

A Positive Pressure Approach against Air Pollution Using Sensorless Brushless DC Motor Powered Respirator

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Abstract

The recent increase in air pollution have made air quality in many cities extremely hazardous. This has necessitated the use of respirators as a safeguard against the impact of air pollution. This study is concerned with modelling a forced air respirator using matrix converter fed sensorless Brushless DC motor (BLDCM) drive. Here, the electrical model of human lungs along with mathematical model of the said converter is considered for the simulation. The forced air respiration system is modelled to study the characteristics of both normal and adverse condition of volumetric flow parameters with different respiratory rates. The model is implemented in MATLAB/Simulink for stable airflow and volumetric pressure. The simulation model borrows the BLDCM output motor parameters (i.e., RPM, max output torque), which is fed to the lungs model as input to find volumetric pressure and airflow. Finally, a detailed study on implemented matrix converter reveals significance improvement over a non-converter fed one. The output results show that the scheme described in this scope of work handles DC power using matrix converter and delivers a stable Rotation per min (RPM) and output torque to the respirator for stable airflow and volumetric air pressure in the lungs parameter.

Keywords: Sensorless brushless DC motor, Flyback converter, Positive pressure respirator, Human lungs modelling

1. Introduction

The present scenario has shown the increased threats represented by respiratory illness like chronic obstructive pulmonary disease (COPD), asthma etc. That risk has increased due to increase in air pollutants like PM2.5, PM10 etc. a respirator can be utilized as an immediate countermeasure on an individual level safety measure as bringing down pollution levels require much longer time than the severity of the problem is allowing. The normally used N95 respirators are of negative pressure variant i.e., they require the wearer's lungs to inhale air through the resistive membranes of the filter layers. This is strenuous and uncomfortable to wear for a long duration. This is non-existent in positive air pressure respirators as they use external filters and has a motorized air supply system. The pandemic in recent scenario also necessitates respiration apparatus as a part of its treatment. Respirators that are in commonly used are negative pressure system which require the power of lungs to draw-in purified air which is not suitable and sometimes not possible if the person lacks sufficient lungs strength, or if they suffer from respiratory illness. This work proposes a forced air (positive air pressure) solution to the problem.

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2. Mathematical Model

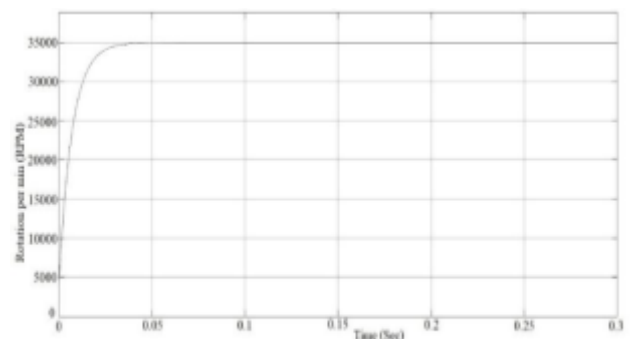


Figure 2: RPM waveform of BLDC motor

Mathematical model of BLDCM

The mathematical model of BLDCM a sensorless can be modeled and implemented by the means of mathematical modeling (transfer functions) shown in equations shown below. The winding of a three phase BLDC motor can be modeled as a series circuit consisting of a resistance R , an inductance L and a speed dependent voltage source which is known as the back EMF voltages due to the rotor magnet. While designing a BLDC motor, a few parameters like induced current in the rotor due to stator harmonics fields, iron and stray losses are neglected. Self and mutual inductances are considered as constant [1-5]. The BLDC motor is supplied three phase voltage represented in Eq.1, Eq.2 and Eq. 3

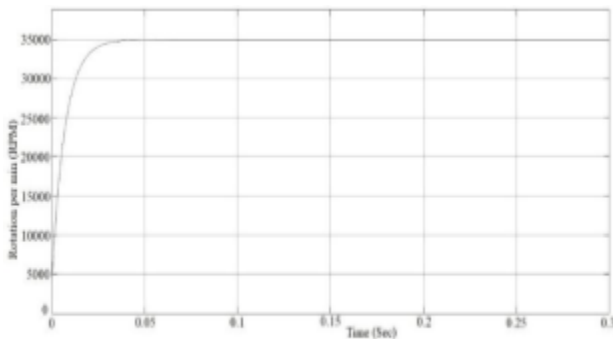


Figure 1: Example of figure caption

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Table 1: Example of a table caption

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$$\frac{dx}{dt} = \frac{ax}{1+Ky} - bx^2 - \frac{(\beta+\sigma y)(1-m)xy}{1+a(1-m)x} \quad (1)$$

$$\frac{dy}{dt} = \frac{c(\beta+\sigma y)(1-m)xy}{1+a(1-m)x} - \gamma y \equiv G(x, y) \quad (2)$$

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3. Conclusion

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5. References

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