iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 2 **Issue:** IV **Month of publication:** April 2014

DOI:

ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

A Telemedicine Device for Monitoring of Patients with Respiratory Diseases

Neethu K.L. #1, E. Smily Jeya Jyothi*2

#Electronics and Instrumentation Department, Karunya University

Abstract— ***A wireless portable system for monitoring respiratory diseases using a thermal flow sensor to monitor respiratory air flow, a Triaxis micro accelerometer to monitor the body posture, and a photo electric sensor to monitor blood oxygen saturation, is proposed. The system uses Bluetooth as data communication approach to achieve ubiquity via mobile cellular networks or internet. Algorithms for derivation of respiration parameters and estimation of body posture are proposed. A cellular phone or a laptop connected to the internet will function the monitoring and transfer terminal, so that testing results can be analyzed, recorded or transmitted to a remote center or physicians. Respiratory flow sensor can detect weak respiration. Employing the triaxis accelerometer to detect motion and body posture provides a reference for respiration movement. Different respiratory parameters like tidal volume, peak inspiratory flow, minute volume and respiratory rate are derived from the respiratory flow data obtained. Body postures are classified into two categories: motion and rest. In the motion state, walk/run and other states are identified. In the rest state, different body postures of sit/stand, lie on the back, lie on the face, lie on the right, and lie on the left are identified. This system can be used both as a sleep recorder as well as a spirometer, making the system capable of monitoring and diagnosing various respiratory disorders like obstructive sleep apnea, asthma and chronic obstructive pulmonary disease. A mobile or a laptop connected to the internet serving as the monitoring and transfer terminal makes the system capable of remote monitoring and timely risk alarming when severe respiratory distress occurs.***

Keywords— ***Respiratory disease, Telemedicine, Telecare, Respiration monitoring, wireless monitoring***

I. Introduction

Disturbance of the normal breathing process can cause the development of severe metabolic, organic, central nervous and physical disorders. Respiration monitoring allows the continuous measurement and analysis of breathing dynamics and thus, the detection of various disorders. A remote monitor with a respiratory monitoring and the oximetry will greatly ease the patients from frequently coming and going to hospitals. In short, a simplest monitor for such respiratory diseases must be capable of monitoring the respiratory air flow and deducing certain respiratory parameters based on the air flow.

There are a number of respiratory disorders, but obstructive sleep apnea (OSA), chronic obstructive pulmonary disease (COPD) and asthma are very common all around the world.OSA is characterized by periods of interrupted breathing and reduced breathing (apnea and hypopnea).Each apnea event can last from seconds to minutes. These pauses of breath must last at least 10 seconds to be considered in apnea event. Apnea events occur 5 to 30 times an hour. Symptoms of sleep apnea include depression, learning and memory difficulties, fatigue, poor concentration and day time sleepiness. Untreated obstructive sleep apnea may lead to high blood pressure, cardiovascular diseases such as heart failure, stroke and heart arrhythmias. Therefore diagnosis of this disease is critical.

COPD is a lung disease defined by persistently poor airflow as a result of breakdown of lung tissue (known as emphysema) and dysfunction of the small airways. It typically worsens over time. Primary symptoms include shortness of breath, cough, and sputum production. Worldwide, COPD ranked as the fourth leading cause of death, killing over 3 million people in 2011. Narrowing of the airways reduces the airflow rate to and from the air sacs (alveoli) and limits effectiveness of the lungs. In COPD, the greatest reduction in air flow occurs when breathing out (during expiration) because the pressure in the chest tends to compress rather than expand the airways. In theory, air flow could be increased by breathing more forcefully, increasing the pressure in the chest during expiration. If the rate of airflow is too low, a person with COPD may not be able to

ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

completely finish breathing out (expiration) before he or she needs to take another breath.

Another factor contributing to shortness of breath in COPD is the loss of the surface area available for the exchange of oxygen and carbon dioxide with emphysema. This reduces the rate of transfer of these gases between the body and the atmosphere and can lead to low oxygen and high carbon dioxide levels in the body. A person with emphysema may have to breathe faster or more deeply to compensate, which can be difficult to do if there is also flow limitation or hyperinflation. Some people with advanced COPD do manage to breathe fast to compensate, but usually have shortness of breath as a result. Others, who may be less short of breath, tolerate low oxygen and high carbon dioxide levels in their bodies, but this can eventually lead to headaches, drowsiness and heart failure.

