International Journal of Aquatic Science
ISSN: 2008-8019
Vol 12, Issue 03, 2021

A Fuzzy Logic Controller Based Srm With Torque Ripple Suppression For Ev Applications

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Abstract— Switched motor reticence (SRM, for its inexpensive cost, its simple form, its defect tolerance and its great controllability) is widely used as a variable speed drive for industrial applications. The greatest issues with high torque rips are the switching reluctance motor as a consequence of a doubly salient design that causes vibration and rumble. The torque ripple can be minimised, either by geometric engine designs or by other control approaches. This study suggests the use of an intelligent control, such as a Fuzzy Logic Control, to reduce torque rib suppression, and to build an AC power supply boost converter driven by SRM motors. Increased speed control and improved efficiency were obtained. The proposed system is simulated with MATLAB/Simulink with SRM fixed parameters.

Keywords— SRM, Torque ripple, Speed Control, Power Factor Correction, Fuzzy Logic Control, MATLAB/ Simulink

1. INTRODUCTION

Due to increased concerns on energy use and environmental preservation, the development of electricity vehicles (EVs) has become a prominent study subject. The electric motor drives have high efficiency, have high power density, are controlled, operate at enormous speeds and operate free of maintenance. The switching reluctance drive (SR) allows most of these goals to be realized. Many SRM advancements were motivated by desire in higher performance and reliability in recent years.

Due to its low cost, simple structure, fault tolerance, and great controllability, the switching reactivity motor is used as a variable speed driver in industrial applications in particular. Nonetheless, the switching reticence motor is struck torque and causes noise and vibration. One of the main difficulties is torque rip which may be minimised by either modifying the geometric design of the engine or by various control approaches. The SRM torque ribbon removal technology includes mainly optimising switching angles, direct torque control, torque-sharing function, intelligent control and changing DC link voltage.

The approach to optimize the switching angle is usually modest and the torque control algorithm is difficult. Without power factor adjustment, the SRM supply unit results in a harmonic pollution, poor factor and low efficiency.

The switched response engine is a type of engine that has two stage spools mounted around diametric opposite stator poles (SRM). No windings or fixed magnets are present in the rotor. The (laminated) steel portion of the rotor is, in reality, a shape that generates magnificent poles. There are the bows in the stator.

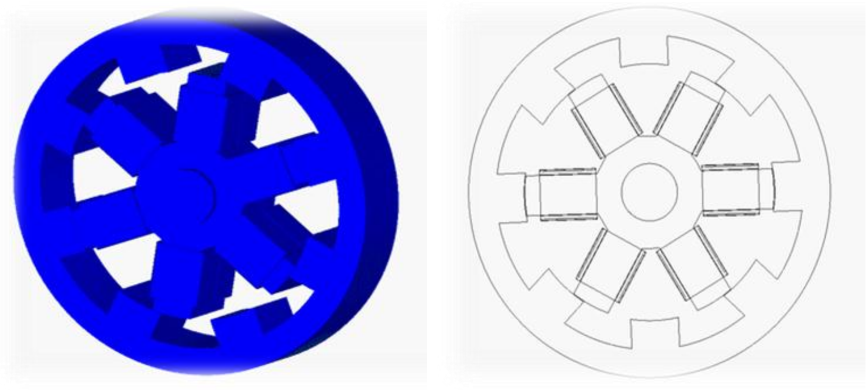

Fig: 1 Constructional view of SRM

2. OBJECTIVE

Overall objective of this paper is to:

- Study and investigation of the performance of the switched reticence engine:
- Develop an intelligent control to decrease the torque ripple removal from the SRM drive. (Soft Computing Techniques such the Fuzzy, Neural Network, Neuro-fuzzy and Genetic Algorithm, etc.)
- Converter design to enhance AC mains power quality.
- Improved speed control performance and improved power quality.

