Switched Reluctance Motor Speed Control

[1]Amol Laxman Chaudhari, [2]Prof S.P.Kharde, [3]Dr. J. R.Mahajan

Department- Electronics & Telecommunication Engineering,
Shreeyash College Of Engineering & Technology, Aurangabad, India.

Abstract- This study presents a speed control design for switched reluctance motor (SRM) drive based on PID controller for Electric Vehicle application. Switched Reluctance Motors (SRMs) can be used in electric vehicle as, it has High starting torque and it is suitable for high speed application. but this type of motors represents a highly nonlinear system, therefore there are a lot of difficulties in modelling and controlling them. We have used a four phases 8/6 poles SRM with asymmetric converter and PID controller with Electric Vehicle as Load then simulated it through Simulink/ Matlab facilities. The control design results are then compared with & without PID controller for electric vehicle in real-time by Simulink/Matlab software package.

Keywords - Switched reluctance motor. Electric Vehicle

Introduction

The switched reluctance motor (SRM) is a type of motor doubly salient with phase coils mounted around diametrically opposite stator poles. There are no windings or permanent magnets on the rotor. The rotor is basically a piece of (laminated) steel and its shape forms salient poles. The stator has concentrated coils. Switched reluctance motors (SRM) have a simple and robust structure, thus they are generally suitable for high-speed applications. High-speed motors have the advantage of high power density, which is an important issue of traction motors in electric vehicles (EV). Therefore, high speed SRM seems to be promising candidates for EV application.

The many attractive characteristics of Switched Reluctance Motor (SRM), such as inherent simplicity in construction, high torque to mass ratio, low maintenance cost makes it a strong competitor to induction machine [1], [2]. When used in hybrid electrical vehicles, SRM provides superior performance as compared to induction motor and permanent magnet motor [3], [4]. However, the drawback associated with SRM is high torque ripple leading to acoustic noise and vibration. The large torque ripple is due to highly nonlinear electromechanical behavior caused by non-linear magnetic characteristics because of saturation [5]. Application of switched reluctance motor such as high power servo system require minimum torque ripple [6].

There are two approaches to boost SRM's performance. The first is to enhance mechanical design, and the second is to incorporate advanced control mechanisms electronically. Only at the expense of motor performance is it feasible to increase performance by mechanical design elements, such as by altering the stator and rotor pole's structure and design [7]. The control mechanism must account for the switched reluctance motor's nonlinear electro-mechanical behaviour, which is made feasible by the wise choice of several operational parameters including turn on and turn off angle, shaft load, operating voltage, and current [8]. Numerous methods have been documented in the literature for reducing torque ripple by altering the torque profile, which alters the current waveform [9], [10], [11], [12], and [13]. To regulate the current waveform in electrical drives, these strategies involve the creation of intelligent controller systems like fuzzy logic [9] and/or neural networks [14]. However, the actual use of these intelligent approaches requires professional user input throughout design. Additionally, the absence of formal model theory and mathematical complexity associated with these approaches make them vulnerable to the degree of expertise in issue definition possessed by specialists. On the other hand, optimisation techniques have enormous potential since they can obtain detailed knowledge about systems problems through deeply ingrained models. Recently, methods for building a controller based on contemporary heuristic optimisation techniques have been developed. Although several intelligent control approaches have been created, the PI controller is the most used controller in industries due to its efficiency and ease of use. The Classical Proportional Integral (PI) controller is a popular choice among engineers because to its numerous appealing features, including dependability, structural simplicity, and a favourable relationship between price and performance. In addition to these benefits, PI controllers also address important challenges in engineering practise, such as simple dynamic modelling, less user-skill requirements, and little development effort. In light of the foregoing, PI controllers are chosen to enhance SRM performance. The SRM performance may be increased by reducing torque ripple and quickly and accurately monitoring speed and current to their corresponding reference values. SRM's performance may be greatly enhanced by using the ideal settings for its control parameter. The current waveform in electrical drives has been modulated in the literature using a variety of optimisation

strategies [15]. The literature[15] has described the use of a variety of heuristic optimisation strategies for fine-tuning the PI controller.

A review of the literature reveals that several methods have been suggested for SRM speed control. Some writers have suggested minimising the torque ripple while also controlling the speed of the SRM by changing the torque profile [6, [11], [15]. By choosing the right commutation angle control, the SRM performance improves [9], [10]. In this study, an optimal turn-on and turn-off angle selection method is provided together with a control strategy for regulating the speed of SRM. The torque ripple of the proposed speed control system is reduced by regulating the current profile and by carefully choosing the switch on and turn off angles.

