International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Implementation of Optical Micro Displacement Sensor System using Single Mode Coupler for Lasers at (532&810) nm

Samar Y. AL-Dabagh[1], Nahlia A. Aljbar[2], Zeinah K.Abdaldeen[3]

[1,3]Baghdad University, College of Science for Women, Physics Department
[2]Ministry of Science and Technology, Optoelectronic Center

Abstract: ***In this paper implementation of optical micro displacement sensor system using single mode 50:50 coupler based on intensity modulated technique is presented. A single mode fiber coupler (L=2.5 m) has coupling ratio 0.5, excess loss 0.2 dB, directivity 60dB and 9µm core diameter is used .Two optical sources IR laser diode (810 nm) and green laser diode (532 nm) with optical power meter to detect the variation in output laser power due to micro displacement for movement body under test ,a planar mirror and spectrum analyzer to detect the change of the light intensity as function of the displacement were utilized .Results show that the sensor is able to detect object displacement in front of mirror.The sensor characteristics are measured at the slope. Good sensitivity of the sensor 202.8 µW / mm for IR laser source and sensitivity of the sensor 411.2µW / mm for Green laser source.***

Keywords: Green laser source**,** single mode coupler**,** spectrum analyzer**,** optical fiber, sensor

1. Introduction

An optical sensor is a device that converts light rays into electronic signals.The advantages of the optical sensors are noncontactmeasurement, no added mass or modification of the structure being measured, compactness, widebandwidth, simplicity, high resolution [1].Optical fiber sensor is one of the most interesting and developing field. The fiber sensor are becoming day by day more attractive over other sensors, due to immune to EMI, non-electrical, highaccuracy, easy to install, noncontact, explosion proof small size and weight, the opticalfiber replaces othersensors. A number of varieties of parameters like temperature, humidity, pressure, pH, chemicalconcentration and displacement can be measured accurately [2, 3].Fiber optic displacement sensors have several disadvantages that make them particularly advantageous as compared to conventional capacitive and inductive displacement sensors, including compact size, thermal and chemical resilience,multiplexing capacity, and electromagnetic immunity. These attributes have led to the successful application ofoptical fiber sensors in structural monitoring and machine control [4,5].Displacement sensors and measurement techniques have been widely applied in manyfields, including advanced fabrication machines, health monitoring devices, and medicine [6-7].

2. Experimental Setup

The experimental setup is shown in Figure 1 It consists of two types of laser sources (532 and 810) nm, input power(1.96 and 0.973) mW input power, fiber coupler, a planar mirror, optical power meter, and optical spectrum analyzer. The fibercoupler used is structured 2x2 (core diameter is 9 µm and cladding is 125µm) and2.5m in length. The single mode fiber coupler hascoupling ratio 0.5, excess loss 0.2 dBand directivity 60 dB, The power measured against the corresponding change in micrometer translational stage.

We have proposed a reflective intensity optical fiber displacement sensor. The sensor can directly measure the linear displacement of a flat surface. First is construction concept using intensity modulation techniques using 50:50 single modeoptical fiber coupler (9µm diameter), NA(0.02) and directivity (60dB). In these measurements our aim is to study the different results of displacement sensor using optical fiber coupler and two laser source(532 and810)nm.

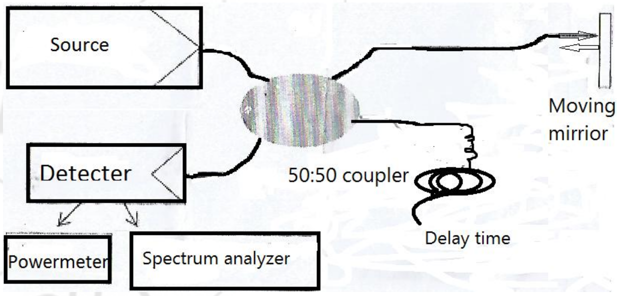

Figure 1: The basic setup of displacement sensor using single mode fiber coupler.