Asthma is a disorder that causes the airways of the lungs to swell and narrow. It causes wheezing, shortness of breath, chest tightness, and coughing. A number of people in the world have been affected by asthma now a days and it is considered as one of the important respiratory disease causing death of the people.

Conventional overnight standard sleep studies or polysomnography (PSG) to diagnosis upper airway obstruction is a complex and expensive procedure. The standard diagnostic nocturnal PSG consists of the following vital parameters: electroencephalogram (EEG), electro-occulogram (EOG), electromyogram (EMG), nasal air flow (NAF), abdominal and/or thoracic movements, body position, snore microphone, electrocardiogram (ECG), and saturation of peripheral oxygen (SpO_2). The low availability of sleep laboratories relative to the number of patients and the burden of its associated cost has made PSG not readily assessable to the general population. Over the recent years, substantial interest was focused in portable devices that can be used as a substitute for PSG in the diagnostic assessment of patients with suspected OSA.

The diagnosis of COPD and asthma is performed based on the results of a lung function test which includes spirometry and oximetry. Spirometry measures the forced expiratory volume in one second (FEV_1), which is the greatest volume of air that can be breathed out in the first second of a breath. Spirometry also measures the forced vital capacity (FVC), which is the greatest volume of air that can be breathed out in a whole large breath. Normally, at least 70% of the FVC comes out in the first second, giving a FEV_1/FVC ratio of greater than 70%. A ratio of less than this defines a person as having COPD.

A number of studies were made for developing portable monitors for OSA since 1990's. A wireless portable sleep monitor with an electrocardiogram and a triaxis accelerometer was developed by Chang *et al.* An accelerometer was used to monitor sleep posture and Bluetooth was used as transmission media [1]. Oh *et al.* developed an apnea diagnosis system with zigbee network and wireless LAN. The system monitored five different biomedical signals electrocardiogram, body motion by a gyroscope, nasal airflow by a pressure sensor, chest efforts by a piezoelectric sensor and oxygen saturation [2]. Rofouei *et al.* developed non invasive wearable neck cuff system capable of real time monitoring of three different physiological signals oxygen saturation, breath, and body movement [3].

A wireless portable system for monitoring respiratory diseases using a thermal flow sensor to monitor respiratory air flow, a Triaxis micro accelerometer to monitor the body posture, and a photo electric sensor to monitor blood oxygen saturation, is proposed in this paper. The system uses Bluetooth as data communication approach to achieve ubiquity via mobile cellular networks or internet. Algorithms for derivation of respiration parameters and estimation of body posture are proposed. A cellular phone or a laptop connected to the internet will function the monitoring and transfer terminal, so that testing results can be analyzed, recorded or transmitted to a remote center or physicians. Respiratory flow sensor can detect weak respiration. Employing the triaxis accelerometer to detect motion and body posture provides a reference for respiration movement.

This system can be used both as a sleep recorder as well as a spirometer, making the system capable of monitoring and diagnosing various respiratory disorders like obstructive sleep apnea, asthma and chronic obstructive pulmonary disease. A mobile or a laptop connected to the internet serving as the monitoring and transfer terminal makes the system capable of remote monitoring and timely risk alarming when severe respiratory distress occurs.

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

II. SYSTEM DESIGN

A. System Overview

Fig-1 shows the system block diagram which comprises of a thermal flow sensor, a body posture sensor, an oximeter, wireless transmitters and a PC or laptop that connects with the internet. A thermistor based circuit is designed to monitor respiration. The sensor is placed over the nose/mouth and infers airflow by sensing differences in the temperature of the warmer expired air and cooler inhaled ambient air. The flow signal generated is related directly to the sensor temperature and indirectly to airflow. A triaxial accelerometer is used to detect body posture. The accelerometer is placed on the spinal cord of the subject with the help of a belt.This accelerometer can detect tri-axis acceleration information and measured acceleration information of X, Y and Z according to the subject's posture and activity. Body postures are classified into two categories: motion and rest. Saturation of peripheral oxygen (SpO_2) is an estimation of the oxygen saturation level usually measured with a pulse oximeter device. The sensor is worn on the subject's finger tip.

