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A Device to Monitor Lung Disorders and Various Sleep Modes Using LabVIEW

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Abstract: This device calculates patient's breathing rate by detecting changes in temperature. The pressure of breath is detected through a pressure sensor and the flow rate is calculated from differential pressure using Bernoulli's formula. In addition this device include an alarm for APNEA which sounds when the patient stops breathing for 5 seconds and a low battery indicator signal. This device also detects the various sleep modes of the patient using the number of breaths taken per minute. The design and implementation involved NI DAQ and LabVIEW software for processing. Existing respiration monitors used in medical centers are too expensive to be used in low resource environments. This a low-cost respiratory monitor to address this issue.

Index Terms: Thermistor, Pressure Sensor, Flow Rate, Bernoulli's formula, Sleep Modes.

I. INTRODUCTION

Air pollution exposure can trigger new cases of Chronic Obstructive Pulmonary Disorder , exacerbate a previously existing respiratory illness and provoke development or progression of chronic illness including Asthma, Dyspnea, Pneumonia and Bronchitis. The overall pollution mix will vary from one geographical area to another concentration of air pollution can vary depending on the weather and season the effects of air pollution on our lungs depend on the type and mix of pollutants , the concentration in air and how much of pollutant actually gets into your lungs .If your are exposed to high pollution levels you may have symptoms straight after these can include irritated airways ,feeling out of breath and an increased chance of having an lung disorder.

Asthma is a chronic disease involving the airways in the lungs. These airways, or bronchial tubes, allow air to come in and out of the lungs. Airways are always inflamed during asthma. They become even more swollen and the muscles around the airways can tighten when something triggers. This makes it difficult for air to move in and out of the lungs, causing symptoms such as coughing, wheezing, shortness of breath and/or chest tightness.

Fig. 1 Asthma

Bronchitis is of two types as follows

Acute bronchitis: This is the more common one. Symptoms last for a few weeks, but it doesn't usually cause any problems past that.

Chronic bronchitis: This one is more serious, in that it keeps coming back or doesn't go away at all. Symptoms last for a long period of time.

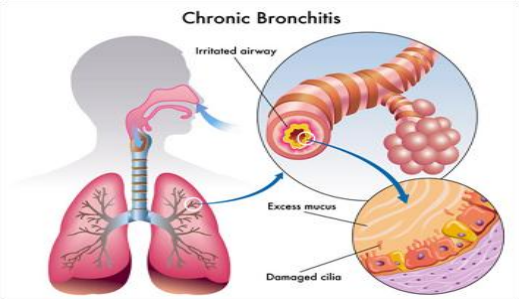

Fig. 2 Bronchitis

Many people mistake their increased breathlessness and coughing as a normal part of aging. In the early stages of the COPD, you may not notice the symptoms. It can develop for years without noticeable shortness of breath. We can begin to see the symptoms in the more developed stages of the disease.

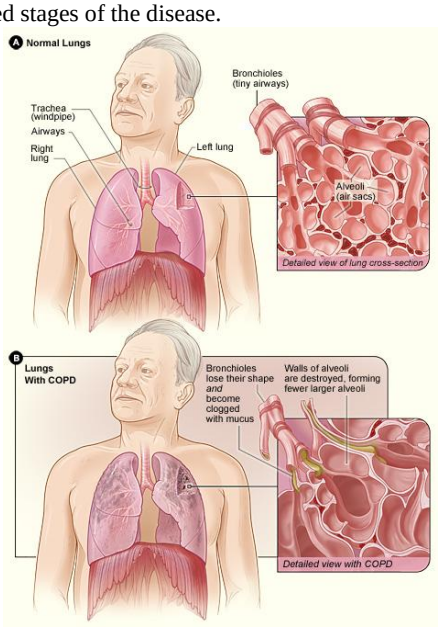

Fig. 3 COPD

Shortness of breath, also known as dyspnea, is a feeling like one cannot breathe well enough. The American Thoracic Society defines it as "a subjective experience of breathing discomfort that consists of qualitatively distinct sensations that vary in intensity", and recommends evaluating dyspnea by assessing the intensity of the distinct sensations, the degree of distress involved, and its burden or impact on activities of daily living. Distinct sensations include effort/work, chest tightness, and air hunger.