3. Results and Discussion

A. Light intensity with the displacement measurements

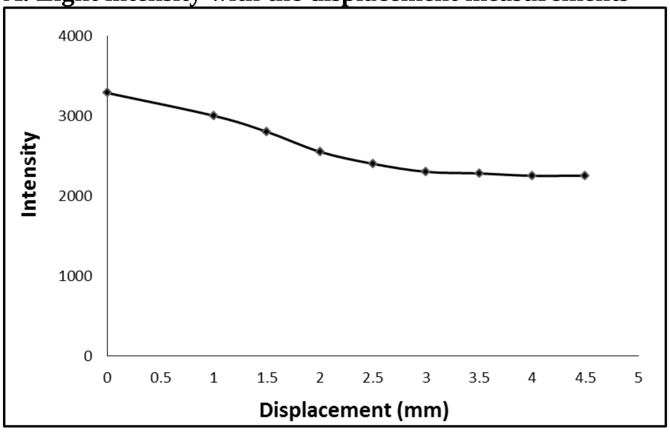

Figure 2: Intensity of the green laser source (λ=532nm) as function of mirror's displacement

Licensed Under Creative Commons Attribution CC BY

Figure (2) shows the relationship between the intensity of the green laser source and the displacement. The sensors only have one slope and the sensitivity is higher at smaller core diameter.Figure (3) Shows the intensity of the infrared laser source (λ=810 nm) decay exponentially with displacement of the object.

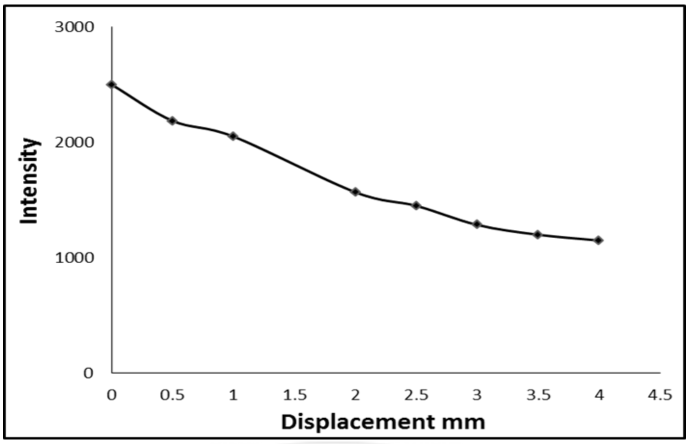

Figure 3: Intensity of the IR laser source (λ=810nm) as function of mirror's displacement

B. Light intensity with wavelength measurements

By using high resolution spectrometer connected to a personal computer, we obtained the spectrums of the laser sources. The spectrum of laser sources at different wavelengths is shown in figure 4

