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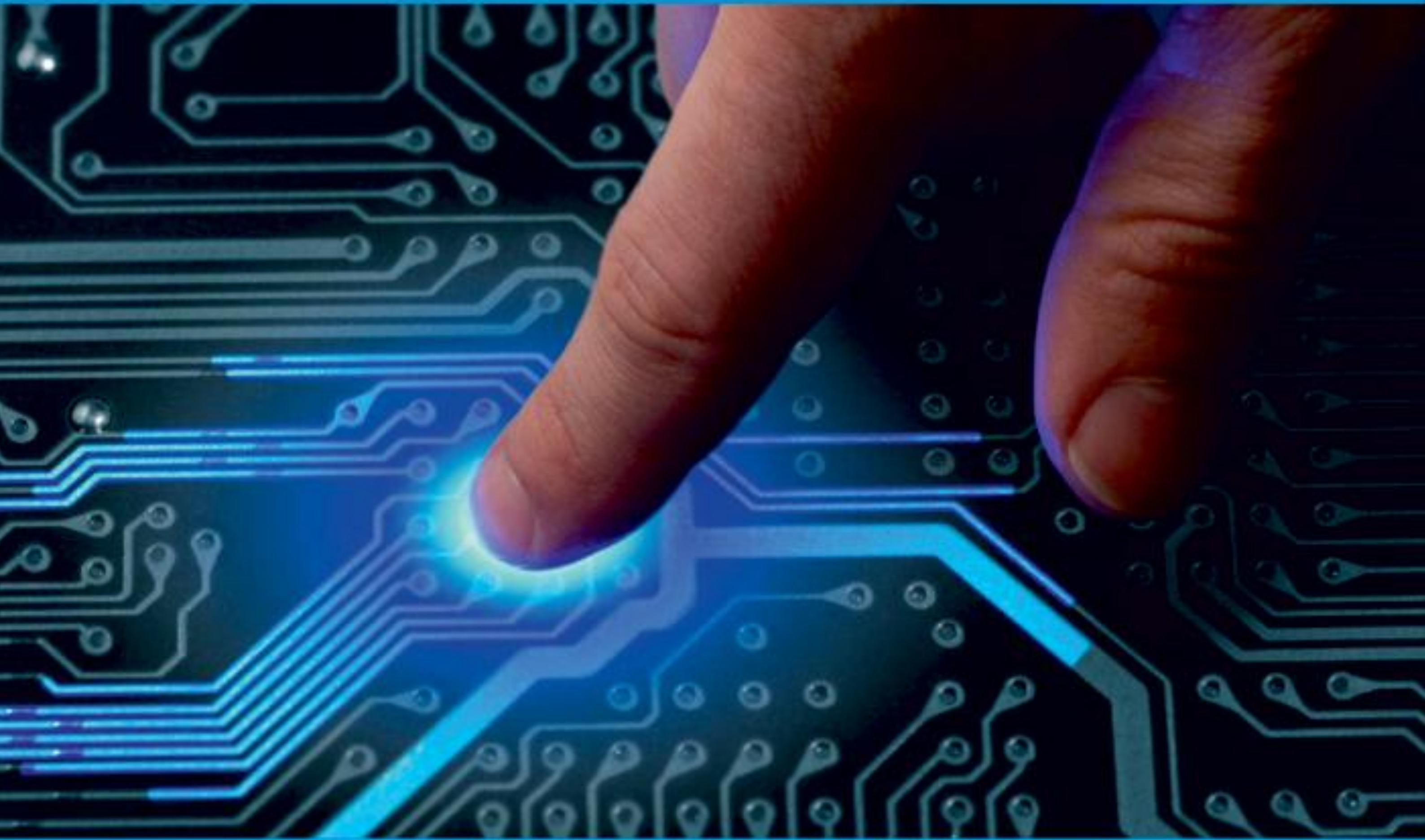

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Polymer Sensor T-Shirt for Respiratory Monitoring Using IOT

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ABSTRACT: Sleep Disordered breathing is an increasingly common condition among the general population. Conventional sleep disordered breathing diagnosis depends on in-lab polysomnography, while at-home sleep test devices are becoming a more widespread. Both systems are cumbersome and typically data is collected offline, typically limiting use to only a few nights recording. We present the design, implementation and preliminary results from a novel "IOT ready" sleep test device "new model". The device utilizes electro resistive polymer sensors and accelerometer to measure respiratory, cardiac and actigraphy information. The device uses Bluetooth 5 to stream and transfer data and is capable of reliably acquiring high quality sleep data. The device significantly improves the user experience by completely concealing the hardware into a t-shirt while providing five days of battery life, full speed Bluetooth 5 live data streaming/ downloading with local storage capable of more than a year worth of sleep data

