

[2] J. Huang, Z. Zhou, Y. Tan, M. Liu, and D. Zhang, "Design and Experimental Study of A fiber Bragg Grating Pressure Sensor," International Conference on Innovative Design and Manufacturing, Montreal, Quebec, Canada, pp. 217-221, Aug. 2014.

[3] E. Li, X. Wang, and C. Zhang, "Fiber Optic Temperature Sensor Based on Interference of Selective Higher Order Modes," Applied Physics Letters, Vol. 89, pp. 091119 (1-3), 2006.

[4] P. S. Reddy, R. L. N. S. Prasad, K. S. Srimannarayana, "A novel Method for High Temperature Measurements using Fiber Bragg Grating Sensor," Optica Applicata, Vol. XL, No. 3, pp. 685-692, 2010.

[5] V. R. Mamidi, S. Kamineni, L. N. S. P. Ravinuthala, S. S. Madhuvarasu, V. R. Thumu, V. R. Pachava, and K. Putha, "Fiber Bragg Grating Based High Temperature Sensor and its Low Cost Interrogation System with Enhanced Resolution," Optica Applicata, Vol. XLIV, No. 2, pp. 299-308, 2014.

[6] B. B. Padhy, S. N. Kale, R. B. Sharma, and A. D. Shaligram, "Cost Effective Fiber Bragg Grating Temperature Sensor Using Power Measurement," International Journal on Emerging Technologies, Vol. 5, No. 2, pp. 110-113, 2014.

[7] M. L. Yousf, I. A. Kadham, T. S. Mansour, and K. I. Hajim, "Optical Fiber Bragg Grating Temperature Sensor," Diyala Journal of Engineering Sciences, Vol. 7, No. 4, pp. 40-46, Dec. 2014.

[8] S. A. Kadhim, S. A. A. Taha, and D. A. Resen, "Temperature Sensor Based on Fiber Bragg Grating (FBG), Implementation, Evaluation and Spectral Characterization Study," International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4, No. 9, pp. 8038-8043, Sep. 2015.

[9] Optiwave Corporation "Optisystem 7.0 component library "2008.