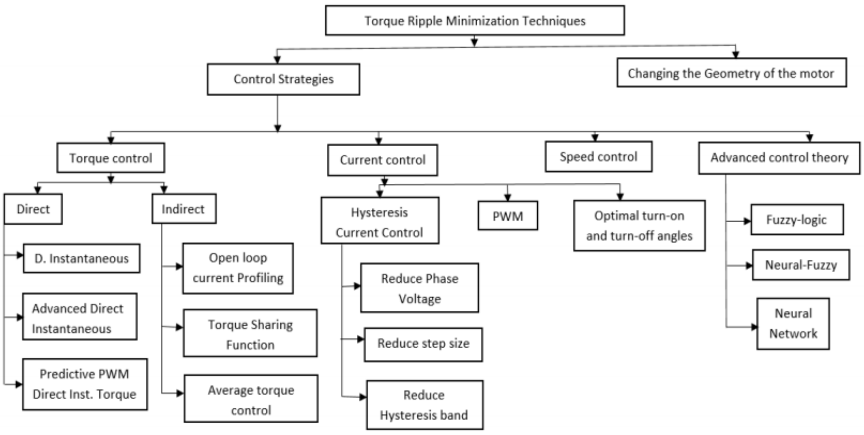

Fig: 2. Classification of Torque Ripple Minimization Techniques

3. TORQUE RIPPLE MINIMIZATION TECHNIQUES ADOPTED

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The SRM may be operated using many techniques such as torque, current, speed and optimization with the use of contemporary control technologies such as the Fuzzy, Neural-Fuzzy and Neural Network Architectures. Fig.2 shows four unique types of control techniques for SRMD used for the classification and advancement for each control technology.

A. Torque Control

SRM torque control may be divided into direct and indirect techniques of control. Direct torque monitoring advances are similar to DITC-based, Advanced DITC and Pulse Width Predictive Modulation (PWM). Direct torsional control (DITC) is the same. In an indirect control the torque sharing function (TSF) and mean torque control (ATC) are categorised as an open-loop current profiling [8].

1) Direct Torque Control (DTC)

Following the debut of the typical AC torque controller[9], a new approach was developed for direct SRM torque control in which DTC employed SRM. This novel method analyses and simulates the torque in the non-linear region. The results demonstrate that the shown system surpasses standard linear, non-linear SRM controls and ensures smooth torque and flow control. However, it was still dubious to implement this method in real time for SRM drives.

In 2012, the functional roused, directed torque control of a swipe reticence motor drive system reduced the torque to less than 10 percent[10]. In 2012, it was suggested and demonstrated experimentally. This paper[11] introduces the areas of the DTC sector and reparts new control algorithms, which reduce to a certain level the torque rivets and are also very efficient in comparison with prior approaches. In order to accomplish the high torque ampere rate of SRM, new DTC technology has been introduced[12] to remove flow control and select several flexible voltage vectors to ease time and discover fair benefits ranging from 38.33 to 16.67%.

2) Indirect Torque Control

a) Torque Sharing Function (TSF)

[17] This study recommends four distinct types of TSF's and improves the way in which a valid TSF is to be selected to reduce torque torsion. For offfline torque sharing in 2015, a linear, exponential, cubic and conventional TSF was given showing both the linear and magnetic saturations of lower torque winds[18]. An updated version of[18] is suggested in

[19], and the proposed TSF indicates that flux link features offer increased tracking performance at greater speeds compared with the standard offline TSF.

b) Average Torque Control (ATC)

[20] Three new techniques for average SRM drive torque controls for the Electric Vehicle (EV) application and these three approaches for selecting the most suited EV controller are being comparable with traditional Instantaneous Torque Control.

B. Current Control

1) In all stages of an SRM, the current profile is substantially impacted by torque control. The current may be changed by several techniques, such as Hysteresis Current Control (HCC), Pulse Width Modulation (PWM) and matching turn-in and off angle.

2) Hysteresis Current Control

Based on phase-current modification during the leading period, a novel current profiling technology is introduced. An instantaneous torque check approach that helps minimise torque ripples instead of the usual timed average torque check is utilised. This approach obtained less than 14% of the torque [21]. In addition to the closed loop speed control a new technique for optimising the common hysteresis current controller is verified and torsion rippling can be lower than 5% reduced. [22] In 2018, a unified torque/ampere ratio check was suggested for SRM to increase at high speeds and to eliminate medium- and low-speed torque ribs. In addition to improving the confidence of the system, the DITC and the current control (CC) were combined with a unique notion dubbed the demagnetization controller [23].