1. INTRODUCTION

Sleep-disordered breathing (SDB) is an increasing common, with at least half of people over the age of 65 experiencing disturbed sleep [1], with a further 25% of children experiencing SDB by adolescence [2]. Obstructive Sleep Apnea, Central Sleep Apnea, Upper Airway Resistance and obesity hyperventilation are the most common SDB observed [3] and are characterized by interrupted breathing with different causes. For example, the most common sleep disorder, Obstructive Sleep Apnea, is caused by cessation of breathing due to obstructed airways [3]. Central Sleep Apnea, which is more common among heart failure patients, is caused by impaired cardiovascular and breathing control systems [4]. Due to an aging population as well as to an increase in the obesity among the general population, the numbers of patients with SDB is expected to rise significantly in the future. Consequently, sleep disordered research and requirements for more convenient sleep monitoring devices are predicted to expand rapidly [5].

The polysomnogram is considered the medical gold standard means of assessing the quality of sleep [6]. It requires the patient to spend multiple nights at a specialized sleep clinic. While the quality of diagnosis is the best available, it comes at a cost of limited sleep clinic access, high cost (~$800 – $2,000) [7], and the time required to generate the diagnosis. Furthermore, the polysomnogram is performed in an unfamiliar environment and generally uncomfortable due to the number of sensors applied. Most importantly, polysomnography evaluates only a single night/few nights snapshot of conditions and is not suitable for long-term sleep monitoring.

These limitations have led to the development of alternative diagnostic tests that can be conducted inside a home with minimal supervision. These systems generally included a wearable device with fewer sensors. However, IOT platforms for widespread sleep monitoring are not commonly used today. While these technologies are developing rapidly, healthcare industry adaptation is slow. Data quality, reliability and utility combined with ease-of-use of the device are limiting factors for greater uptake of these technologies. In an attempt to address these issues, we present "new model", a novel IOT ready, sleep monitoring device utilizing a new technique of cardiac and respiratory measurement with polymer based electro resistive band (ERB) sensors. Further, the device facilitates single lead ECG and Accelerometer measurements.

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II. BACKGROUND WORK

2.1 Sleep disordered breathing
Authors: C. M. Baldwin and S. F. Quan
In this paper the authors proposed Epidemiology, pathophysiology, behavioral manifestations, cardiovascular comorbidity, clinical evaluation, and treatment for OSA are the main topics covered. The article concludes with the role of the nurse in SDB.

Disadvantage: Raw values collected from different sensors which are not accurate

2.2 Cardiac arrhythmias and sleep-disordered breathing in patients with heart failure
Authors: Wolfram Grimm, Ulrich Koehler
In this paper the authors proposed current review focuses on the relationship between central sleep apnea (CSA) and atrial fibrillation as the most common atrial arrhythmia in heart failure (HF) patients, and on the relationship between CSA and ventricular tachycardia and ventricular fibrillation as the most frequent cause of sudden cardiac death in HF patients.
Disadvantage: Identified how sleep disorder affects human body but concentrated only on Heart failure.

2.3 Unobtrusive sleep monitoring using cardiac, breathing and movements activities: an exhaustive review
Authors: Jean-Marc Lina; Julie Carrier; Georges Kaddoum
In this paper the authors aims at providing the reader with a multidimensional research perspective by presenting a review of research literature on developments made in unobtrusive sleep assessment. from data acquisition frameworks and physiological measurements, to information processing.
Disadvantage: Fails to assess sleep stages and sleep quality less intrusively, and reliably.

