A NOVEL CONVERTER TOPOLOGY FOR SRM

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Abstract - *Switched reluctance motor has become competitive among many application recently due its relatively simple in construction of salient pole stator and rotor. It has both salient pole stator and rotor. They use different stator constructions, including the commonly use stator with concentrated coils. . Rotor has no windings and hence it is rugged in construction. It possess the advantages of high starting torque without high inrush current. It has simple structure together with recent advances in power electronic equipment. SRM works based on this principle; when stator is excited, the reluctance torque makes rotor to move towards the minimum reluctance position. When the rotor reaches the minimum reluctance position the next phase is switched on, thus required rotating torque is produced.*

The ongoing research for the effective controlling mechanism for the switched reluctance motor contributed many converter topologies such as asymmetric converter, bifilar converter. A new converter topology with reduced number of switches ***and reduced heat loss is capable to meet the today's*** *existing deficiency together with property inheritance of asymmetric converter. The converter mainly concentrates to control the freewheeling time so as to minimize the magnetic saturation. Minimization of the magnetic saturation reduces the nonlinear losses, which in turn reduces the non-linearity of magnetic flux and current flown.*

Key Words: SRM, IGBT, Nr

1. INTRODUCTION

Switched reluctance motor (SRM) is a double salient motor, which runs by variations in reluctance torque. The main limitation of the switched reluctance motor is the difficulty in controlling of phases. The modern era of power electronic switches and microcontroller provides a better environment for the control of SRM. With modern electronic devices this is not a problem, and the SRM is a popular design for modern motors. The main disadvantage of SRM is the torque ripple. SRM has wound field rotor as in DC motors. The rotor has no coils attached. It is a solid salient pole rotor made of soft magnetic material. When power is applied to the stator windings, the rotor's magnetic field creates a force that attempts to align the rotor pole with the nearest stator pole. In order to maintain rotation, an electronic control system switches on the windings of successive stator poles in sequence. The rotor pole is thus pulled forward.

Rather than using a troublesome high-maintenance solid state electronic mechanical commutator to switch the winding current as in traditional motors, the switched reluctance motor uses an electronic position sensor to determine the angle of the rotor shaft and solid state electronics to switch the stator windings, which also offers the opportunity for dynamic control of pulse timing and shaping. The mechanical simplicity of the device. However, comes with some limitations like the brushless DC motor, SRMs cannot run directly from a DC bus or an AC line, it should be always electronically commutated. The saliency of the stator and rotor is necessary for it causes strong non-linear magnetic characteristics, complicating the analysis and control of the SRM.

2. PROPOSED SYSTEM

The new converter for the switched reluctance motor incorporates many features. For simplicity we had taken a converter for the three phase SRM. Each phase consists of two windings. For each phase therefore two IGBT switches are used. Also each phase winding consists of thyristor switch for the freewheeling. Thus converter consists 6 1GBT switches with 3 thyristors.Thus the proposed system consists of totally 9 power electronic devices. The converter mainly concentrates on to control the switching during the freewheeling period. The major difference from the asymmetric converter is that it makes use of the thyristor switches in addition to the IGBT switches. The thyristor switches are connected in the freewheeling direction. The thyristor is switched at a half the frequency of the IGBT,during each switching new phases are switched on. But at same time the energy stored in the previous phases must be discharged. For that freewheeling time is provided. By suitably controlling the thyristors for the freewheeling the discharge amount can be varied. Here the freewheeling time is limited to one half cycle only. Within this time the majority of the stored energy is discharged. When the energy stored the magnetic field is discharged to maximum value, during the next charging the saturation of the magnetic field can be reduced, which in-turn reduces the nonlinear effect of fluxes as well as inductance during the charging. Thus this converter can reduces the torque ripples.