3*) Pulse Width Modulation Technique (PWM)*

By replacing the typical hysteresis controller, a digital PWM controller is suggested. This controller gives the advantages of such a decreased current ripen and a lower sampling rate in comparison with standard HCC [24]. There will be discussed the major restrictions of the present SRM and torque torsion. The PWM proposal presents an ideal novel control technique to lower PWM's suggestion by about 12 per cent in order to reduce its torque shrinkage of around 20% and its current shrinkage [25].

C. Advanced Control Techniques

In order to further optimise the difficulties of the motor, advanced optimisation control approaches like Fuzzy, Neural-Fuzzy and Neural Networks are needed.

1) Fuzzy-Logic Controller (FLC)

Fuzzy-logic SRM drive control was set up in 1996 and results reveal an increase in driving robustness with the FLC speed loop [26, 29]. According to the 1999 proposal for an Adaptive Fuzzy controller for torque rib reduction issues such as SRMD. It provides a smoother torque and removes the need for cost-effective position sensors with torque rip at about 20 percent. Using a sophisticated adaptive fuzzy controller [27, 30] for a fault-resistant SRMD, a smooth torque with minimal torque rips was obtained. Two enhanced PIs such as Fuzzy controllers were introduced which showed great stability and strength throughout 2011[28, 31].

2) Neural – Fuzzy control

Taken as one of the key problems torque torsion is being used for shaping phase currents, thereby decreasing torque shrinkage in engine via the use of a novel combination controller (neuro-fuzzy).

3) Neural Network

Neural networks are one of the most effective ways of optimisation. CMAC is a neural network that best suits the study of non-linear functions. Methods for checking non-linearity may also be applied in real time to reduce torque rips in order to optimise and alter the phase current.

4. ANALYSIS OF TORQUE RIPPLE

The doubly scalable switch-over reluctance engine features standalone stage windings on the stator.

$$U = Ri + L\, di/dt + i\, dL/dt \quad (1)$$

If U is the stage voltage, R is the winding resistance, I is the phase current and L is that phase inductance that relies on the position of the rotor and the current of the phase. The Electromotive Force (EMF) E phase back is defined

$$E = i\, dL/dt = i\, dL/d\theta\, d\theta/dt = i\omega\, dL/d\theta \quad (2)$$

Where θ and ω represent the rotor angular position and the rotor velocity, respectively. So, the phase voltage equation can be written as

$$U = Ri + L\, di/dt + E \quad (3)$$

Assuming the magnetism is linear, the phase torque can be given by [5]

$$T = 1/2\, i^2 dL/d\theta = 1/2\, i^2 K, \quad (4)$$

Where K denotes the change rate of phase inductance with angle.

The torque is equated to the current quadrature (4). K depends on the current phase currency and rotor location, but is typically much below the current squared [27], and hence the current torque stability is primarily measured. If the phase voltage is equal to the electronic phase-back force, the torque will be continuous if the resistance drops from the equation (4). The electric force in the backstage is proportional to the speed of the rotor so as to provide roughly the desired inverter voltage of the SRM drive and to vary the desired voltage of the SRM drive.

The most frequent technique for the switching motor reluctance is a current chopping control, especially at low speeds and start-up zones. The present cutting block for the switching hesitation engine may be shown in Figure 1. With double-pronged poles and intense field stimulation, the switching rebellion engine is susceptible to substantial vibration and acoustic noise. Vibration and noise are particularly noticeable at low speeds and start-up rates in the current cutting process.

The vibration of SRM is caused by the fluctuation of the radial power and the tension change in the winding, which causes the voltage variations.

With a maximum voltage change gradient, the common control system employs the full voltage provided to the curve over the entire speed area, thereby maximising vibration and accompanying sound. Moreover, the current generally surpasses the width of the hysteresis which leads to a larger current reef coupled with a greater torque rib [29] .