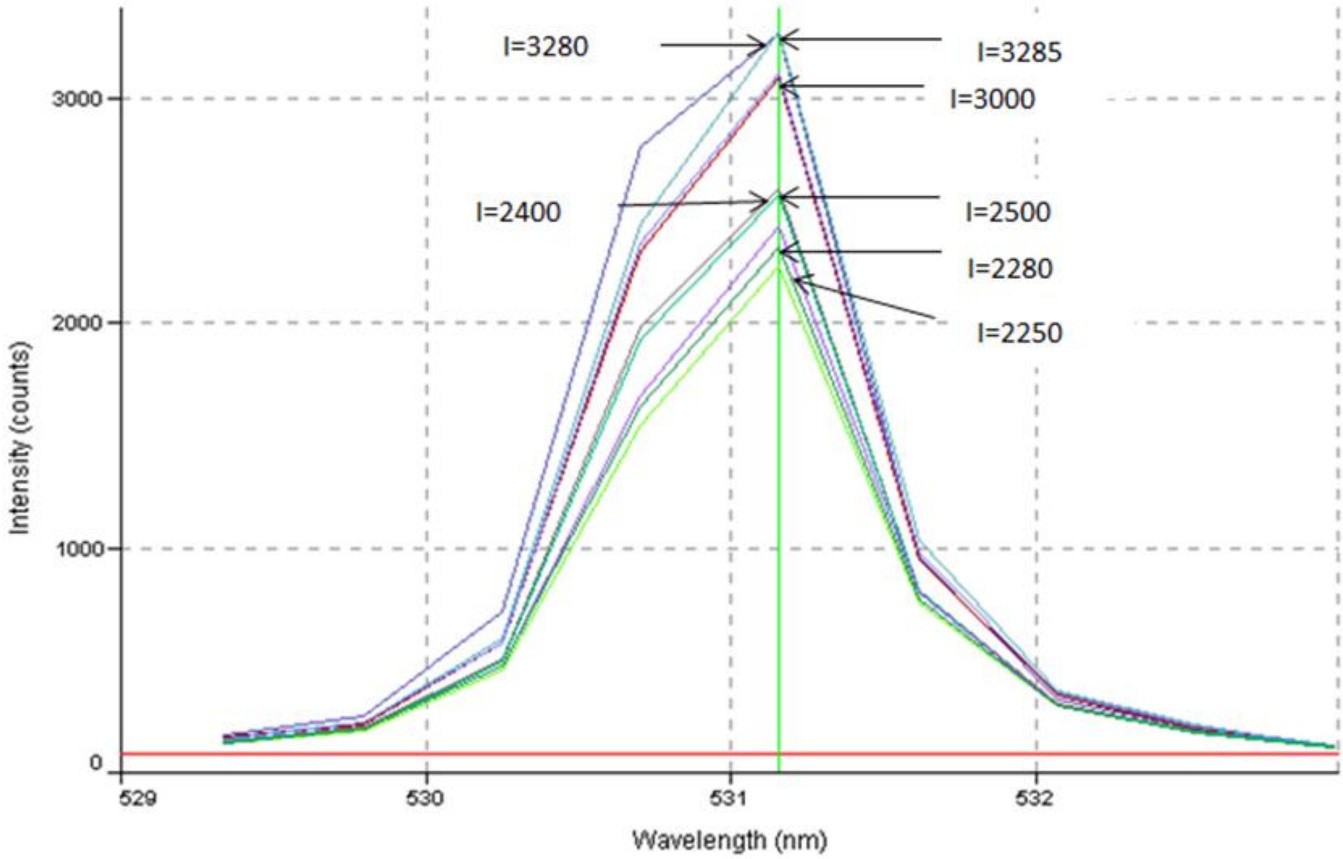

Figure 4: Green laser spectrum (λ=532nm)

Figure 4 shows the relationship between the intensity (counts) and the wavelength of the green laser source in visible region in units of nanometers (λ=532nm). A range of the peaks intensities from 2250 to 3285. In figure 4 no peak shifting is observed.

Licensed Under Creative Commons Attribution CC BY

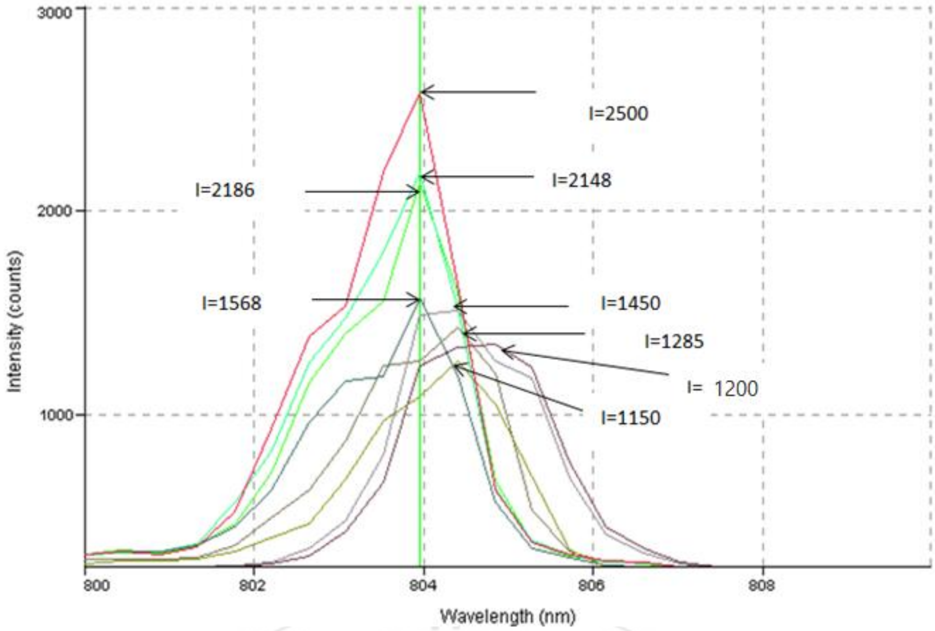

Figure 5: IR laser spectrum (λ=810nm)

Figure (5) Shows the relationship between intensity (counts) and the wavelength of the IR laser source(λ=810nm)units of nanometers. A range of the peaks intensity from 1000 to 2500.