The outputs of the respiratory flow sensor, triaxial accelerometer and the oximeter sensor are fed to the ADC port of the ATmega 16 microcontroller which converts the analog voltage value to digital value and displays in a LCD. The respiration data, acceleration data, and oximetry data obtained are transmitted wirelessly to a PC using a Bluetooth module. A Bluetooth receiver connected with a PC receives the data including respiration data, acceleration data, and oximetry data. The calculation of respiratory flow rate, tri axial acceleration, and SpO_2 and derivation of respiratory parameters and body postures are then conducted. Different respiratory parameters like tidal volume, peak inspiratory flow, minute volume and respiratory rate are derived from the respiratory flow data obtained. Body postures are classified into two categories: motion and rest. In the motion state, walk/run and other states are identified. In the rest state, different body postures of sit/stand, lie on the back, lie on the face, lie on the right, and lie on the left are identified.

B. Sensors

1) Thermal Flow Sensor for Respiratory Air Flow: A thermistor based circuit as shown in Fig-2 is designed to monitor respiration. The sensor is placed over the nose/mouth and infers airflow by sensing differences in the temperature of the warmer expired air and cooler inhaled ambient air. The flow signal generated is related directly to the sensor temperature and indirectly to airflow.

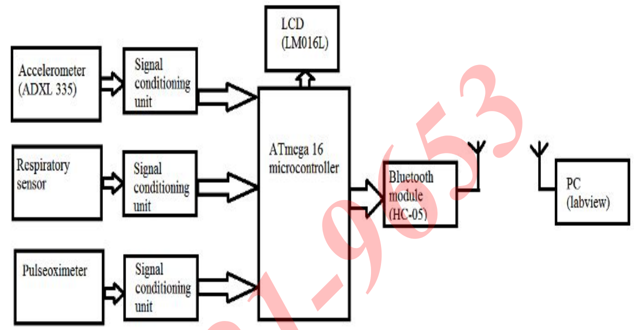


Fig. 1 Schematic diagram of the monitoring system

Thermistor used for the respiration measurement is connected in the resistor bridge network. Under constant current, a thermistor will change its resistance a function of the temperature. This value is converted as voltage by using voltage divider circuit with 10K resistor. The difference in the voltage is amplified by LM741 op-amp. In this configuration, an op-amp produces an output potential (relative to circuit ground) that is typically hundreds of thousands of times larger than the potential difference between its input terminals. In order to achieve high input impedance two resistors of 1kΩ is added to the differential input voltage. A resistor of 10 kΩ is inserted between the non-inverting input and ground (so both inputs "see" similar resistances), reducing the input offset voltage due to different voltage drops due to bias current, and may reduce distortion in some op-amps. The feedback resistor value is determined by the impedance levels to be established. The feedback resistance is chosen to be 470K variable one and the input resistance is 1K so it can amplify (-470K/1K) *differential voltage. So the required amplification can be made by adjusting the variable resistor. Next stage the amplification is done with the active low pass filter (integrator). This circuit is used to filter the high frequency in the respiration side. This amplified output is directly given to the comparator circuit. Here two input voltages are compared where one is the reference voltage and another one is from integrator. Here the reference voltage can be varied by adjusting the variable resistor VR2 this voltage varied from -12V to +12V. This voltage is given to non inverting pin so whenever the reference voltage is higher than the respiration

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

voltage the negative voltage (-12V) will be the output and whenever the integrator voltage is greater the positive voltage (+12V) will be the output.

This output is directly given to the BC547 Transistor. So when it gets the positive voltage that means respiration voltage high it gives low as output to the LED as well as NOT Gate so the LED lights up and the high output is generated by the NOT gate and given to the microcontroller. So when the

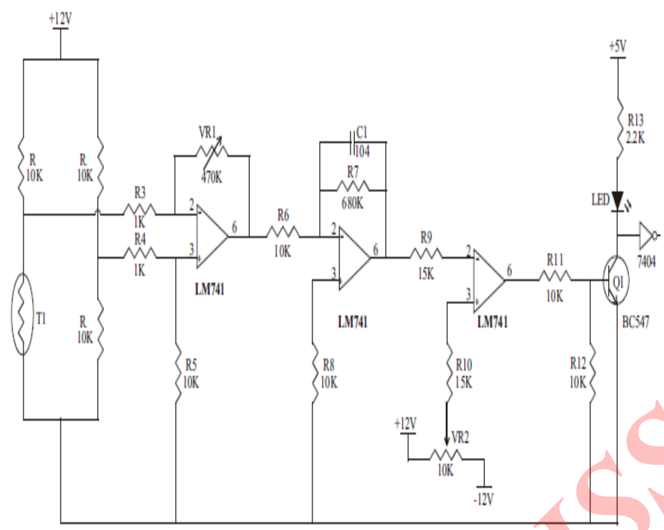


Fig.2 Circuit diagram of respiratory air flow sensor

2) Triaxial Accelerometer for Body Posture: The ADXL335- a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs is used to recognize the gross body posture during respiration monitoring. The product measures acceleration with a minimum full-scale range of ±3 g. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. It contains a poly silicon surface-micro machined sensor and signal conditioning circuitry to implement open-loop acceleration measurement architecture. The output signals are analog voltages that are proportional to acceleration.