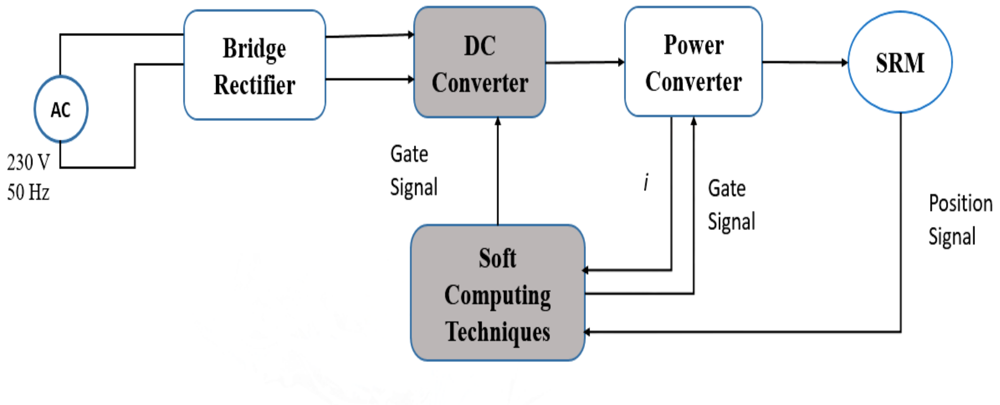


Fig: 3. Block Diagram of proposed Control Technique of SRM Drives

5. THE PROPOSED CONTROL STRATEGY FOR SRM

The SR model Simulink with a fuse logic method is illustrated in figure 4. Instantaneous, direct torque management technology reduces the engine torque rips.