We observed the peaks of the intensities curve shift toward higher wavelengths as shown in figure 5. At displacement (0, 0.5,1,2 and 2.5) mm ,the position remain constant of the peaks i.e. Δλ is 0,while a red shifting is occurred at 3 mm distance when the intensity is 1285and Δλ is 0.5 nm while Δλ is 1nm at displacement 3.5 mm when the intensity is 1200 as shown in figure 6 . In general the reason of the peak shifting is due to the fiber numerical aperture changing that very much depends on angle θ that change because of light beam reflecting.Angle θ theoretically indicatesthe beam is homogeneous and perfect cone-shape. But, in experiment the outgoing laser beam from sensing port is Gaussian shape beam.

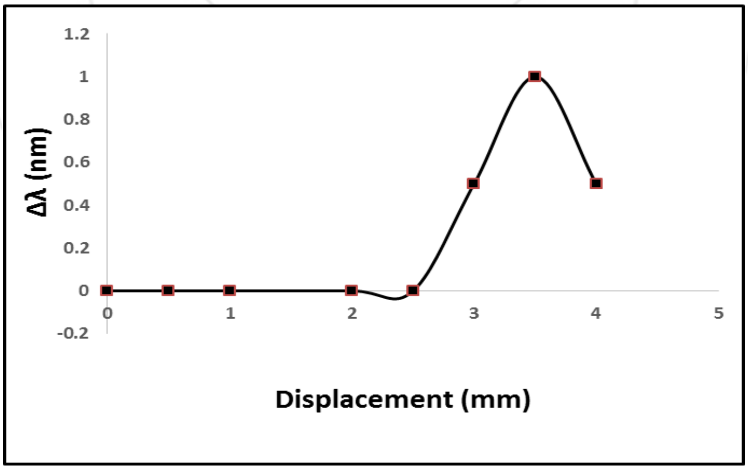

Figure 5: Δλ of IR laser via displacement

C. Light power with the displacement measurements

In these measurements our aim is to study (experimentally) the output power of laser displacement sensor by using two types of the laser sources (532 and 810) nm, single mode optical fiber coupler. The output power light is plotted with respect to displacement of the mirror as shown in the following figures

Licensed Under Creative Commons Attribution CC BY

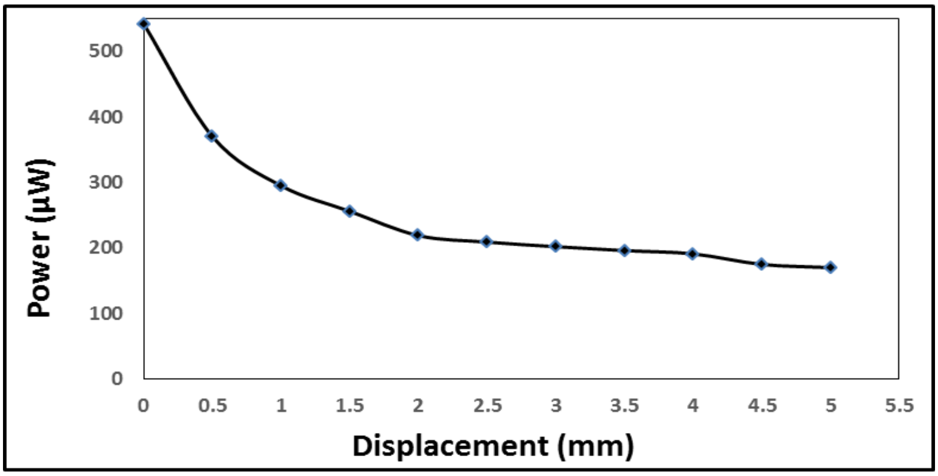

Figure 7: The output power received by the detector via mirror displacement of visible laser source (532 nm)

