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Simulation of New Switched Capacitance Power Converter for Srm

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Abstract
In this paper, design and simulation of switched capacitance power converter are proposed for 6/4 switched reluctance motor (SRM) drive. The operating principle and design consideration of the proposed converter is explained. The proposed converter performance is better in reduction of torque ripple and constant speed can be achieved quickly with reduced power loss when compared with asymmetric converter. The proposed system is simulated by using MATLAB Simulink and their results are clearly presented.
Index terms-SRM, Switched Capacitance, power converter drives, MATLAB Simulink.

I. I.INTRODUCTION

The switched reluctance motor (SRM) drives for industrial applications are of recent origin. Because of its simple construction and easy operation, the SRM can be an ideal alternative for other motors if its problems can be solved [1]. Serious acoustic noise caused by the torque ripple is still a primary reason for the SRM to be unacceptable in variable speed drive market [2]. The three phase switched reluctance motor drives are suitable for the applications of the high power electric drive. The SRM drive is made up of the reluctance motor, the power converter, the controller and the rotor position sensor [3]. The general block diagram for SRM drive is shown in the fig.1.

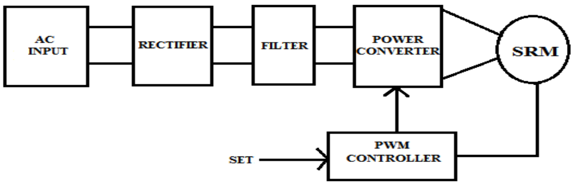

Fig.1.General block diagram of SRM Drive

The modeling and analysis of the three phase (6/4) switched reluctance motor with torque ripple reduction is explained in [4-7]. The control strategies of SRM drive is dependent on the requirement of particular control applications. Normally control strategies are applicable in the areas of

- Position sensor information.
- Speed control using PI, PID, Sliding mode controller, Fuzzy logic control etc.
- Converter/inverter design including power quality control.
- Torque ripples minimization.
- Reduction of acoustic noise.
- Current controller like PWM current controller, Hysteresis current controller etc.
- Fuzzy logic controller for desired operation.[8]

The design and simulation of a PI Controlled Soft Switched Front End Converter and speed control for Switched Reluctance Motor is explained in [9-10]. The power converter is the main part of the motor drive. The various topologies are normally used for the SRM drive is explained in [11-14]. The design and simulation of new power converter for SRM drive with power factor correction is explained in [15]. It consists of two diodes, one switch and bifilar winding for each phase. The main drawback of this converter is the improper connection of diodes. Due to that connection, demagnetizes of each phase will occur slowly. The constant speed cannot be achieved quickly. The cost of this converter and power losses will be more due to the presence of more number of diodes.

The torque ripple is reduced and speed settling time is also reduced by introducing new switched capacitance power converter in this paper. The operating principles of the proposed converter and its design considerations are explained in the following sections.

II. II.OPERATING PRINCIPLES OF THE PROPOSED CONVERTER

Fig.2. shows the circuit diagram of the proposed converter. It consists of switch, current limiting element, capacitor and diode for each phase. The operation of this converter is similar to the conventional asymmetric converter. The magnetization and demagnetization of the phase inductance of each phase is shown in the fig.3.

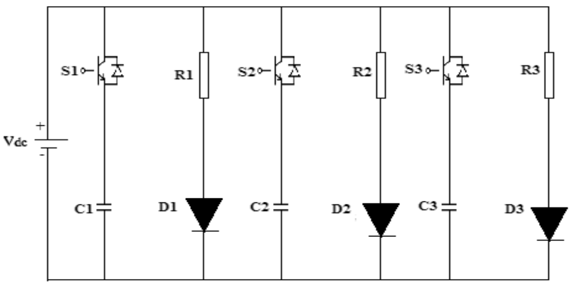

Fig.2. Circuit diagram of the proposed new switched capacitance converter

The operating modes of this converter are divided into three modes. They are magnetization, demagnetization and freewheeling.

Operating Modes

Mode 1: Magnetization

During the operating mode 1, the SRM phase A starts to magnetize through the switch S1 and the diode D1 when the DC voltage is applied. At the same time, the capacitor C1 in series with the switch S1 is charging. The switch S1 conducts up to current reaches its limits. During this mode, the remaining phases B & C are not in conduction.