3) Photoelectric Sensor for Blood Oxygen Saturation: A pulse oximeter device is employed for the estimation of peripheral oxygen saturation (SpO_2).The detector is placed on subject's finger tip. Oxygen saturation is defined as the measurement of the amount of oxygen dissolved in blood, based on the

negative voltage is given to the transistor it will be in OFF state and no more conduction between collector and emitter terminal so the high output from the LED directly given to the NOT Gate and low output is taken. So as to avoid the high voltage flowing through the Transistor Base terminal there is a potential divider by using two 10K resistors. So the half amount of the voltage will be given to the Base. Then the final output voltage is given to microcontroller.

detection of Hemoglobin and Deoxyhemoglobin. Two different light wavelengths are used to measure the actual difference in the absorption spectra of HbO2 and Hb. The bloodstream is affected by the concentration of HbO2 and Hb, and their absorption coefficients are measured using two wavelengths 660 nm (red light spectra) and 940 nm (infrared light spectra). Deoxygenated and oxygenated hemoglobin absorb different wavelengths. Deoxygenated hemoglobin (Hb) has a higher absorption at 660 nm and oxygenated hemoglobin (HbO2) has a higher absorption at 940 nm. A photo detector in the sensor perceives the non-absorbed light from the LEDs. This signal is inverted using an inverting operational amplifier (OpAmp) and the result is a signal which represents the light that has been absorbed by the finger and is divided in a DC element and an AC element. The DC element represents the light absorption of the tissue, venous blood, and non-pulsatile arterial blood. The AC element represents the pulsatile arterial blood.

III. ALGORITHM AND SOFTWARE

A. Derivation of Respiratory Parameters

The output of the thermal flow sensor is calibrated and analysed. The output voltage of the respiratory flow sensor during each exhalation of five different persons is shown in Table-I.

TABLE I
RESPIRATORY FLOW SENSOR OUTPUT

Subject No.	Exhalation 1 (V)	Exhalation 2 (V)	Exhalation 3 (V)
1	0.13	0.11	0.10
2	0.25	0.25	0.24
3	0.15	0.13	0.14

ISSN: 2321-9653

4	0.12	0.13	0.12
5	0.13	0.14	0.14

This respiration data obtained can be used for the derivation of different respiratory parameters and thus to detect different respiratory disorders.

A variety of algorithms has to be designed to derive related respiratory parameters, such as peak inspiratory flow (PIF), respiratory rate (RR), minute ventilation (MV) and tidal volume (TV). Table-II shows the calculation methods for the four respiratory parameters.

B. *Estimation of body postures:*

The voltage varies according to the position of the triaxial accelerometer. From this accelerometer data, the patient's body posture and activity can be identified.

An algorithm is designed for the estimation of body postures using measured triaxial accelerations. Body postures are classified into two categories: motion and rest. In the motion state, walk/run and other states are identified. In the rest state, different body postures of sit/stand, lie on the back, lie on the face, lie on the right, and lie on the left are identified. To identify motion and rest, a parameter called signal vector magnitude (square root of the sum of 3-axis accelerations) is introduced. In the rest state, the ranges of accelerations along the three axes are utilized to determine different body postures.

A LabVIEW based user interface as shown in fig.3 and fig. 4 is designed to display the waveforms of the respiratory air flow and the tri-axis accelerations, body posture, respiration parameters and the value of SpO_2.

