LabVIEW Based Model of Switched Reluctance Motor using PI Controller

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Abstract This paper presents new and novel approach towards the development of mathematical model of SRM and controller using Lab VIEW platform. Application of PI Controller in Lab VIEW Platform is presented in this paper to reduce settling time and torque ripple, for different combination of K_p and K_i values. All simulation are completely documented with their block diagram and Lab VIEW Subsystem. In Lab VIEW platform, pi controller vi subsystem is developed which helps in reducing torque ripple and settling time.

Keywords: Lab VIEW, PI

I. INTRODUCTION

The SRM has been one of the recent entrant to the competitive field of variable speed drive. In the past two decades, due to continuous research and development in power semiconductor electronics, there has been drastic growth in SRM drive systems suitable for commercial application. A SRM has very good and promising features like simplicity, ruggedness, high torque to inertia ratio and cost effectiveness. The major drawback is torque ripple which causes vibration and acoustic noise. The flux linkage of SRM is a function of both rotor position and the stator current. When stator is excited through converter, rotor tends to occupy minimum reluctance position leading to production of torque which is discontinuous. To overcome this discontinuity of torque, basically two approaches are their one is machine design and another one is control strategy.

II. LITERATURE SURVEY

This segment briefly gives overview about the work carried out so far on switched reluctance motor in the field of origin of torque ripple and its minimization techniques using various control strategies, the inspection of few of them are discussed here.

Different computing and control techniques review has been carried out. [3] reviews about the techniques used for torque ripple minimization. There are two methods of torque ripple minimization, one is machine design another is control strategy. By machine design methods manufacturing cost is high due to increased in complexity of machine structure, with control strategy cost is less and implementation can be faster. Here control strategy such as current profiling, Direct instantaneous torque control, intelligent control are discussed.[1] gives brief overview about causes of torque ripple and a proposed a torque ripple minimization method based on peak valley complementary principle. This principle includes two sets of motor with same rotor and stator to produce two torque ripple waveforms with same amplitude, same frequency and the 180 degree phase difference. Then the resultant of two torque ripple waveform reduces the overall torque ripple, which is verified both theoretically and practically verified in Matlab Simulink environment.[4] gives overview about different methods of minimizing torque ripple such as, conventional PI controller, Fuzzy logic controller and others significantly reduce torque ripple.[5] This paper gives insight about fuzzy logic controller along with PI controller for minimizing torque ripple in SRM. Here FLC uses rotor position and reference current as input and produces compensating current as output using seven membership function.

Lab VIEW is graphical based programming language which helps in machine monitoring and control, research and analysis, control design and parallel processing. In this paper [8] an summary about implementation of SRM model in FPGA target is discussed. Here using FEMM software virtual model of SRM is designed and it is validated by measurements with the variation of voltage in opposition to current methods. The model is Implemented on FPGA device, using the LUTS present .[6] gives overview about introduction of Lab VIEW, control design and simulation module, PID and fuzzy logic tool kit,Labview math script and examples on the same .[11] gives insight about two graphical programming platform such as MATLAB and LabVIEW. Comparison is done between both the platforms by taking suitable example of PI,PID controller design for DC Motor and results are tabulated with respect to simulation time in both Lab VIEW and MATLAB.[10] describes about FPGA based SRM model, which provides good accuracy, high efficiency, high torque to inertia ratio, speed performance and good response. Here PI speed controller along with hysteresis controller is implemented in lab VIEW using look up table machine model. Lab VIEW FPGA model is seen on R series board with kintex FPGA chip. Current are sensed and is given to DAQ board, which in turn produces switching signal for converter.

III. METHODOLOGY

The analytical model of SRM is based on relevant equations such as torque equation, flux linkage equations, electro mechanical equations and motion equations.
Because of double salience nature and magnetic saturation, flux linked in SRM phase is dependent on rotor position and phase current. The Vi model of SRM in LabVIEW includes the asymmetric bridge inverter, Vi model, Switch signal Vi model, Motor Speed and rotor position Vi model, SRM linear parameters.

A. SRM Linear Model
It simulates a Switched reluctance motor using linear model function. It specifies parameters based on linear model function. Its vi model is as shown figure 1.

B. SRM Asymmetric Bridge Converter.
SRM Asymmetric bridge inverter.vi block diagram is as shown Figure 3. It produces the phase voltage requires for excitation of stator winding for SRM. Based on current command two switch cases are their true or false.

C. SRM Switch signal.
The switch signal is activated to determine the phase of inverter to be turned on in accordance with position of rotor. Model accepts inputs as SRM type, turn on and turn off angles, speed set point, speed error, rotor position and produce switch signal. Based on rotor position, switch signal
activates the next phase. SRM switch signal vi is as shown in fig 6

Figure 6: SRM switch signal vi

D. SRM PWM Gate signal.
This block helps to simulate the pulse width modulation signal and gate signal for inverter. Model accepts Amplitude for gate signal is 30V frequency of 50000 and time from current simulation time control signal as voltage from PI controller and output will be gate signals for inverter. SRM PWM gate signal.vi is as shown fig 7

Figure 7: SRM PWM gate signal .vi

E. Motor speed and rotor position
This models helps to evaluate the motor speed and rotor position .It accepts inputs such as speed, rotor, torque and mechanical parameters The speed and rotor position will be given as input to inverter and controller respectively. Motor speed and rotor position .vi is as shown in fig 8

Figure 8:Motor speed and rotor position block diagram

F. SRM PI Controller
The SRM PI controller .vi is as shown Figure 9. It consists of two PI controller block one is speed PI controller and current PI controller. Speed obtained from motor speed and rotor position is compared with reference speed and produces control output as speed which is given as input to speed PI control.

Figure 9:SRM PI controller.vi block diagram

The output of speed PI control is current compared with output current of SRM produces control output acts as input to asymmetric bridge converter for controlling switches

IV. RESULTS AND DISCUSSION
The SRM linear model block diagram and front panel diagram is showcased. Typical waveforms for 800 rpm and 0.6N-M is as shown below.

Figure 10: Linear model of SRM with PI controller, block diagram

Figure 11:Front panel diagram of SRM model using PI controller
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Figure 12: 3 phase SRM with speed of 800rpm, load torque 0.6 N-m

Figure 13: waveform of current(A) v/s time(sec)

Figure 14: waveform of TorqueNm) v/s time(sec)

Figure 15: waveform of velocity (RPM) v/s time (sec)

V. CONCLUSIONS

In this paper, vi model of SRM is developed in LabVIEW platform. Here new approach is made for minimize torque ripple and settling time by designing PI controller using control and simulation tool box. As a future work ,gating signals for SRM can be derived as a part of hardware implementation.

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