Mode 2 : Demagnetization

During this mode 2, the phase A inductance starts to demagnetize and C1 discharging. The phase B energize through the switch S2 and diode D2 and capacitor C2 starts charging. Similar to phase A & B, phase C magnetizes and demagnetizes.

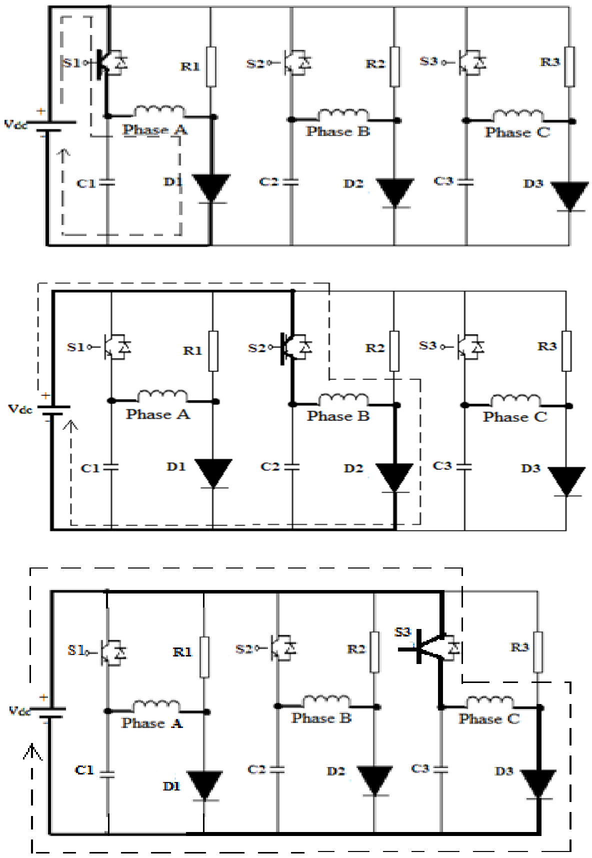

Fig.3. Modes of operation

Mode 3 : Freewheeling

The freewheeling action takes place during demagnetize of each phase, the energy stored in the inductance and capacitor is back to the supply. During all the modes, current limiting elements perform is to limit the current through the phase winding.

III. DESIGN OF THE PROPOSED CONVERTER

V_{in} = 240V, N = 4500 RPM

A. Design of Switch:

The evolution of power semiconductor device technology has caused a progressive overlap in application areas for different devices. Devices with high voltage and current ratings are available. For drive applications the following controllable switches are available[16]:

Switches	Characteristics	Applications
SCR	Has low switching speed.	Very high power applications(>5 MW).
GTO	Switching speed is not very high.	High power applications up to some MW.
MOSFET	Low current ratings up to some hundred amperes.	Low to medium power applications up to some KW.
IGBT	High current ratings up to 1 KA.	Medium power applications (<1MW).

Where,
SCR - Silicon Controlled Rectifier.
GTO - Gate Turn Off Thyristor.
MOSFET - Metal Oxide Semiconductor Field Effect Transistor.
IGBT - Insulated Gate Bipolar Transistor.

Here, Switched Reluctance Motor has used for high speed applications. It leads to high current flow into the power converter thus they requires high current rating switches to control the current flow through the converter.

From the above table, IGBT is more suitable for the SRM drive.

Ratings of switches:

FGB5N60UNDF(600V, 55A,10US)- 3Nos.

B. Design of Diode:

The input voltage is applied to the converter, the IGBT switches conducts the current to energize each winding in the SRM motor. When the switch is turned off, the stored energy in the magnetic field is fed back to the DC source through the winding and diodes.

The demagnetization of each winding must be as quickly as possible to avoid high torque ripple. Thus fast recovery diodes are used for this purpose.

Ratings of Diodes:

STTH8R04D (400V, 8A, and 25 ns)- 3 Nos.

C. Design of Current Limiting Element:

High current rating switches are used to limit the current and torque ripples. In addition to this current limiting element (resistor) in series with the fast recovery diode is used to limit some amount of current ripple.

Ratings of Current limiting element:

0.5KΩ Resistor – 3 Nos.

D. Design of Capacitor:

A capacitor is a passive two-terminal electrical component used to store energy electrostatically in an electric field. They are widely used in electronic circuits for blocking d.c. while allowing a.c. to pass through it.

In the proposed system capacitors are charged when the switches are closed and discharging when the phases are demagnetizing and the switches are not in conduction mode.