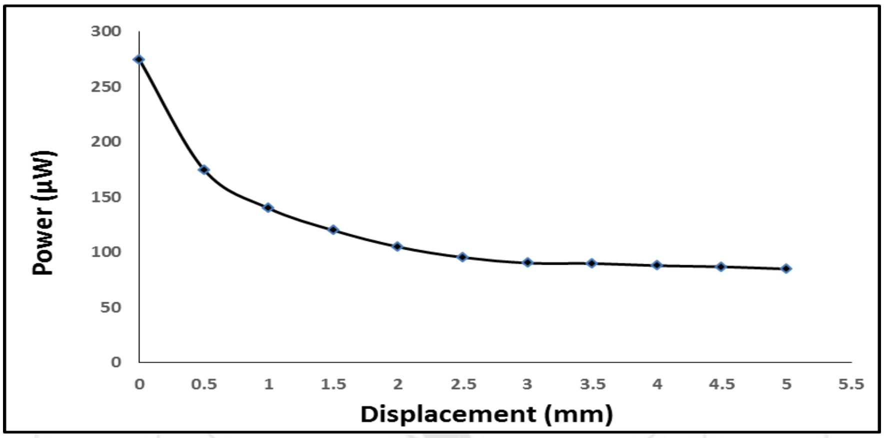

Figure 8: The output power received by the detector via mirror displacement ofIR laser source (λ=810nm)

Figure 7 shows the exponential relationship between the output power of the light source using laser source in visible region at wavelength (λ=532nm) by using single optical fiber coupler (2.5 m) length. A maximum power is 542 µW is obtained when the target (mirror) at 0mm displacement, while the minimum value of the power of the light source is 170 µW when the target at distance 5 mm. This means that when the distance of target (mirror) increases the power of the light decreases due to inverse-square law. We observe a good linearity in range of displacement from (0-0.5) mm.

Figure 8 shows the relationship between power of the light source using laser source in IR region at (λ=810nm) wavelength, optical fiber coupler 2.5 m length. A maximum power is 275 µW is when the target (mirror) is not moving, while the minimum value of the power of the light source is 85 µW at the distance of target distance 5 mm. This means that when the distance of target (mirror) increases the power of the light decreases due to inverse-square law.

4. Conclusion

Based on intensity modulation a simple and effective single optical fiber micro displacement sensor technique is presented. The results are linear for lasers sources at (810 and 532) nm wavelength. The sensitivity of the sensor by using green laser source is (411.2µW/mm)which is higher than the sensitivity for IR laser source (202.8µW/mm) good linearity in range of displacement from (0-0.5) mm.

Due to the simplest and compact design of such type of sensors, they find applications in industries as monitoring automated control, position control and micro displacement measurements in the hazardous regions. Such type of micro displacement sensor has relatively small measurable displacement range, but very sensitive over a small range.

References

[1] R. Dib a,b, Y. Alayli a, P. Wagstaff. “A broadband amplitude-modulated fibre optic vibrometer with nanometricaccuracy”. MeasurementVol. 35, Issue 2, PP. 109-220.March 2004.
[2] YoanyRodr´ıguezGarc´ıa, Jes´us M. Corres, and Javier Goicoechea. “Vibration Detection Using Optical FiberSensors, *Journal of Sensors*, Vol. 2010, Article ID 936487, pp.12 , 2010.
[3] Fidanboylu, K.a, and Efendioglu, H. S.b. “Fiber optics and their application”, *5th International AdvancedTechnologies Symposium*, (IATS’09),Vol. 2, No. 2,pp. 59-66, 2009.
[4] Y. Huang, T. Wei, Z. Zhou, Y. Zhang, G. Chen, and H. Xiao, Meas. Sci.”An extrinsic Fabry–Perot interferometer-based large strain sensor with high resolution”,Technol.Vol.21, pp.105-308. 2010.
[5] R. Tennyson, A. Mufti, S. Rizkalla, G. Tadros, and B. Benmokrane,”Structural health monitoring of innovative bridges in Canada with fiber optic sensors” Smart Mater. Struct.Vol.10, pp.560. 2001.

Licensed Under Creative Commons Attribution CC BY

[6] Andrew, J.F.” A review of nanometer resolution position sensors: Operation and performance. Sens. ActuatorsA Phys. Vol. 190, 1 February, pp.106–126.2013
[7] Poeggel, S.; Tosi, D.; Duraibabu, D.; Leen, G.; McGrath, D.; Lewis, E. Optical “Fibre Pressure Sensors inMedical Applications”. Sensors , Vol.15, pp.17115–17148. 2015.

Licensed Under Creative Commons Attribution CC BY