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Fiber Optic Sensor for Respiration Monitoring of Chronic Obstructive Pulmonary Disease Patients

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Abstract

This paper presents the design of respiratory sensor using optical fiber for monitoring of chronic obstructive pulmonary disease patient (COPD). The sensing mechanism may be integrated into wearable breathe monitoring device for COPD patient and it is not very expensive. The sensor records breathing signals devoid of direct skin contact. The output sensor sends the optical signal into an optical fiber which is subjected to macro-bending and using thorax expansion of COPD simulators; it shows that the system is capable of detecting irregular breath patterns.

Keywords: *COPD, LED, Optical fiber, photo detector, Respiratory sensor*.

1. Introduction

COPD is a deliberating and progressive disease that affects patient during the rest time between respiratory resettlement. It is 4th ranked non communicable disease that is becoming the cause of death worldwide [1]. This disease is progressive and chronic caused by polluted air infection and smoking .The symptoms of COPD are chest tightness, coughing, fatigue, dizziness & wheezing. The COPD patient suffer from exacerbation if sustained then it can cause worsening of symptoms that lead to less air intake during respiration [2]. The COPD patient is likely to survive with right monitoring system of their physical condition [3]. Various monitoring systems have been developed using Fiber Optical sensor. There are many advantages of optical fiber sensor due to its characteristic's properties like flexibility, low cost and electromagnetic insulation, lower risk of infection [4] . Work of Pauwels R et.al. is based on electronic sensor ,comprising two electrodes, telemetric instrument sensor for air flow measurement using fiber optic sensor [5]. D. Dobrev presented the respiration sensors consisting of a monomode optical fiber and it operates at the wavelength of around 1550nm. The optical fiber is integrated in elastic fabric that is placed on chest of COPD patient. The deformation of fiber was found out using photo detector [6]. Merek Krehal et al designed wearable optical fiber sensor to monitor respiration. [6] All the above design is not readily interfaced with any storage mechanism. However, we present the design of fiber optic respiratory sensor using Arduino that may be integrated with IoT infrastructure. Section II presents a basic design, section III describes methods, operating principle and results obtained and section IV concludes the paper.

2. Design of COPD Respiratory Sensor and Monitoring System

The presented COPD respiratory monitoring system is composed of 670 nm LED as a wide-band optical source. Wideband optical source as opposed to narrowband laser was chosen to improve the linearity of sensor. Oscillations may occur in narrowband sources which reduces the reliability of sensor. The diagram block of the system shown in Fig. Light from optical source is coupled with multimode plastic optical fiber which is subjected to a significant amount of bending over the critical value of a curvature so that sensor could detect very low strain analogical to thorax of COPD patient. The curvature of bending makes the light to be reflected at different angles causing losses due to the physical phenomenon of macro-bending [7]. The losses will

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consequently increase with the decrease in bending of curvature. Normal respiratory cycle includes one inhalation and one exhalation [8] inhale and exhale operations were simulated using a balloon.

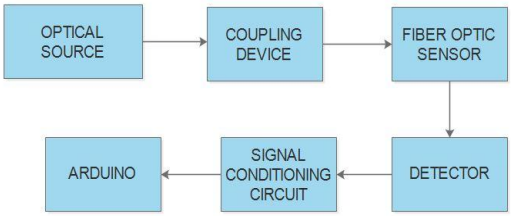

Fig: 1 Block diagram of COPD Respiratory Monitoring System

The fiber subjected to bends is attached to the balloon and it is expanded and contracted respectively with a pump to simulate the breath pattern of patient. To simulate inhale activity in which chest diaphragm tightens which increases chest. cavity volume air is pumped in balloon which is analogous to chest expansion[9]. In contrast during exhale activity the chest diaphragm relaxes, and its upward movement reduces chest cavity volume. Force F is exerted on fiber from tangential and lateral direction during the respiration activity but this force varies during inhale and exhale operation. Assuming fiber deformation has amplitude D and periodicity P then these values change through an amount ∇D and ∇P due to application of force F[a]. According to Hooke's Law and macro-bending theory the transmission coefficient T for propagating light in fiber changes by an amount ΔT[10] which is related to F by (1)

$$\nabla T \propto \left(\frac{\Delta P}{\Delta X}\right) F \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Other end of fiber optic sensor is connected to photodetector to detect the transmitted light through the sensor [11]. The photodetector is used under photovoltaic mode to capture the fiber optic light output. The output signals are filtered using a low pass filter & then amplified by second stage before being processed by Arduino Uno.

The difference between the output values will show the during inhale and exhale activity of breathing may be recorded & rate of respiration can be calculated [13].

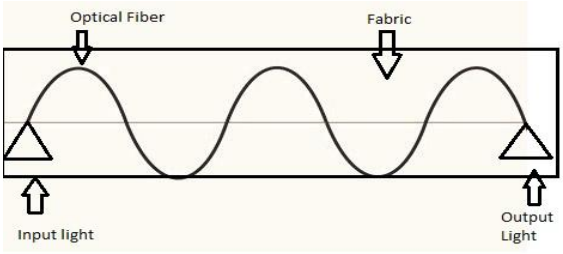

Fig: 2 Optical fiber respiratory sensor

3. Methods

In this work, we will examine the output characteristics of the three configurations of fiber optic sensor. The fiber optic sensor with the help of circuit and Arduino Uno is used to develop respiratory rate monitoring system. The breath of COPD patient was simulated using a balloon initially. All the configurations had different no of bend but fiber length was same 125 cm. First configuration had seven bend with 1 cm diameter, second configuration had five bends with 2 cm diameter of fiber optic and third configuration had, third configuration had seven bends with 1 cm diameter. Based on experiment results, next, For all the three configurations we plotted elongation with power and incorporated the best result to develop final design of respiration monitoring system