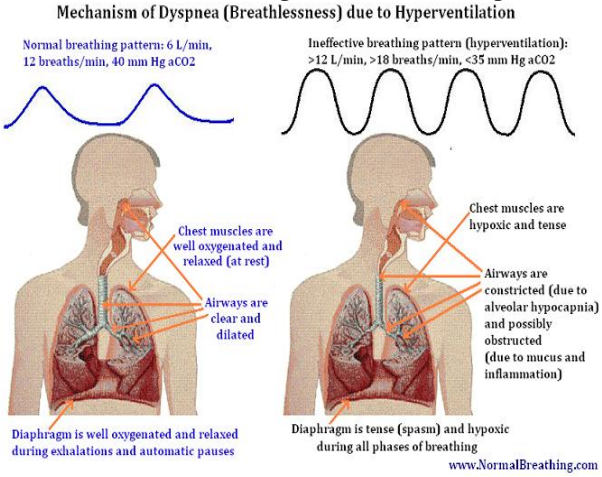

Fig.4 Dyspnea

In bacterial pneumonia, temperature may rise as high as 105 degrees F. This pneumonia can cause profuse sweating, and rapidly increased breathing and pulse rate. Lips and nailbeds may have a bluish color due to lack of oxygen in the blood. A patient's mental state may be confused or delirious. The initial symptoms of viral pneumonia are the same as influenza symptoms: fever, a dry cough, headache, muscle pain, and weakness. Within 12 to 36 hours, there is increasing breathlessness; the cough becomes worse and produces a small amount of mucus. There may be a high fever and there may be blueness of the lips.

Fig.5 Pneumonia

A. Aim

To design a respiratory monitor for low-resource environments. The device calculates a patient's breathing rate by detecting changes in temperature when the patient breathes. “This portable device can be used anywhere to give an alert when a breathing halts and various lung diseases can be detected.”

B. Objectives

- Detection of various lung diseases with parameters like Temperature, Flow Rate and Pressure of the exhaled gases.
- Detection of sleep modes of the patient.

C. Motivation

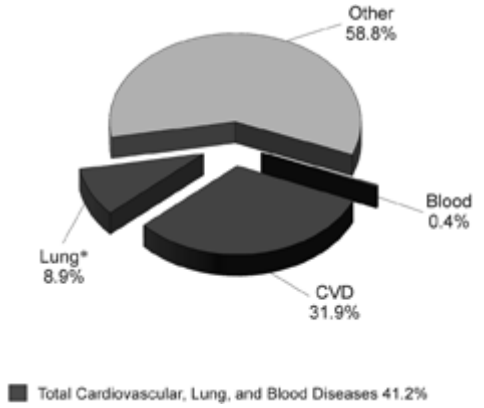

Fig. 6 Major Causes for Death

Courtesy: *www.nhldi.nih.gov*

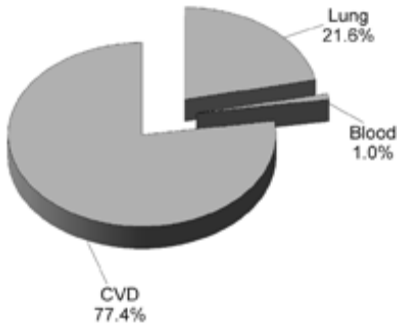

Fig. 7 Deaths from Pulmonary, Cardiovascular, Blood diseases

Courtesy: *www.nhldi.nih.gov*

According to WHO survey pulmonary diseases account for the major causes of death which account for 8.9% next to cardiovascular diseases for example pneumonia is found to be a deadly disease which results in 1 million cases per year. This survey states that nearly 21.6% of people are facing death due to pulmonary disorders.

II. EXISTING METHODS

Many biomedical devices, such as commercially available respiratory monitors, are designed for the developed world and require a stabilized environment to operate. We wanted to implement a solution that is adaptable to different environments.

Other methods of monitoring respiratory rate include a

- Chest Force Sensor
- Impedance Pneumograph
- Pulse Oximetry

In existing devices to monitor respiratory rate, they use motion or force sensors to determine respiration rate. These monitors tend to be better suited for developed countries where a stable power supply is not a concern. We want to design our device geared to the needs of undeveloped areas. Therefore, we aimed for our hardware monitor to be comparatively cheaper, easier to use and reliable.

Common respiratory complaints include asthma and COPD (chronic obstructive pulmonary disease). Peak flow meters and spirometers can be used by health professionals to diagnose and monitor the progress of these conditions. Peak flow meters measure the fastest rate of air that you can blow out of your lungs. It is more convenient than spirometry and is commonly used to help diagnose asthma. Many asthmatics also use peak flow meters to monitor their asthma. For people with COPD, spirometry is a more accurate test for diagnosis and monitoring. A spirometer can be used to determine how well the lungs receive, hold, and utilise air. They are

also used to monitor and determine the severity of a lung disease and to determine whether the lung disease is restrictive (decreased airflow) or obstructive (disruption of air flow). After taking a deep breath, a person forcefully breathes out into the spirometer as completely and forcefully as possible. The spirometer measures both the amount of air expelled and how quickly the air was expelled from the lungs. The measurements are then recorded by the spirometer.