The main purpose of capacitor in this circuit is maintaining the torque in one (positive) direction. The value of capacitance is inversely proportional to the speed of the motor.

Rating of Capacitors:

- 21.75μF * 3Nos. for 5000 RPM.
- 47.50μF * 3Nos. for 4500 RPM.
- 77.50μF * 3Nos. for 4000 RPM.

IV. SIMULATION & RESULTS

The SRM drive is simulated with conventional asymmetric converter is shown in the fig.4. is compared with the new switched capacitance converter is shown in the fig.8.

Case (i):

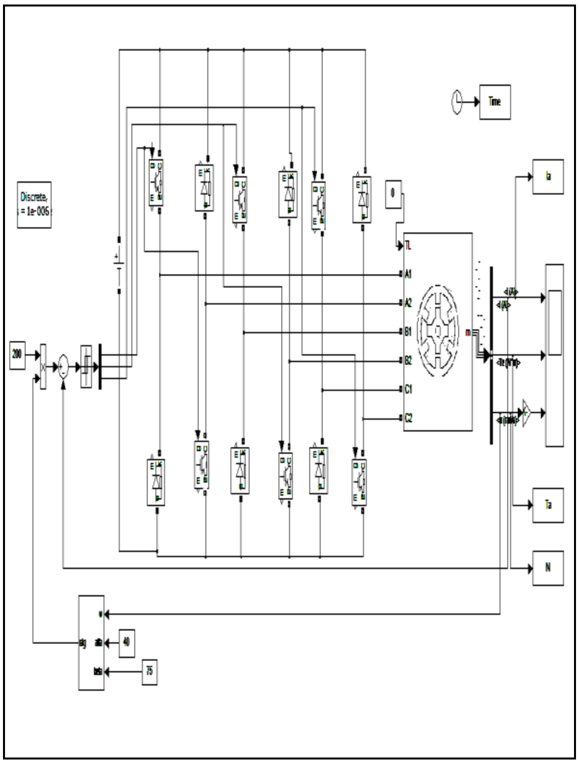

Fig.4.Conventional Asymmetric Converter

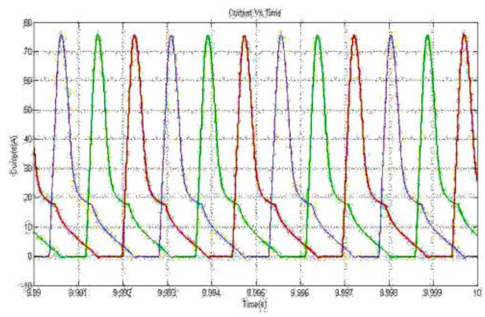

Fig.5. Current profile of Asymmetric Converter

This shows that the current profile of the asymmetric converter. The Current of each phase is independent of other phase. The Current Starts from 0 to 75A for the time period of 0.002S of each phase. When it goes to zero, other phase starts to conducts.

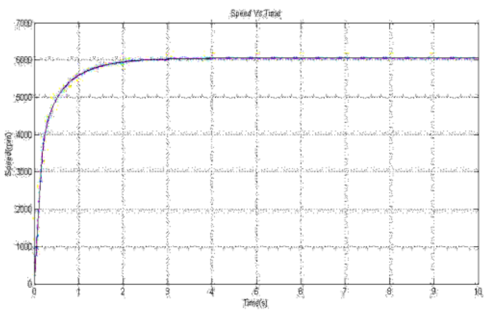

Fig.6. Speed profile of Asymmetric Converter

This shows that the speed profile of the asymmetric converter. It attains the speed of 6050 rpm in 4 seconds.

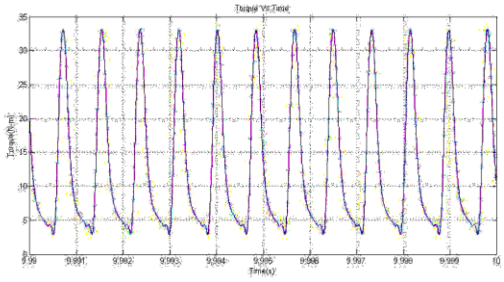

Fig.7. Torque profile of Asymmetric Converter

This shows that the torque profile of the asymmetric converter. The torque produced in the SRM is independent of current in each phase. In this converter, torque is not well settled but it produces only positive torque. The torque ripple starts from 5 N-m to 33N-m. This produces more oscillation in the motor.

