Non-Invasive Detection Of Sleep Apnoea In Neonates By Tracking Abdominal Movements Using LVDT

Akriti Chadda, Manish Thigale, Ritesh Kumar

Abstract: Over 2 million children in the world suffer from sleeping disorders. The most common of these is Sleep Apnoea which may affect the child as early as on the first day of life. Sleep apnoea is a condition when the breathing rate of the patient lowers down drastically. The main problem that one faces is in the detection of the condition and hence delayed treatment. This paper describes the various types of Sleep Apnoea and a quick, effective and non-invasive method to detect the condition at hand.

Index Terms: Abdominal Movements, Breathing, LVDT, Neonatal, Non-Invasive, Sleep Apnoea, Detection.

1 INTRODUCTION

INSTABILITY in the breathing pattern is a common characteristic of healthy infants during sleep. Hence occurrence of apnoea of short durations is a physiological phenomenon that declines with advancing postnatal age [1]. The occurrence of apnoea is higher in premature babies, i.e. those neonates whose birth takes place before the completion of 37 weeks of pregnancy, as compared to those neonates who are born after a full term of 37 weeks. There are three kinds of apnoea: 1) Obstructive Sleep Apnoea, which is usually caused by a blockage. 2) Central Sleep Apnoea, in which there is no blockage but the brain fails to signal the muscles to breathe. 3) Mixed Apnoea, which a combination of the previously mentioned two types of Sleep apnoea. The motivation behind the designing of the device is the paucity of devices that help in the detection of an abnormal sleep apnoea in infants. As a result, the neonatal mortality rate is very high in India. We aim to showcase a device that will not only detect sleep apnoea in infants, but also inform the parents and/or hospital authorities for quicker response and treatment.

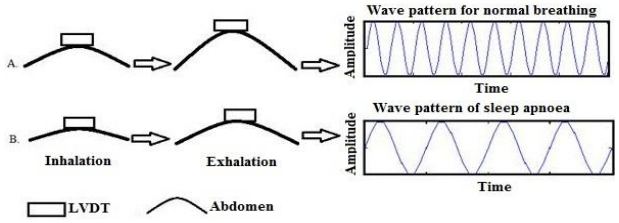

Fig. 1. Description of attachment of LVDT to the Child's Abdomen

2 Methodology

2.1 Role of an LVDT – Linear Variable Differential Transformer

Transducers play a very vital role in all fields of engineering and industries for the purpose of measurement, monitoring, recording and control. LVDT transducers are widely used for the measurement of displacement, force, pressure, force and other physical quantities. They have good sensitivity and linearity over a wide range and show consistence in results [2].

2.2 Description Of Device

The LVDT is placed over the abdomen to detect the abdominal movement, in the form of either a Band-Aid or an abdominal belt. The Band-Aid or the belt holds the LVDT around the abdomen allowing its free movement by stretching.

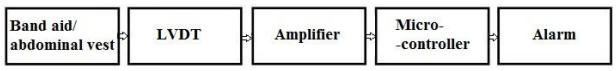

Fig. 2. Flowchart of the Components of the Device

2.3 Working of the Device

During breathing, the abdominal wall expands during inhalation and relaxes during exhalation. This movement tends to stretch the Band-Aid (or the abdominal belt) and in turn, the LVDT. This produces a small voltage (of the order ⟦ 10⟧ ^(-3)). Such small voltage must now be amplified to a reasonable value which can help us in the diagnosis and testing. This purpose is served by an Amplifier. Once an input of adequate order is obtained, it is put to test via a microcontroller. The initial period of about 1-2 minutes is utilized in calibration of the normal breathing pattern (i.e. the abdominal movement). Once a reference pattern is recognized stating the normal

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breathing pattern, readings can be taken. This is completely under the control of the code embedded in the microcontroller. Once the reference breathing pattern is established, the device starts to look for variations. Here, the duration of each breath, the intensity of each breath and the time difference between two consecutive breaths are taken into consideration. When either of the parameters goes beyond the threshold limit, the alarm circuit that is interfaced with the micro-controller is activated. This makes the people around aware of the possible condition.