2.1 Block Diagram

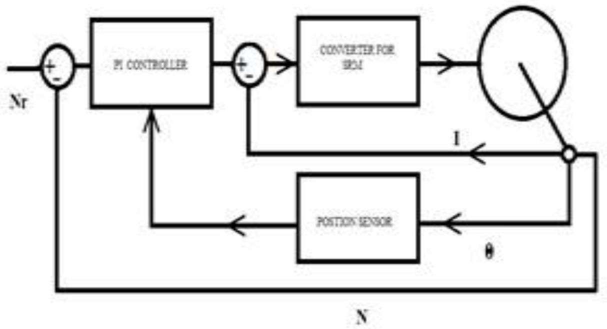

Fig -1 : Block diagram of SRM drive system

2.1.1 Conveter

Converter for the switched reluctance motor consists of 6 IGBT switches and 3 thyristors. The switches are ON during the conducts each phases .The energy stored during the energization of released during the freewheeling period. Through this converter we can reduce the switches, magnetic saturation and losses.

2.1.2 Position Sensor

Position sensor block generates the switching pulses. The position sensor takes the input as speed and it gives output as pulses of different width depending upon the speed to be set.

2.1.3 Switched Reluctance Motor

SRM is an electric motor in which torque is produced by the tendency of the moveable part to move a position where the inductance of the excited winding is maximized. It has wound field coils of a DC motor for its stator winding and has no coils or magnets on its rotor.

3. HARWARE DETAILS

IGBT switches

IGBT switches function is to ON when sufficient gate pulse is given. It can work on very high frequencies. Here we are using IGBT switches with body diode are used. since switched reluctance motor needs high frequency switching, IGBT is more preferred.

Thyristor switches

Switching frequency of thyristor is less compared to IGBT. So thyristor switches for the freewheeling purpose as well as during the conduction time where the switching frequency is half the switching frequency employed in the IGBT.

4. SIMULINK MODEL

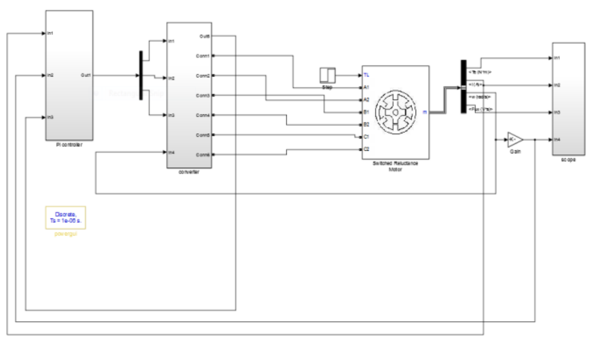

Fig -2 : SRM drive with proposed converter

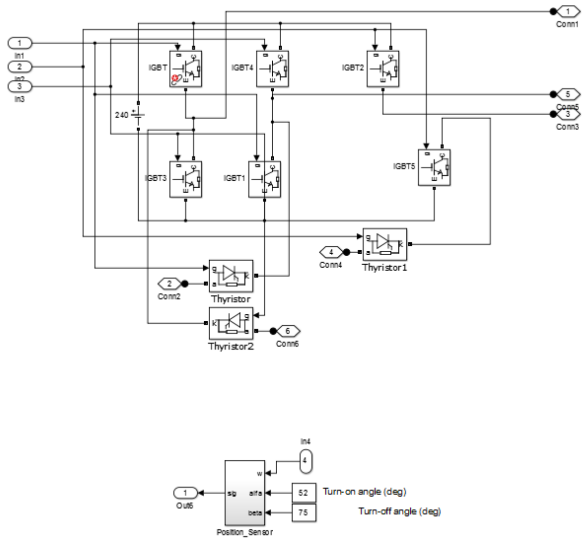

Fig –3 : SRM drive with converter

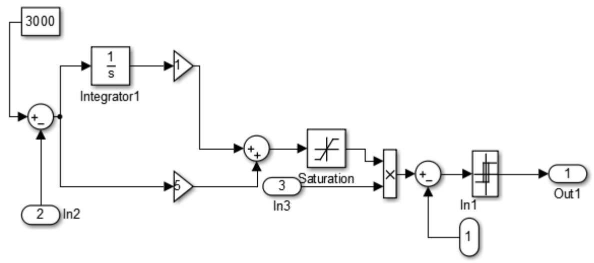

Fig -4 : SRM drive with PI controller

PI controller consists of propotional and integral controller.The input to the PI controller is an error signal corresponding to the actual speed and reference speed. The output of the PI controller is fed through a saturation to a multiplier.The another input to the multiplier is the output from the postion sensor ,which is in the form of pulses.The output of the multiplier is fed to the summer,which compares the current taken by the motor.