An obstructive pattern is caused by a narrowing of the airways. This is typically found in asthma and chronic obstructive pulmonary disease (COPD). The amount of air that you can blow out quickly is reduced, but the total capacity of your lungs is usually more or less normal. With a restrictive spirometry pattern lung capacity is less than the predicted value for your age, sex and size. This is caused by a variety of conditions that affect the lung tissue or restrict the capacity of the lungs to expand and hold a normal amount of air. These include pneumoconiosis, which causes fibrosis (scarring) of the lungs. This may be caused by two conditions, for example, asthma plus another lung disorder. Or, some lung conditions have features of both patterns. In cystic fibrosis (CF) thick mucus causes narrowed airways and damage to the lung tissue tends to occur from repeated infections. Medical professionals use lung function test to diagnose and monitor lung diseases. Your task is to investigate how these tests are carried out and to determine some of the factors which might affect the results. In case of peak flow meter a risk assessment must be carried out before starting any practical work. Check it before you begin. While considering spirometer a risk assessment must be carried out before starting any practical work. . Use of the spirometer must be directly supervised. Wear eye protection when handling soda lime and take care not to raise dust.

III. METHODOLOGY

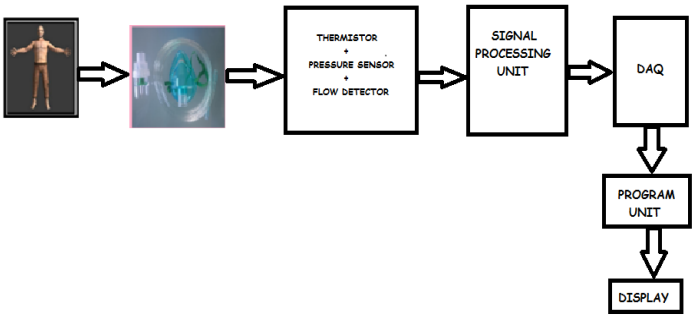

Fig.8 Block Diagram

The breathing temperature of patient is detected by the thermistor. This also provides the breath rate of the patient. The results obtained can be used to find the occurrence of sleeping disorder in patients apart from the detection of diseases in them. Hot air in the patient's breath changes the resistance of the thermistor. As a result of this the voltage across the thermistor also changes proportionally according to the patient's breath. Therefore voltage can be used indirectly to find how the patient is breathing. A pressure and flow sensor is used for detecting pressure and air flow of patients. This in turn is given to the DAQ kit where the analog to digital conversions are done and the results are displayed in LabVIEW software. The details are then listed out in the monitor which enables easy diagnosis by comparing the temperature, pressure and flow rate of exhalation air for various diseases as mentioned in the tabulation. If all the parameters correlate then glowing of a Boolean indicates the presence of disease.

Thermistor used is LM35. This sensor is chosen because it has the following features.
• Calibrated Directly in Celsius (Centigrade)
• Linear + 10-mV/°C Scale Factor
• 0.5°C Ensured Accuracy (at 25°C)
• Rated for Full −55°C to 150°C Range
• Suitable for Remote Applications
• Low-Cost Due to Wafer-Level Trimming
• Operates from 4 V to 30 V
• Less than 60-µA Current Drain
• Low Self-Heating, 0.08°C in Still Air
• Non-Linearity Only ±¼°C Typical

• Low-Impedance Output, 0.1 Ω for 1-mA Load
Pressure sensor used is MPXV2010G SERIES because of the following features and applications.

Features

. Temperature Compensated over 0°C to +85°C
. Ratiometric to Supply Voltage
. Differential and Gauge Options

Typical Applications

. Respiratory Diagnostics
. Air Movement Control
. Controllers
. Pressure Switching

Table I. Data for Lung Diseases

S.NO	DISEASE	TEMPERATURE	PRESSURE	FLOWRATE	BREATHS/MIN
1	Pneumonia	105°F	10 cm H_2O	25-75	24-30
2	Dyspnea	<=25°c	87.009 cm H_2O	64	16
3	Bronchitis	38.8°c	5-20 cm H_2O	74.9	28
4	COPD	33°c	4-20 cm H_2O	<30	28
5	Asthma	40°c	7 cm H_2O	<=20	24

Table II. Data for Sleeping Stages

S.NO	SLEEP STAGE	BREATHS/MIN
1	Awake	12-18
2	NREM Sleep stage 1	3-4
3	NREM Sleep stage 2	3-4
4	NREM Sleep stage 3	3-4
5	NREM Sleep stage 4	3-4
6	REM Sleep	24-36

A. Flow Rate Calculation

From Bernoulli's equation,

V = (2P/d)^0.5

Where V is the velocity
P is the differential pressure
d=air density at STP

A = 3.14*(r^2)

Where A is the area of nostrils
r is the radius of nostril.