SRM Configuration

The PID based SRM drive as shown in fig 1; mainly consist of Asymmetric Converter, 3-phase SRM, PID based Controller, position and speed sensor. Here Asymmetric Converter is used to energized and de-energized the 3 phases of Switched Reluctance motor (SRM). The shaft position sensor sends rotor position and speed information to the controller, These inputs are processed by PID controller and generated on off signal, which provides signals to the power Asymmetric Converter to synchronize the energizing of the three stator phase windings and rotor,
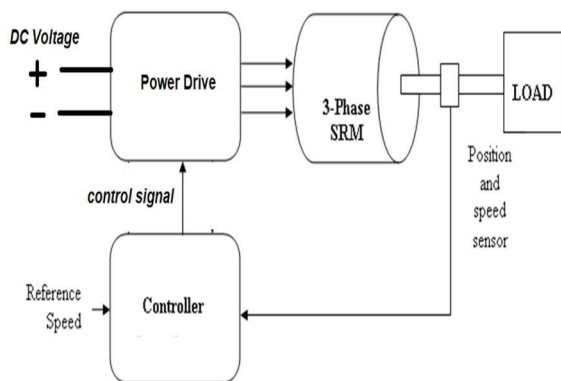
Fig,1 Block diagram SRM control.

The PID control operates on input error signal come from sensor. The proportional, integral derivative terms are summed to calculate the output of the PID controller. Defining U(t) as the controller output, the final form of the PI algorithm is

$U(t) = Kp\ e(t) + Ki \int e(t)\ dt + Kd\ d/dt\ e(t)$

Where
Kp = Proportional gain
Ki = Integral gain
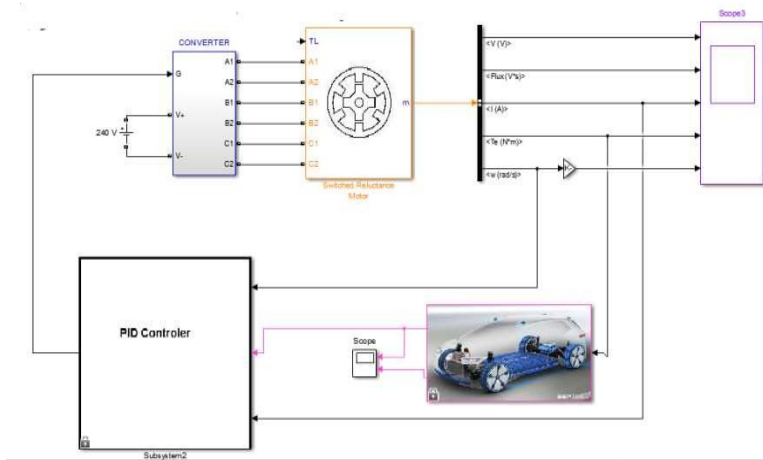Kd= Derivative Gain
E = Error value

Fig 2 Closed Loop Model with PID Controller

Here we proposed a SRM model of a four phases 8/6 poles SRM with asymmetric converter and PID controller then simulated it through Simulink/ Matlab facilities figure shows Closed loop model of SRM with PID controller shown fig 2.

Here we used two loop current control and speed loop, Current control for detection of over control and protect it from damage, given reference input current and actual current from motor is compeered and error signal is generated that will be control by PID control

Result

Graph shows five output of switched reluctance motor and relation with each other (voltage current ,flux ,torque and speed).Speed of switched reluctance motor reaches 5000 rpm with in very short time
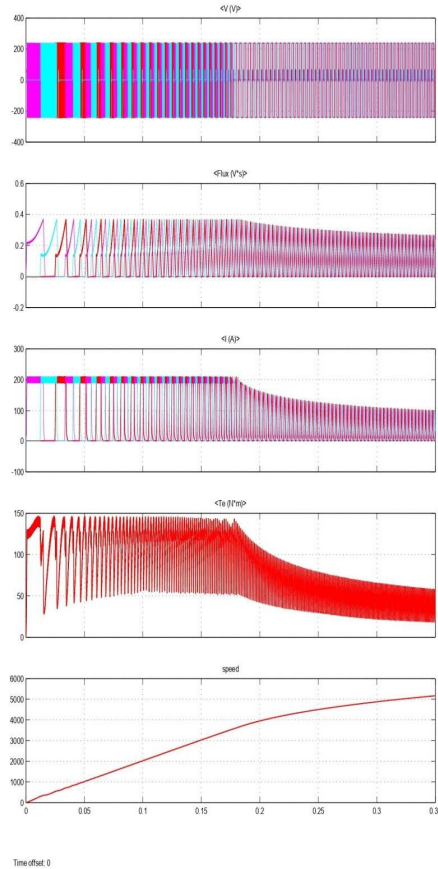

Fig 3 SRM output graph

Speed response is tabulated below which indicate speed in km/hr with respective time in sec with no load, Electric vehicle speed reaches 39.01 km/hr with in 0.3 sec .