Table-1: Parameters used in simulink model of SRM

Sl no	Parameters	Specification
1	Stator/rotor	6/4
2	Stator resistance	0.01
3	Inertia	0.0082
4	Initial speed and position	[0 0]
5	Sample time	-1
6	Maximum flux linkage	0.486
7	Unaligned inductance	0.67e-3
8	Aligned inductance	23.6e-3
9	Saturated aligned inductance	0.15e-3
10	Maximum current	450

5. SIMULATION RESULTS

a) Waveforms of proposed system

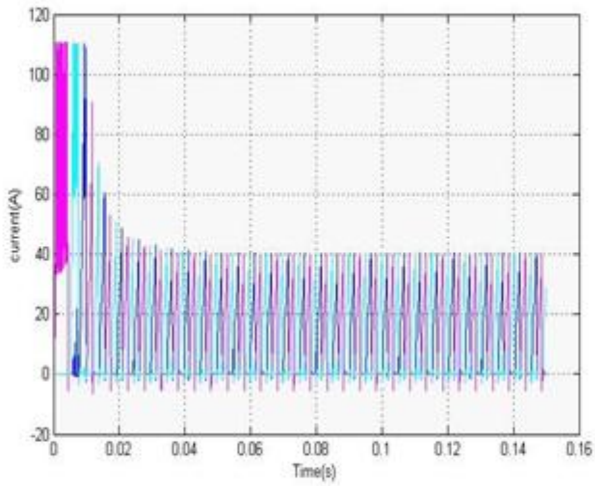

Fig -5 : Current waveform

The current wave form of the proposed converter is shown in the fig no 5.The converter is designed for three phase SRM.Each of the three colour waveform represents the phase current.It suddenly decreases from (0-0.04)s and after 0.04s the current attains a steady state nearly 40A.

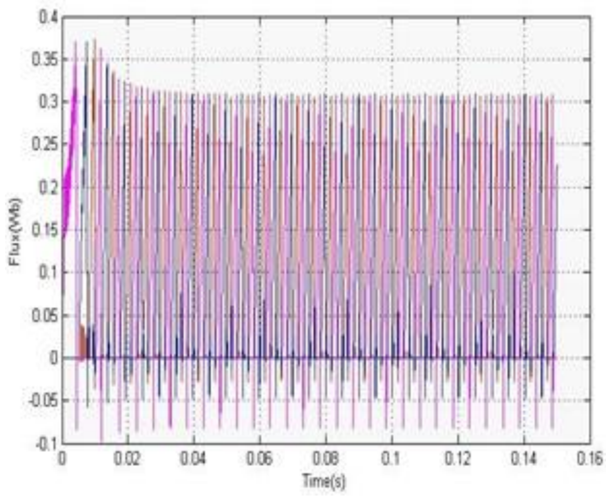

Fig -6 : Flux waveform

The flux waveform of the proposed converter is shown in the fig no 6.The flux waveform is a triangular waveform.The flux waveform also contains three waveforms,which represents three phases.Maximum flux is 0.37Wb and the flux varies between 0 & 0.37.