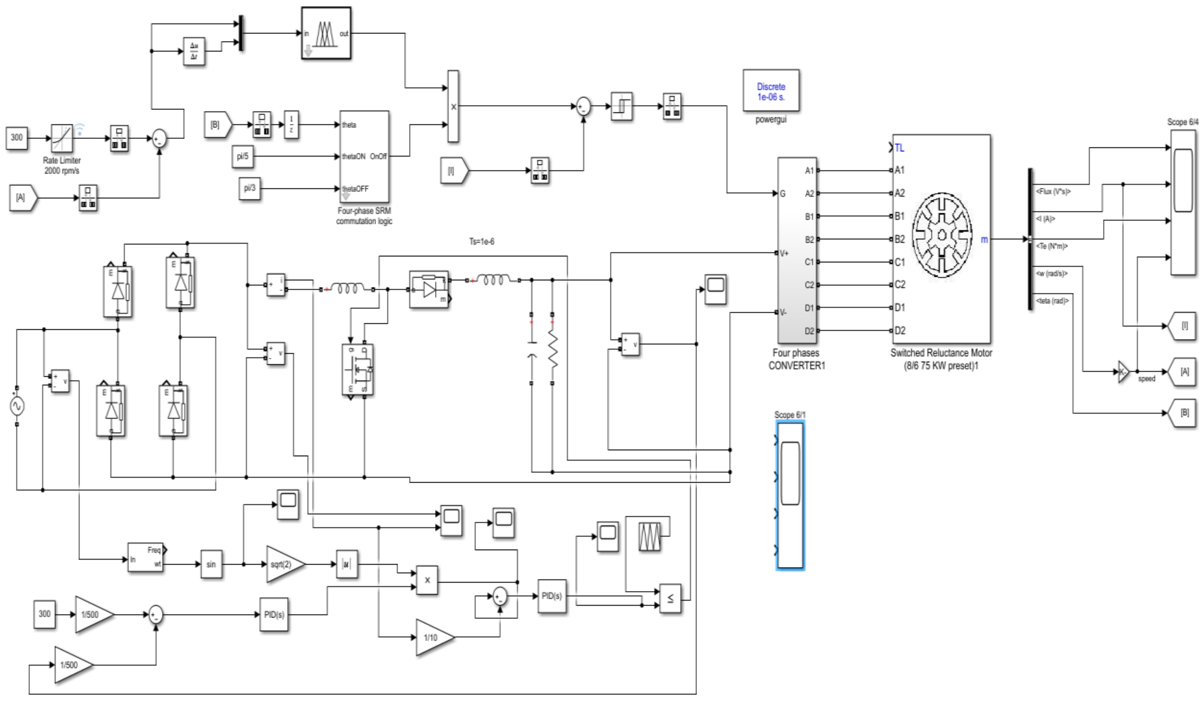


Fig: 4 Matlab Simulink for development of SR motor using Fuzzy logic algorithm

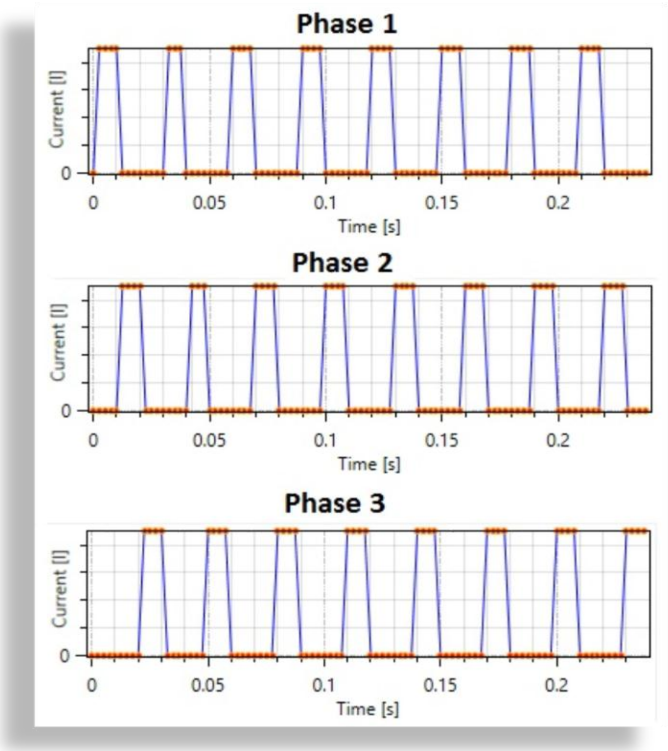