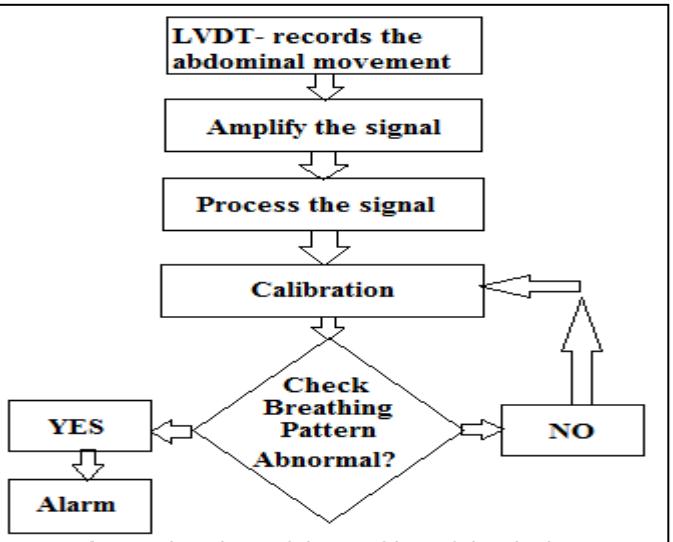

Fig. 3. Flowchart of the working of the device

2.4 Description of the Program Code for the Device

The code for this device has been structured using the simple knowledge about the shape of the signal. The peaks in the signal reveal much about the breathing pattern. The peak-peak intervals and period and amplitude for each wave in the output signal can be inferred and compared to the 'average' range of values found out by continuous experiments. As and when an output is gives values outside a set 'safe limit', an alarm rings and notifies the concerned people/authorities.

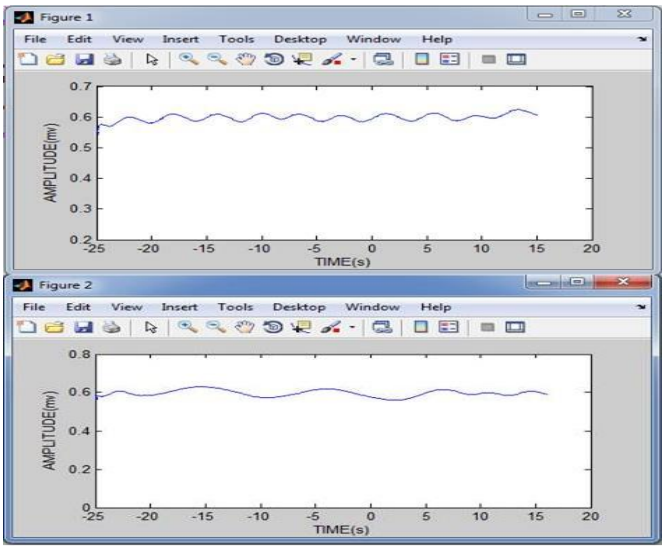

Fig. 4. Normal Breathing Pattern and the breathing Pattern of a Patient with Apnoea

3 Experimental Analysis and Interpretation

A comprehensive experiment was performed using an LVDT setup and the output was obtained on a Digital Storage Oscilloscope (DSO). The normal breathing pattern was reciprocated using an LVDT (as shown in figure4) and also of an apnoea breathing pattern (as shown in figure5). Each signal was recorded for duration of 40s. Hence, it can be concluded that an LVDT can accurately describe the exact breathing pattern just by placing it over the abdomen. The signal, thus obtained, can be used for the analysis and the study of the condition

4 Conclusion

This paper showcases the use of an LVDT to detect the abdomen movements of a baby and hence detects the occurrence of sleep apnoea instantaneously. The LVDT can be in the form of a belt or a Band-Aid that can be attached to the abdomen of the concerned child. A quick nudge to the parents and hospital authorities can help to treat the child as soon as possible. It is an innovative, low cost and efficient device which can assist parents and hospital authorities to detect Sleep Apnoea in babies and hence save many lives.

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