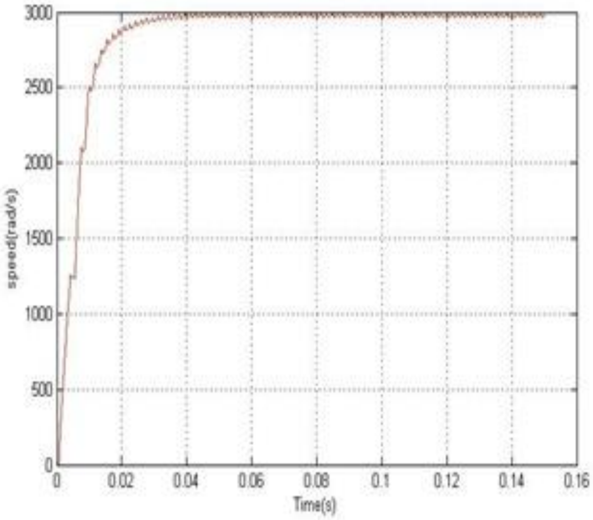

Fig -7 : Speed waveform

The speed waveform of proposed converter is shown in the fig no 7.The slope between (0 & 0.04)s the speed is increasing linearly with time.After 0.04s the speed attains the steady state.The steady state speed is 3000.

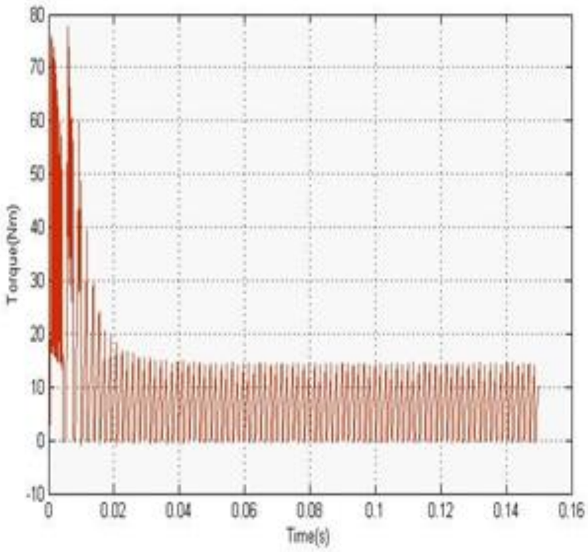

Fig -8 : Torque waveform

The torque waveform of proposed converter is shown in the fig no 8. Maximum torque that occour in our system is in between 70 & 80.From 0.04s the toruqe attains steady state between 10 & 20.

a) Waveforms of existing system

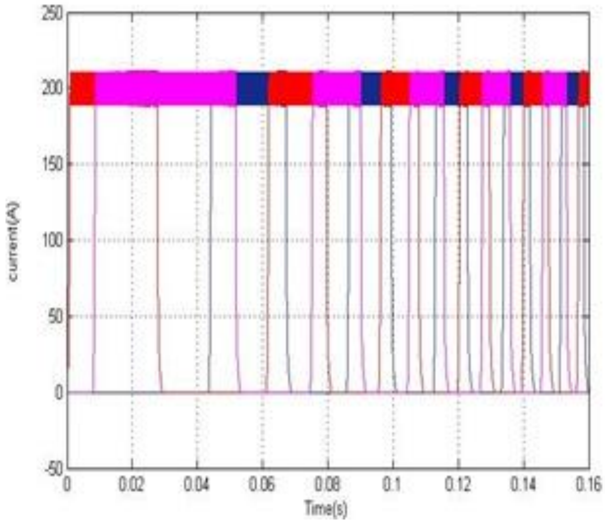

Fig -9 : Current waveform

The current waveform of existing converter is shown in the fig no 9. Each of the three colour waveform represents the phase current and maximum value of current is 200A.From starting point, the current is in steady state.