Time	0.05	0.1	0.15	0.2	0.25	0.30
RPM	1000	2000	3000	3900	4500	4900
Speed Km/hr	7.96	15.92	23.88	31.05	35.83	39.01

Table 1 Speed response with respective time

Graphical representation for speed control using this method and simple on off control, Blue line represent system without PID controller and Green line shows speed response of this system, which indicate speed reaches 39.01 km/hr in 0.3 sec
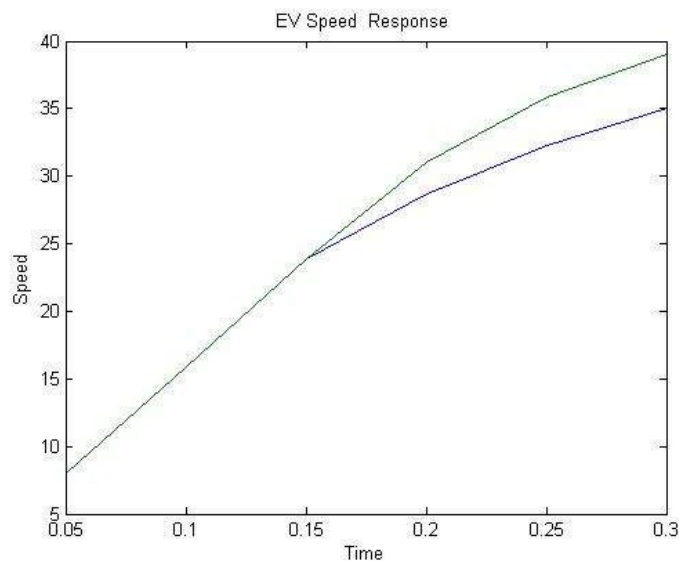
Fig 4 EV Speed Response

Conclusion

In this paper a simulink model of PID based converter topology for Electric Vehicle for controlling switched reluctance motor drives with and without PID controller models has been implemented and tested using Matlab/simulink software package.. result show it is taking less time than other and has better performance for electric vehicle applications.

Refernce

[1] Amol Laxman Chaudhari, Prof S.P.Kharde," Switched Reluctance Motor Speed Control" International Journal for Research in Engineering Application & Management (IJREAM)
[2] Haroutuon A. Hairik Rabee' H. Thejel Samar Hameed, " Speed Control of Switched Reluctance Motor Drive Based on PID Controller"
[3] A SURVEY ON COMPARISON OF ELECTRIC MOTOR TYPES AND DRIVES USED FOR
[4] ELECTRIC VEHICLES, 16th International Power Electronics and Motion Control Conference and Exposition, Antalya, Turkey 21-24 Sept 2014.
[5] Speed Control of Switched Reluctance Motor, JETIR June 2022, Volume 9, Issue 6
[6] Switched Reluctance Motor Drives: Fundamental Control Methods By Manuel Fernando Sequeira Pereira, Ana Mamede and Rui Esteves Araújo
[7] Hussain, Minimization of torque ripple in SRM drives, IEEE Trans. Ind. Electron 49 (2002) 28–39.
[8] V.P. Vujicic, Minimization of torque ripple and copper losses in SR drives, IEEE Trans. Power Electron. 27 (2012) 388–399.
[9] M. Rodrigues, P.J. Costa Branco, W. Suemitsu, Fuzzy logic torque ripple reduction by turn-off angle compensation for switched reluctance motors, IEEE Trans. Ind. Electron 48 (2001) 711–715.
[10] J. Faiz, G.H. Solani-Khosroshahi, Torque ripple reduction in switched reluctance motor by optimal commutation strategy using a novel reference torque, Electr. Power Compon. Syst. 30 (2002) 769–782.
[11] E.G. Shehata, Speed sensoreless torque control of an IPSM drive with online stator resistance estimation using reduced order EKF, Electr. Power Energy Syst. 47 (2013) 378–386.
[12] N.C. Sahoo, S.K. Panda, P.K. Dash, A current modulation scheme for direct torque control of switched reluctance motor using fuzzy logic, Mechatronics 10 (2000) 353–370.
[13] Z. Lin, S. Reay, W. Williams, Torque ripple reduction in switched reluctance motor drives using B-Spline neural networks, IEEE Trans. Ind. Appl. 2 (2006) 1445–1453.
[14] L.O.A.P. Henriques, L.G. Rolim, W.I. Suemitsu, P.J.C.J.A. Dente Branco, Torque ripple minimization in a switched reluctance drive by neuro-fuzzy compensation, IEEE Trans. Magn. 36 (2000) 3592–3594.
[15] L. Kalaivani, P. Subburaj, M.W. Iruthayarajan, Speed control of switched reluctance motor with torque ripple reduction using non dominated sorting genetic algorithm (NSGA-II), Int. J. Electr. Power Energy Syst. 53 (2013) 69–77.