Case (ii):

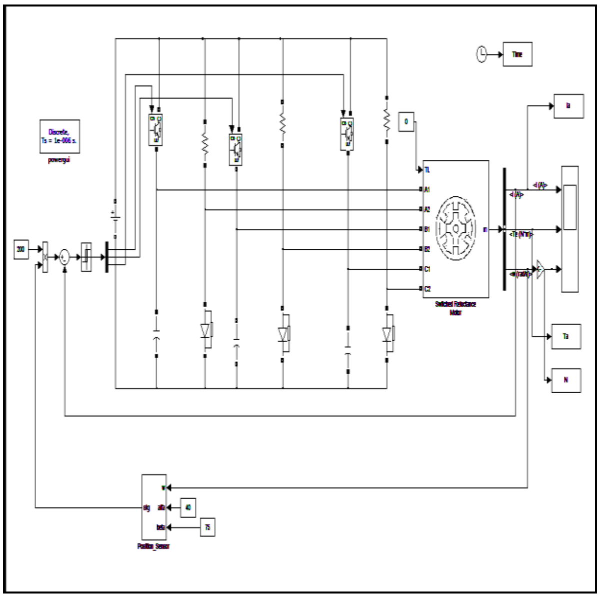

Fig.8.Proposed Switched Capacitance Converter

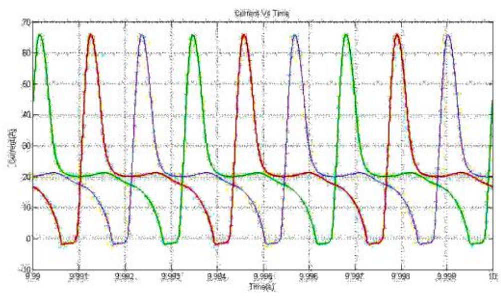

Fig.11. Current profile of Proposed Converter

This shows that the current profile of the proposed switched capacitance converter. The Current of each phase is independent of other phase. The Current Starts from 0 to 70A for the time period of 0.003S of each phase. When it goes to zero, other phase starts to conducts. The current ripple is less than the conventional asymmetric converter due to the presence of current limiter used in the circuit.

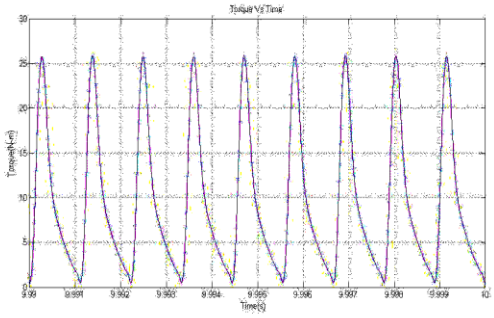

Fig.12. Torque profile of proposed converter

This shows that the torque profile of the proposed switched capacitance converter. The torque produced in the SRM is independent of current in each phase. In this converter, torque is well settled with zero, it also produces only positive torque. The torque ripple starts from 0 to 26 N-m. This produces only less oscillation in the motor compared to asymmetric converter.

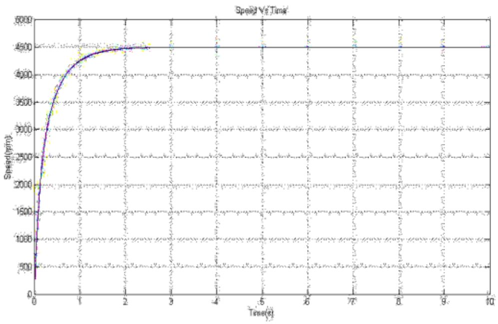

Fig.13 Speed profile of proposed Converter

This shows that the speed profile of the proposed switched capacitance converter. It attains the speed of 4500 rpm throughout the operation. It is suitable for low and medium speed applications.

V. CONCLUSION

In this paper, a new switched capacitance converter SRM drive is proposed. In this converter circuit mode of operations are discussed. It highly reduces the torque ripples and keeps it us positive torque of the motor compared with the conventional asymmetric converter. One more advantage of the proposed converter is reduced number of switches & diodes and it will reduce the cost. Both asymmetric & proposed circuits are simulated by using MATLAB Simulink. Finally their results are analyzed in this paper.

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VI. ACKNOWLEGEMENT

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