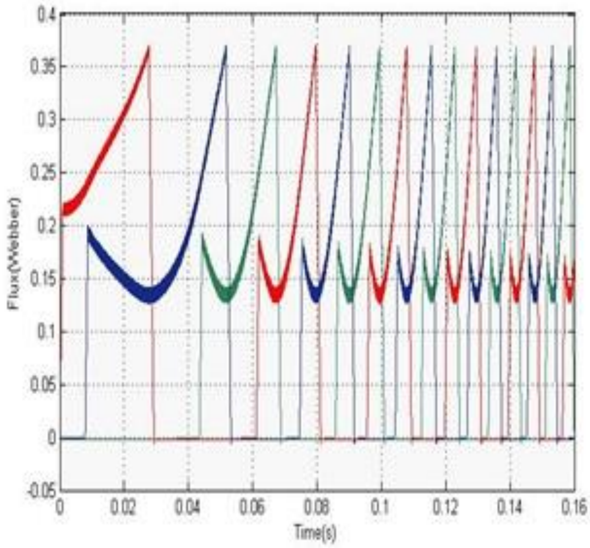

Fig -10 : Flux waveform

The flux waveform of the existing converter is shown in the fig no 10.The flux waveform also contains three waveforms,which represents three phases.Maximum flux is 0.37Wb and the flux varies between 0 & 0.37.

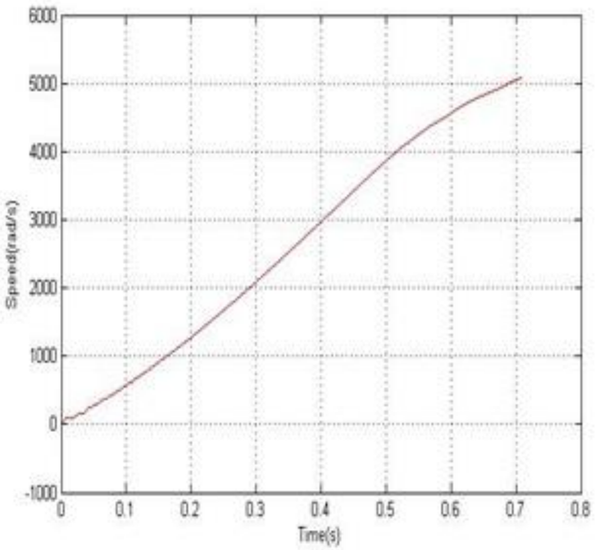

Fig -11 : Speed waveform

The speed waveform of existing converter is shown in the fig no 11.The slope between (0 & 0.7)s the speed is increasing linearly with time.After 0.07s the speed attains the steady state.The steady state speed is 5000.

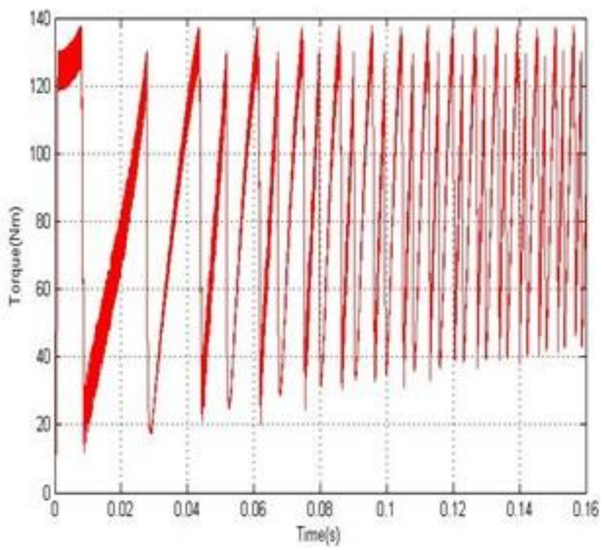

Fig -12 : Torque waveform

The torque waveform of existing converter is shown in the fig no 12.. Maximum torque that occour in this system is in between 120 & 140.It attains steady state slowly.

Table -2 : Comparison between existing and proposed converter

sl no	Parameters	Existing converter	Proposed converter
1	Max. current	200 A	110 A
2	Max. flux	0.37 Wb	0.37 Wb
3	Max Speed	increases	decreases
4	Torque ripple	(20 - 140)Nm	(0-80)Nm

6. CONCLUSION

The converter holds good in controlling the switched reluctance motor. The controller with reduced number of the switches makes it compactable to efficiency highlighting environment. The reduced number of switches in turn helps to reduce the losses. The converters main highlight is the freewheeling control. Torque ripples and acoustic noise problems are reduced by effectively controlling the freewheeling and also nonlinear magnetic saturation due to the accumulation of the stored energy in the coils of each phases decreases.

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