III. PROJECT MODULES

- **ADXL345 Accelerometer**
- **Heart Rate Monitor - AD8232**
- **Arduino uno microcontroller**
- **Temperature sensor DHT 11**
- **LCD 16X2 display**

3.1 ADXL345 Accelerometer
It is a digital accelerometer sensor and outputs digital values of acceleration in three axes. The sensor outputs data formatted as 16-bit two's complement that is accessible via SPI or I2C interfaces. ADXL345 measures static acceleration due to gravity as well as dynamic acceleration resulting from motion or shock By using ADXL345 we can extract following parameters 1. Breathing pattern 2. Respiration effort 4. Body movement

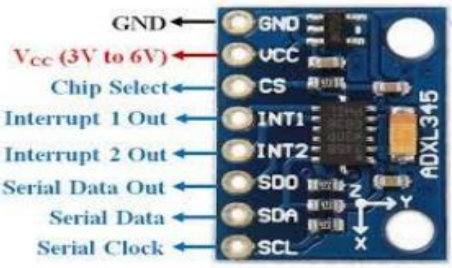

Figure 1: ADXL345 Accelerometer

3.2 Heart Rate Monitor - AD8232
The electrocardiography or ECG is a technique for gathering electrical signals which are generated from the human heart. to calculate the electrical movement of the human heart. This action can be chart like an Electrocardiogram and the output of this is an analog reading.
AD8232 includes the pins like SDN pin, LO+ pin, LO- pin, OUTPUT pin, 3.3V pin, and GND pin. So that we can connect this IC to microcontroller board.

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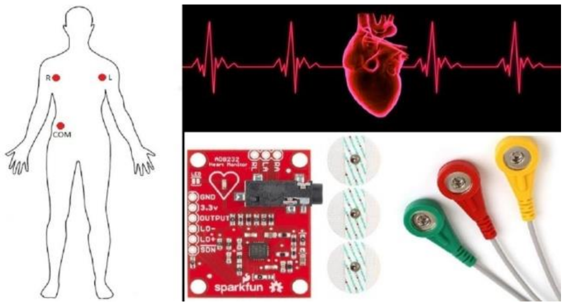

Figure 2: Heart Rate Monitor - AD8232

3.1.3 Pulse sensor

When a heartbeat occurs blood is pumped through the human body and gets squeezed into the capillary tissues. The volume of these capillary tissues increases as a result of the heartbeat. But in between the heartbeats (the time between two consecutive heartbeats,) this volume inside capillary tissues decreases. This change in volume between the heartbeats affects the amount of light that will transmit through these tissues. This change is very small but we can measure it with the help of Arduino.

Figure 3 : Pulse sensor

3.1.4 Temperature sensor DHT 11

The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). Its fairly simple to use, but requires careful timing to grab data. You can get new data from it once every 2 seconds, so when using the library from Adafruit, sensor readings can be up to 2 seconds old.

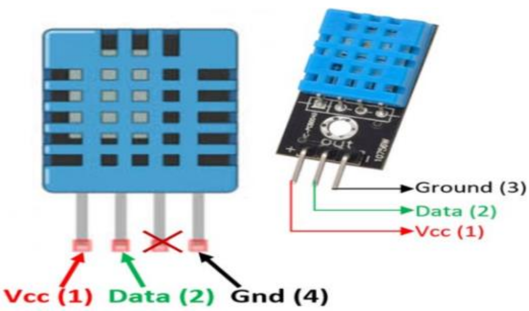

Figure 4 : DHT 11 sensor

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IV. RESULTS

Figure 5: Telegram Notification

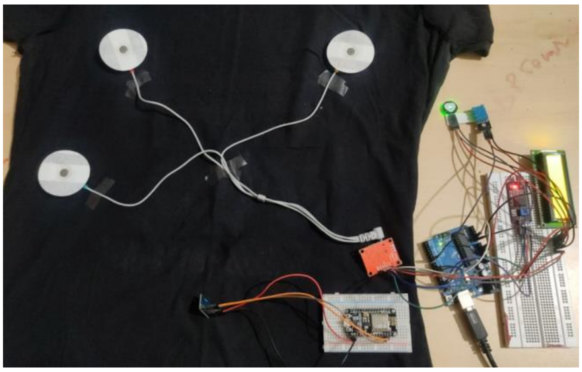

Figure 6: proposed model

Figure 7: Temperature and pulse readings

V. CONCLUSION

We present the design, implementation and preliminary results from a novel "IOT ready" sleep disorder device The device utilizes accelerometer and ECG sensor to measure respiratory, cardiac and actigraphy information The device uses Wi-Fi to stream and transfer data and is capable of reliably acquiring high quality sleep data. The device significantly improves the user experience by completely concealing the hardware into a t-shirt In a distress condition of the patient alert will be sent to the telegram app. As a future enhancement we can use more accurate sensors to predict different kinds of sleep disorders by integrating IoT with artificial intelligence is possible design more commercial health devices

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