Q = V*A

Where Q is the Flow Rate

IV. FUTURE WORKS

MEMS is Micro Electro Mechanical System is a technology that in its most general form can be defined as miniaturized mechanical or electro-mechanical elements that are made using the techniques of micro fabrication. The functional elements of MEMS are miniaturized structures, sensors, actuators and microelectronics the most notable elements are the microsensors and micro actuators. The sensors used now can be placed in the nebulizer mask used by the asthma patients. In future, we have planned to replace these sensors by MEMS devices so that it occupies a miniaturized space. Pulmonary abnormalities occur mainly because of the use of methotrexate. Pulmonary toxicity is unrelated to Cumulative dose but it is associated with a divided weekly dose regimen rather than a full weekly dose regimen. Therefore we have planned to include dose monitoring as a part of our project in the future.

V. RESULTS AND DISCUSSION

Here is the front panel and block diagram wherein the project has been successfully implemented.

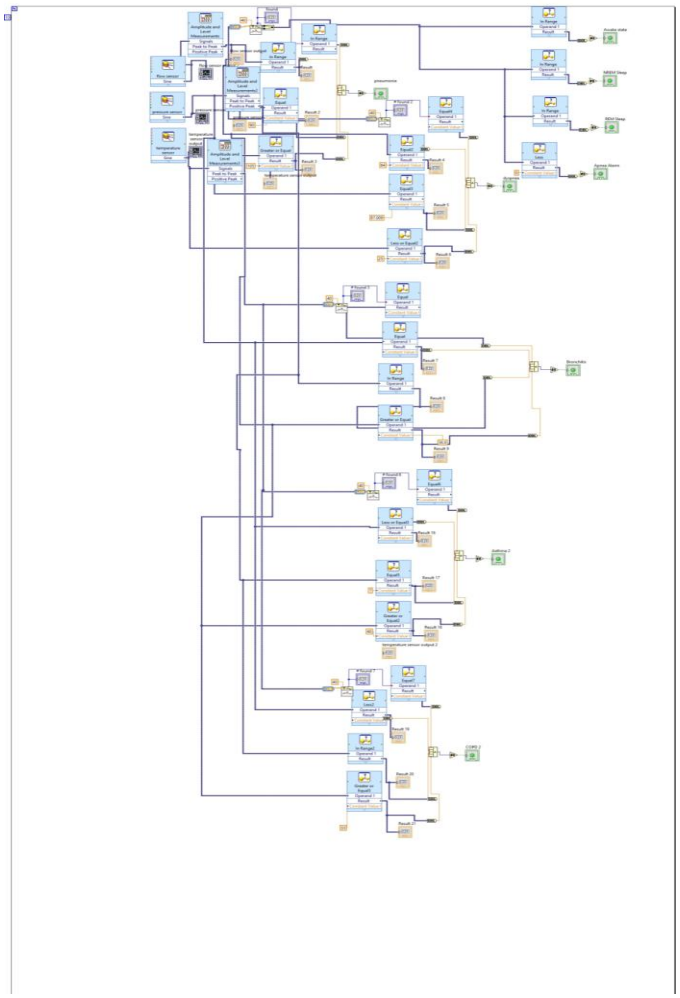

Fig.9 LabVIEW Block Diagram

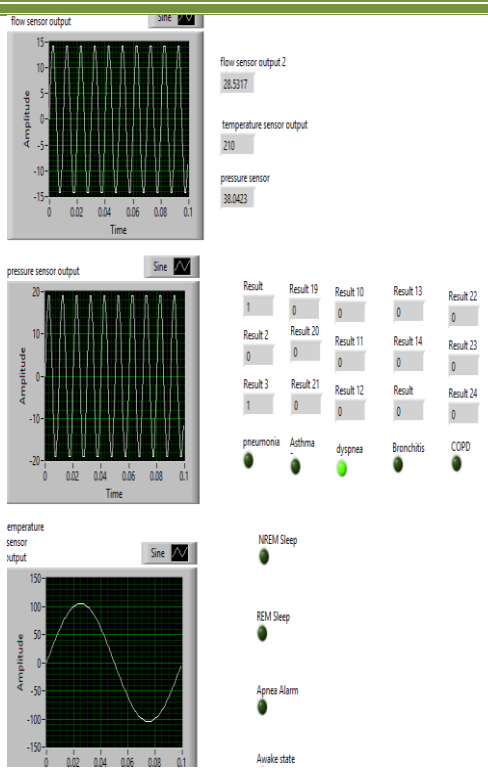

Fig. 10 LabVIEW Front Panel

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