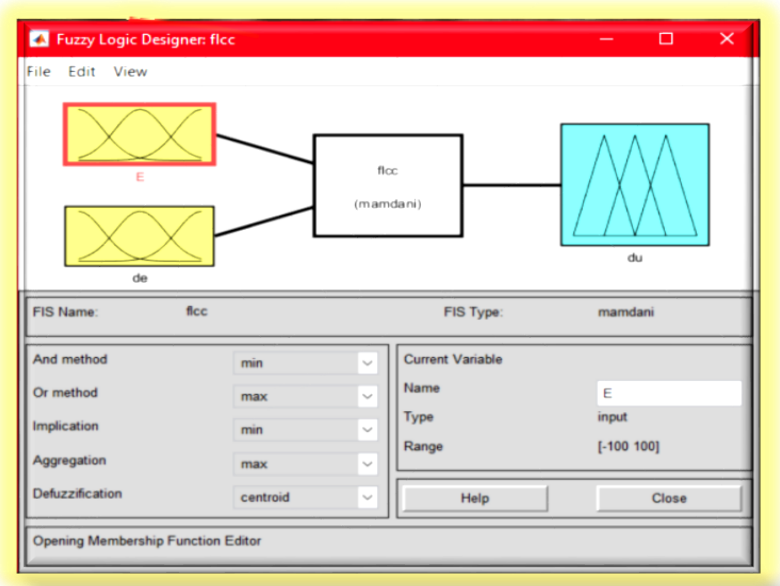
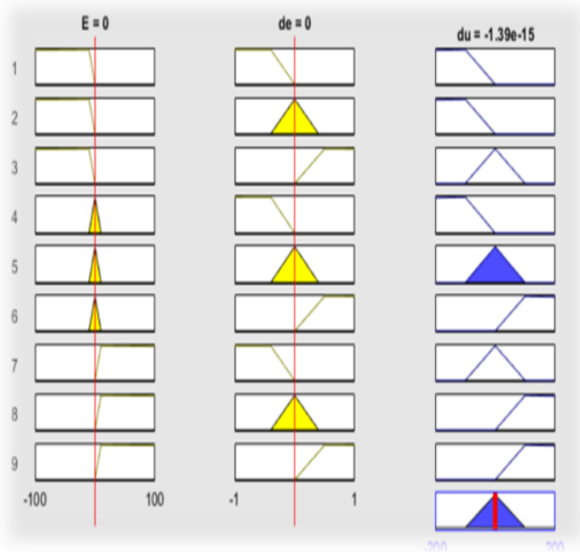
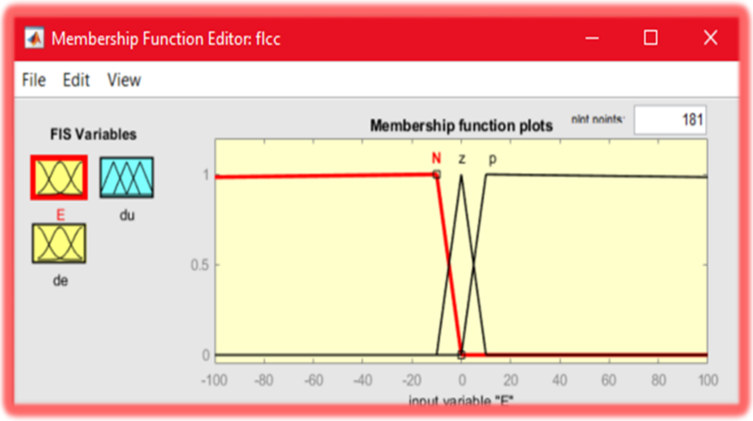
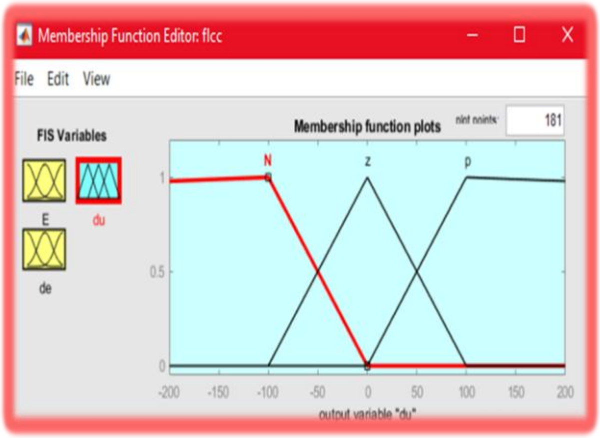