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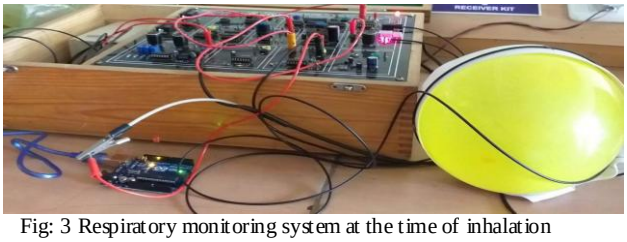

Fig: 3 Respiratory monitoring system at the time of inhalation (balloon)

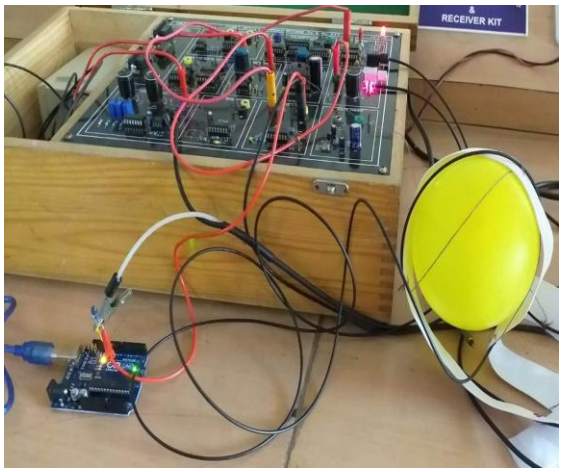

Fig: 4 Respiratory monitoring system at the time of exhalation (balloon)

The figure (3) show that fiber optic sensor based on Respiratory monitoring system demonstrated with the help of contracted balloon and the figure (4) show that fiber optic sensor based on Respiratory monitoring system is demonstrated with the help of expanded balloon.

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4. Result

Fig: 5 CRO Display normal breaths

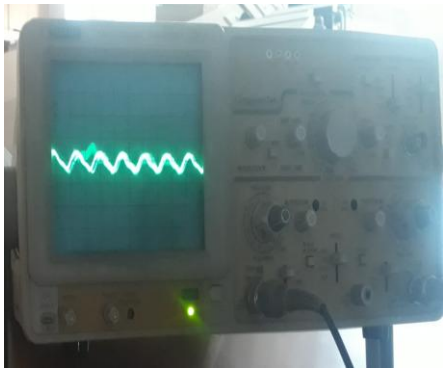

Fig: 6 CRO Display Heavy breaths

The COPD patient, when he takes heavy breath which show in fig (6) and the normal breath show in fig (5).

Table 1: Summary datasheet of Arduino Mega

Microcontroller	ATmega328
Operating Voltage	5V
Input voltage	7-12V
Analog Input pins	6-20V
Digital I/O Pins	6
DC Current per I/O Pin	40mA
Flash Memory	32KB
SRAM	2KB
Clock Speed	16MHz
EEPROM	1KB
DC Current for 3.3V Pin	50mA

5. Conclusion

The COPD patient using respiration sensor for respiration monitoring is convenient to use and has been made successfully. The respiratory monitoring of COPD patients during the rest period between breathe and rehabilitation exercise. The main advantage of this design is that devices were very low cost and easy to use for COPD patient.

References

[1]. Mannino DM, Buist AS, Global burden of COPD: risk factors, prevalence, and future trend".Vol.9:765–73.(2007)
[2]. Wedzicha, J. A., & Seemungal, T. A. COPD exacerbations: defining their cause and prevention. *The Lancet*, *370*(9589), 786-796(2007)
[3].Pauwels, Romain,et.al."COPD exacerbations the importance of a standard definition." *Respiratory medicine*98.2, 99-107,(2004).
[4]. Nelson, Christy Le Ann. "Branched-chain amino acid nutrition and respiratory stability in premature infants." 5770-5770,(2003).
[5]. D. Dobrev and I. Daskalov, Med. Eng. Physics 20,729-734 (1998).
[6].X. Yang, Z. Chen, C. Elvin, L. Hong, Y. Janice, S. Ng, J. Tao, and R. Wu, IEEE Sensors Journal, 15/2, 757(2014).
[7]. K. Jiri, L. Alexandr, H. Miroslav, and S. Ratanak, "Acoustic Method for Respiratory Monitoring," in *11thInternational Conference on Advance Semiconductor Device and Microsystems-2006 pp.117-120*, ASDAM Proceedings.2006, edited by H. Štefan, D. Jaroslav and V. Gabriel (IEEE Electron Devices Society, Danvers, MA, 2016).
[8]. J. Witt, F. Narbonne, M. Schukar, K.Krebber, J.D. Jonckheere, M. Jeanne, D. Kinet, B. Paquet, A. Depré, L.T.D' Angelo, T. Thiel, and R. Logier, IEEE Sensor Journal, 12/1 245-254 (2012)
[9]. R. S. Khandpur, *Biomedical Instrumentation* (Tata McGraw-Hill Publishing Company Limited, New Delhi, pp.7-8,(2003).
[10]. J.B. West, *Respiratory Physiology: The Essentials*, (Lippincott Williams & Wilkins, Philadelphia **8**, pp. 95-124(2012).
[11]. J. D. Bronzino, *the Biomedical Engineering Handbook*, (Boca Raton, CRC Press LLC, Boca Raton **3**, pp. 223(2000)).
[12]. K.Witcher, Fiber optics & its security vulnerabilities (University of Wasington), p.421,(2005).