TABLE II
CALCULATION METHODS FOR RESPIRATORY PARAMETERS

Respiratory Parameter	Calculation Methods
PIF	Find the maximum value of the respiratory peak
RR	Count the peaks of the respiration waveform in a half minute
MV	Digital integration of respiratory flow rate in a half minute
TV	Minute ventilation divided by respiration rate

IV. CONCLUSION

A wireless portable system for monitoring respiratory diseases using a thermal flow sensor to monitor respiratory air flow, a Triaxis micro accelerometer to monitor the body posture, and a photo electric sensor to monitor blood oxygen saturation, is presented in this paper. The system uses Bluetooth as data communication approach to achieve ubiquity via mobile cellular networks or internet. A cellular phone or a laptop connected to the internet will function the monitoring and transfer terminal, so that testing results can be analyzed, recorded or transmitted to a remote centre or physicians. Respiratory flow sensor can detect weak respiration. Employing the triaxis accelerometer to detect motion and body posture provides a reference for respiration movement. This system can be used both as a sleep recorder as well as a spirometer, making the system capable of monitoring and diagnosing various respiratory disorders like obstructive sleep apnea, asthma and chronic obstructive pulmonary disease. A mobile or a laptop connected to the internet serving as the monitoring and transfer terminal makes the system capable of remote monitoring and timely risk alarming when severe respiratory distress occurs. The proposed telemedicine device can be used for remote monitoring and diagnosis of OSA, COPD and asthma.

ACKNOWLEDGEMENT

The authors would like to thank the members of the Department of Respiratory Medicine and the members of the Biomedical Engineering Department in Baby Memorial Hospital, Calicut for their valuable advices, feedback and support. The authors would also like to thank to Karunya University for providing technical support.

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

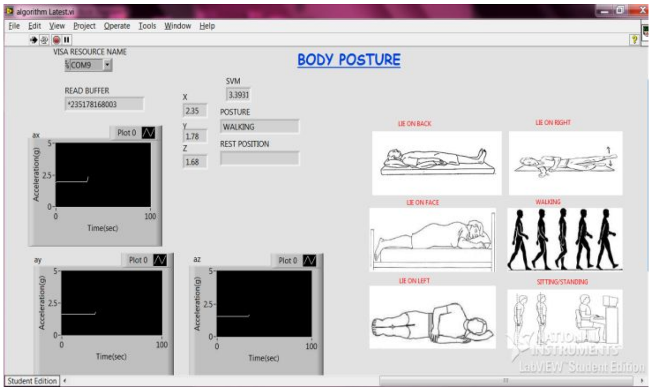


Fig.3 User interface for monitoring body posture

Fig.4 User interface for monitoring respiratory parameter

REFERENCES

[1]. K.M.Chang and S.H.Liu, "Wireless Portable Electrocardiogram and a Tri-Axis Accelerometer Implementation and Application on Sleep Activity Monitoring," Telemed. E-Health, Vol. 17, Pp. 177-184, 2011.

[2]. S.Oh, H.Kwon and V.K. Varadan (2011), "Wireless Remote Monitoring System for Sleep Apnea", Proceedings of Society of Photo-Optical Instrumentation Engineers, Vol.7980, pp.27-37.

[3]. M. Rofouei, M. Sinclair, R. Bittner, T. Blank, N. Saw, G. Dejean and J. Heffron (2011), "A Non-invasive Wearable Neck–Cuff System for Real Time Sleep Monitoring", Proceedings of 8th International Conference Body Sensors Network Los Alamitos, CA, May 23-25, 2011, pp 156-161.

[4]. Laiali Almazaydeh, Khaled Elleithy, Miad Faezipour and Ahmad Abushakra (2013), "Apnea Detection Based on Respiratory Signal Classification", Elsevier article on Procedia Computer Science, Vol.21, pp. 310 – 316.

[5]. Bijoy Laxmi Koley and DebangshuDey (2013), "Automatic detection of sleep apnea and hypopnea events from single channel measurement of respiration signal employing ensemble binary SVM classifiers", Elsevier article on Measurement Volume 46, Issue 7, Pages 2082–2092.