Fig: 5 Three Phase Voltage for SRM Motor









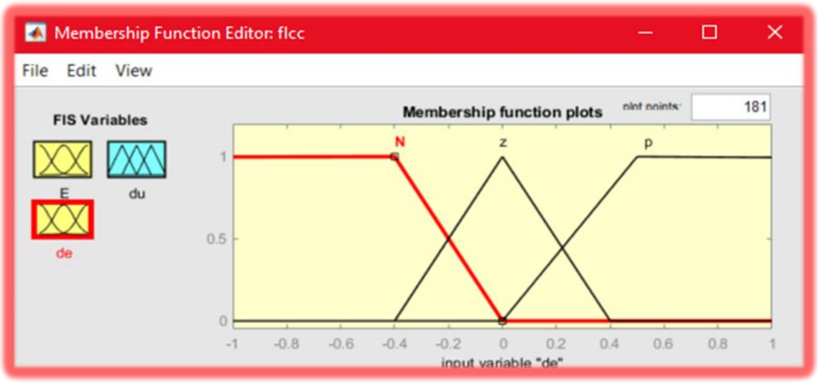


Fig: 6 Fuzzy Logic Membership Function and Rule

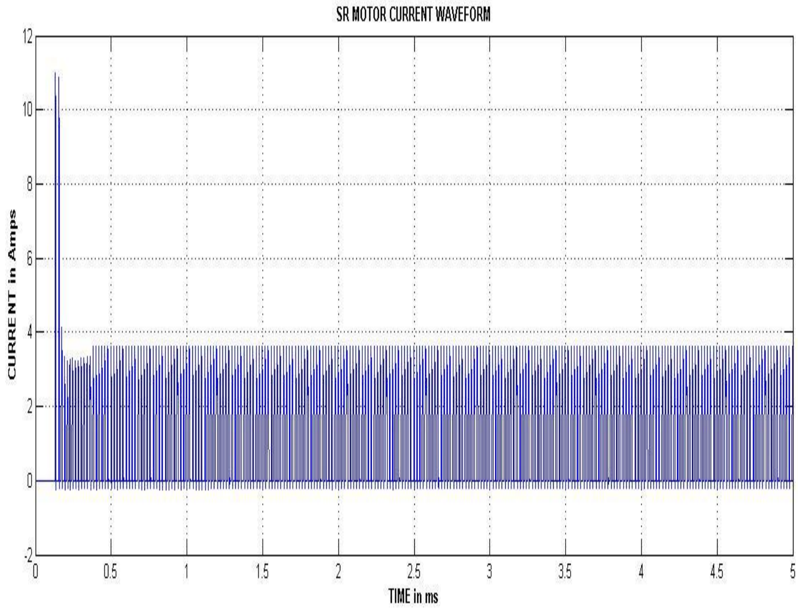


Fig: 7 SRM Current Waveform

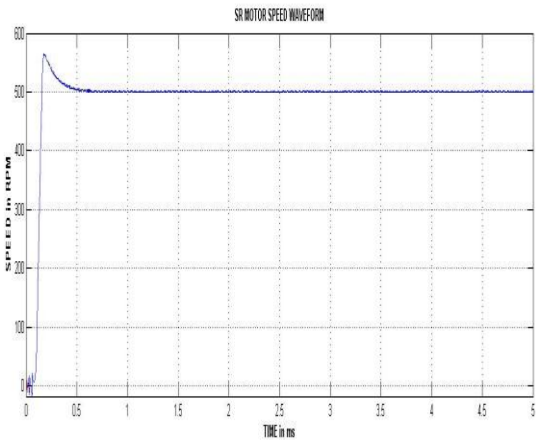


Fig: 8 SRM Speed Waveform

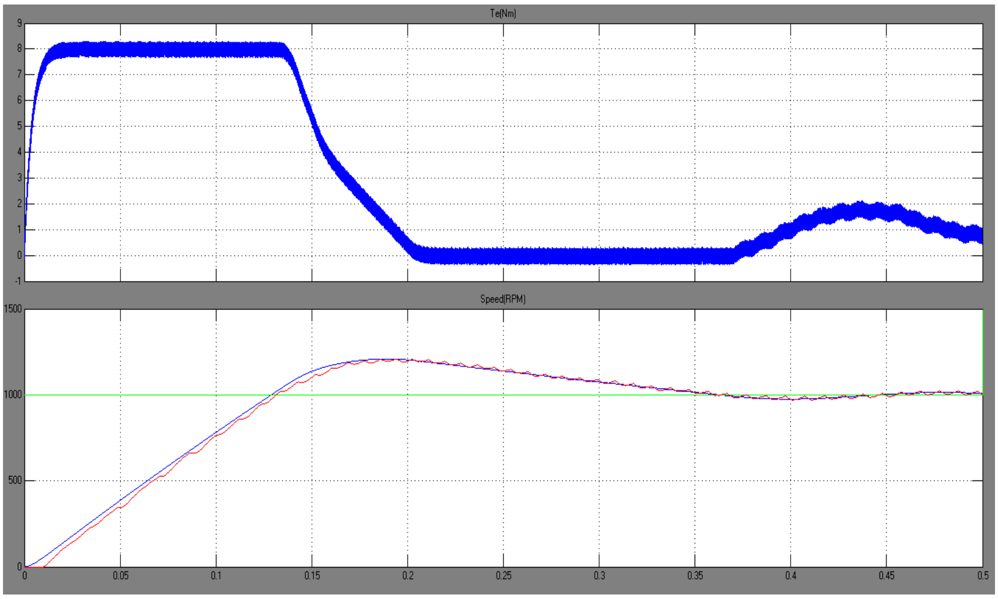


Fig 9 SR Motor speed and torque waveform using fuzzy logic controller

This fuzzy logic controller reduces speed, since Fuzzy is the technique for self setting. The motor speed, torque and torque waveform are displayed in figure 9 using the fuzzy logic controller. The torque rips at 1,75 Nm in the fluctuating state.

6. CONCLUSION

The study has corrected a power factor in order to minimize the torque ribs provided by the buck converter using fluid logical controllers, the supplied SRM motor drive. The buck conversion provides the right voltage for the SRM drive by adjusting the DC bus voltage and by making it directly distinct at engine speed. This minimizes the torque ripple. In the interim, a power adjustment function of the AC power supply is performed by the front end buck converter. It has been accomplished to improve speed control performance and enhance power quality in AC power supply. Finally, the suggested drive is validated by an experimental SRM motor drive, and the test results demonstrate the efficacy of the proposed drive.

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