

Real Time Design and Implementation of Brushless DC Motor Drive based Continuous Positive Airway Pressure (CPAP) based Respirator System for Patients with Chronic Obstructive Pulmonary Diseases (COPD)

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ABSTRACT

This paper aims at designing a cost-effective, portable and easy-to-use brushless DC (BLDC) motor driven continuous positive airway pressure (CPAP) based respirator for patients with acute breathing trouble. The proposed system is intended to facilitate continuous monitoring of patient's condition with positive airway support provided by a brushless DC (BLDC) motor driven respirator blower fan by measuring Respiration Rate (RR). To measure the respiration rate, a pair of capacitive type respiration rate sensors are mounted below Right Nostril (RN) and Left Nostril (LN), in such a way that the nasal airflow during inspiration and expiration impinge on the sensor diaphragms directly. Due to irregularities in nasal airflow in some respiratory diseases, the respiration rate (RR) varies from the normal rate (12-20). Thus, a supporting airflow regulatory system has been designed to reduce abnormalities in respiration rate (RR). In this case a low cost sensorless commutated BLDC drive is implemented with a three phase inverter and microcontroller by using feedback of rotor rpm. A suitable cost effective algorithm has also been developed to generate an appropriate six transistor switching sequence to commute the BLDC motor according to the RR of the subject. The characteristics of the implemented drive give satisfactory outputs over a wide range of controlled speed variation from 200 to 2440 rpm which requires a match with the patient's breathing demand. The effectiveness of the designed system is populated by the real time experimental results.

Keywords

Positive Airway Respirator, Blower Fan, Brushless DC Motor, Respiration Rate, Chronic Obstructive Pulmonary Diseases.

1. INTRODUCTION

Chronic obstructive pulmonary disease (COPD) has become the fourth leading reason of death across the world which caused around 2.7 million deaths in 2000. By the end of 2020, COPD is expected to come up as a third most common cause of death [1]. There are two types of COPD diseases namely emphysema and chronic bronchitis. Emphysema (caused by continued smoking) and chronic bronchitis (caused by the exposure to indoor and outdoor air pollutants) both of them are major reasons of breathlessness. These diseases obstruct

the windpipe to the lung and which may in turn choke the respiratory system if it is not taken care properly. In the earlier days, polysomnography was the method followed in order to diagnose the sleep related disorders but it involved time consuming procedure, caused some amount of discomfort as a number of electrodes are attached to the patient's body and was costly as well [2]. This led to the further developments of devices such as respiratory polygraphy which may be another option to detect sleep disorders. Both of these detection techniques are complex and required to be carried out in the presence of qualified healthcare staff. Because of these severe drawbacks, new trends in this field of healthcare came forward namely continuous positive airway pressure (CPAP) machine which was invented by Colin Sullivan in June 1980 and he applied this therapy initially for five patients with severe obstructive sleep apnea syndrome [3]. In this system, air is pumped under pressure into the airway of the lung so as to keep the windpipe to the lung open at the time of sleeping. This system comprises of a small machine with a hose that is placed at the side of the patient's bed.

This paper begins with introduction, given in Section I. In Section II, we have described the condenser type capacitive sensor. Section III puts forward the description of the drive system for three phase BLDC motor. After this, section IV throws light on the real time implemented hardware. Followed by, Section V which establishes the results describing the response of the sensor and aptness of the blower. Section VI concludes the work with the essence of outcome of this proposed scheme.

2. OVERVIEW OF THE PROPOSED SYSTEM

The CPAP machine proposed here provides a fixed airway pressure to the subject under study by eliminating the need of conventional cylinders of life-support gases. Moreover, the portability and robustness of the designed machine makes it a quick option to be considered into the field of healthcare [4]. While taking the subject under study to hospital, the proposed device can be considered as a very effective means of providing continuous air support.