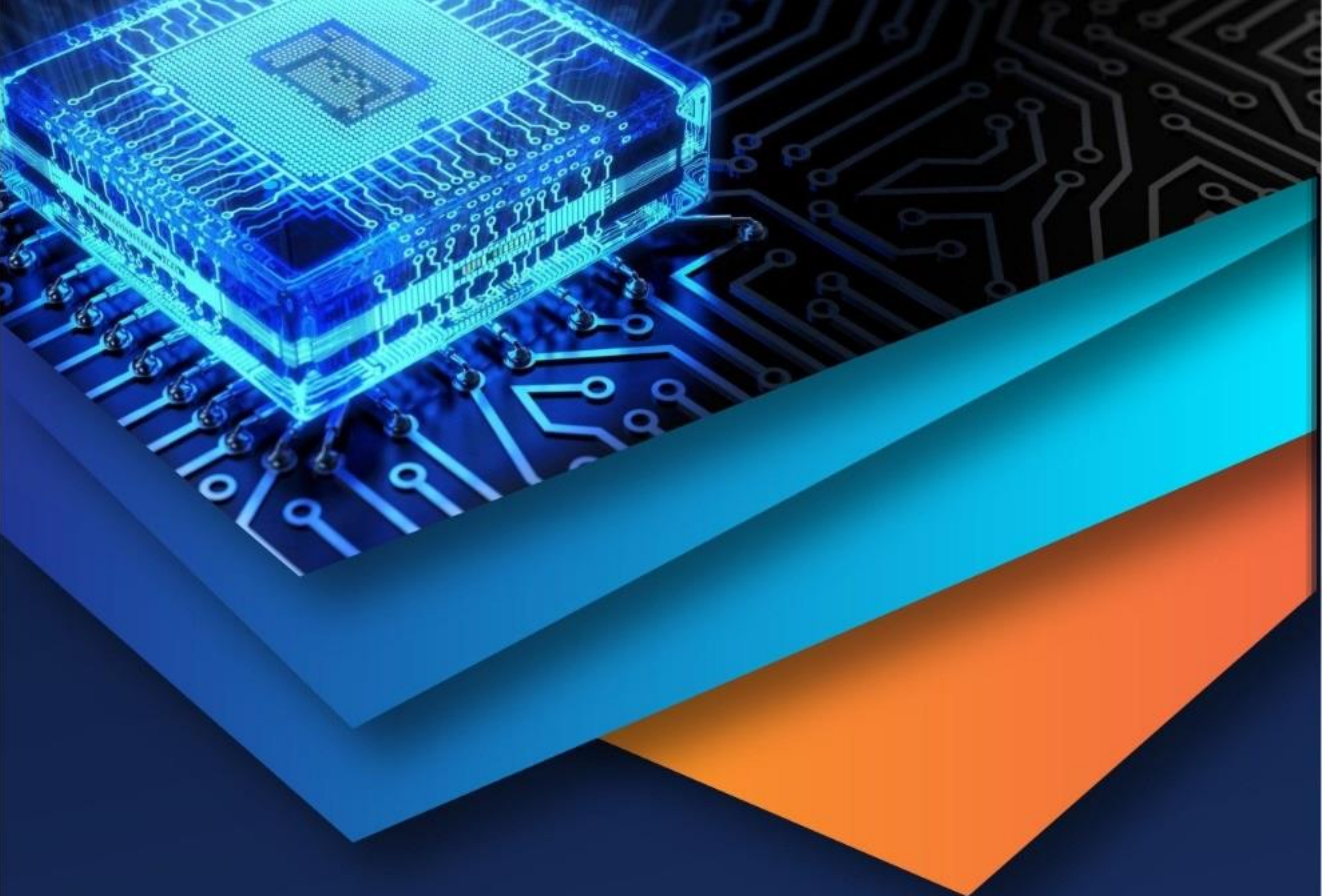
[6]. M. Laghrouche, L. Montesc, J. Boussey and S. Ameur (2011), "Low cost embedded spirometer based on micro machined polycrystalline thin film", Elsevier article on Flow Measurement and Instrumentation, Volume 22, Issue 2,pp. 126–130.

[7]. Mi-hee Lee, Jungchae Kim, Kwangsoo Kim, Inho Lee, Sun Ha Jee, Sun Kook Yoo (2009), "Physical Activity Recognition Using a Single Tri-Axis Accelerometer", Proceedings of the World Congress on Engineering and Computer Science, vol 1, pp.14-17.

[8]. N. Oliver and F.F. Mangas (2007), "Health gear: A real time wearing system for monitoring and analyzing physiological signals", Journal of Communications, vol. 2, no. 2, pp. 1-9.

[9]. Andrea Tura, Paolo Santini, David Longo and Luca Quareni (2007), "A telemedicine instrument for home monitoring of patients with chronic respiratory diseases", Annali dell' Institito Superiore di Sanita, Vol. 43, no. 1, pp 101-109.

[10]. Y. Nishida and T. Hori (2002), "Non invasive and unrestrained monitoring of human respiratory system by sensorized environment", Proceedings of IEEE sensors, vol.1, pp.705-710.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY