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MATLAB/Simulink based a comparative analysis of single switch and double switch topology for 6/4 switched reluctance motor (SRM)

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Abstract
Now a day's switched reluctance motor (SRM) is getting attention from various industries due to its simple construction, robustness, low cost manufacturing and reliability. In this paper, single switch and double switch drive for a 6/4 switched reluctance motor has been simulated and analysed with the help of MATLAB/Simulink. SRM drives are controlled by synchronizing the energization of motor phases with the rotor position. These two switching methods are compared in terms of current, torque and speed.

Keywords: switched reluctance motor, single switch and double switch topology, MATLAB/Simulink

1. Introduction
Switched reluctance motor (SRM) is one of the oldest electric motor. Its concept is very old dating back to 1838 when a locomotive was propelled by this motor in Scotland [1]. In 1969, S.A. Nasar introduced the basic concepts of the modern switched reluctance machine [2]. A variation on the conventional reluctance machine has been developed and is called as the "switched reluctance machine (SRM)".
In the modern era of power electronic devices and computer aided electromagnetic design, the switched reluctance motor could realize its real potential. SRM"s are the electrically commutated machines. As the name "switched Reluctance" suggest, there are two features of the machine: (a), switched means the machine must be operated in continuous switching mode without which this machine can not rotate. This continuous switching made possible only because of availability of good semiconductor devices; (b), reluctance, it is basically a reluctance machine in which both stator and rotor have salient poles and hence variable reluctance magnetic circuit.
Switched reluctance motor works on the principle that a salient rotor tries to move to a position of minimum reluctance or maximum inductance to the flow of flux in magnetic circuit. Improved magnetic materials and advances in design of machine have brought the switched reluctance motor into variable speed drive market. The simple brushless construction of the motor makes it cheaper and reliable in operation. Because of brushless construction there is no restriction on speed in SRM motor. The unipolar current requirements of the phase windings results in a simple and reliable power converter circuit.
Switched reluctance motor obeys the law of physics. The torque in a reluctance motor is developed by the change in reluctance with respect to the rotor position.

2. Basic SRM drive system
A typical SRM drive system is shown below. It combines four basic components: power converter, control logic circuit, position sensor and the switched reluctance motor.

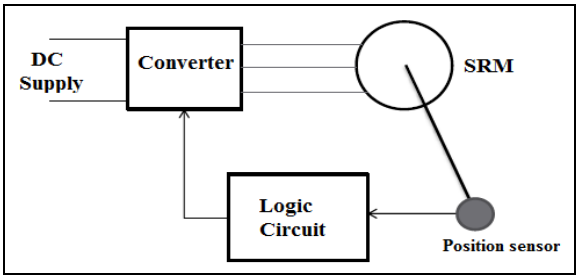

Fig 1: Basic block diagram for SRM drive

Unlike induction motors or DC motors, the reluctance motor cannot run directly from supply. Correct position of rotor pole with respect to stator pole must be known to logic circuit and according to that rotor position logic circuit generates pulses for converter circuit.
A typical 6/4 SRM is shown below in fig.2 whose inductance varies according to rotor position as shown in fig.3.

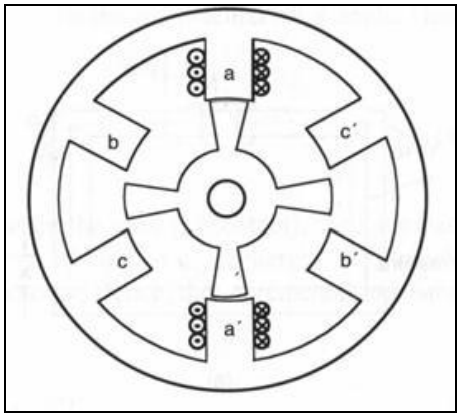

Fig 2: 6/4 switched reluctance motor

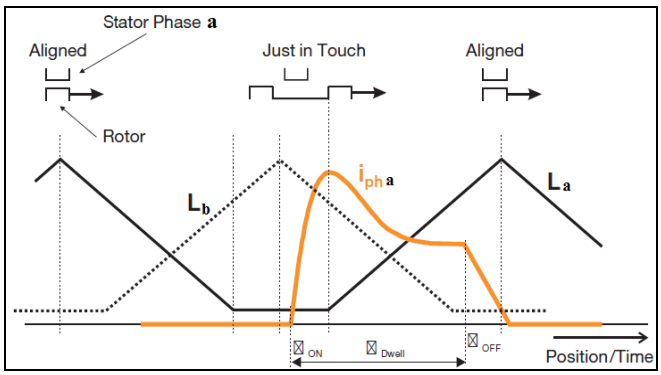

Fig 3: Phase inductance and current profile

Here 6/4 SRM is being discussed where 3 phases are coming out and for each phase there is one switching arrangement made in converter. Based on the minimum reluctance or maximum inductance position of rotor pole, switching is done for a particular phase winding.
Switching circuit is designed in various ways [3, 4] but in this paper we are mainly concerned with two types of topology.
1) Single switch topology 2) Double switch topology

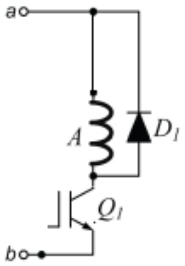

Fig 4: Single switch

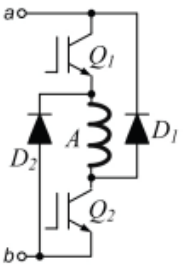

Fig 5: Double switch

In single switch topology, only one transistor is connected per phase for switch „on ‟ and „ off‟. But in case of double switch topology, two transistors per phase are connected for switching the circuit as shown in fig.4 and fig.5.
These two types of topologies are used while designing the converter in MATLAB/Simulink and comparative results are analysed in terms of current, torque, speed etc.

3. Simulink model for SRM drive

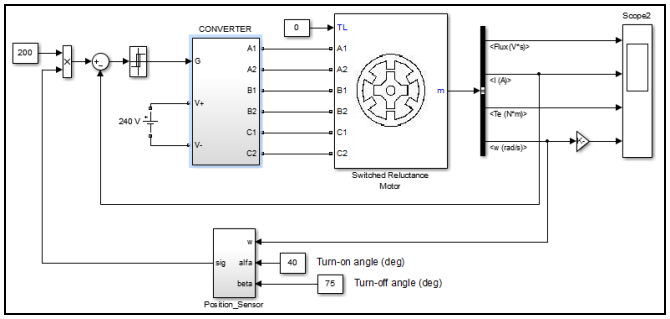

Fig 6: Complete SIMULINK model of SRM drive

The converter we have designed contains two types of switching circuit separately

1) Single switch per phase

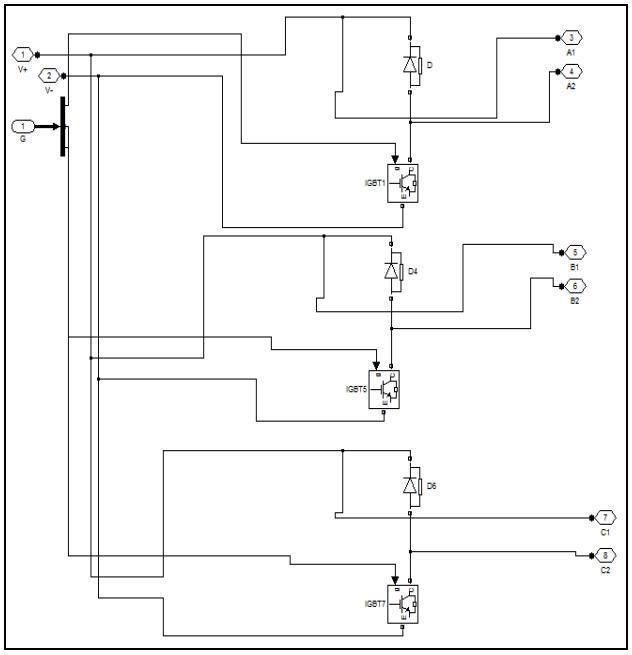

Fig 7: Single switch per phase circuit design

In this case winding is connected between port 3 and port

4. There is only one IGBT switch for one phase.
2) Double switch per phase

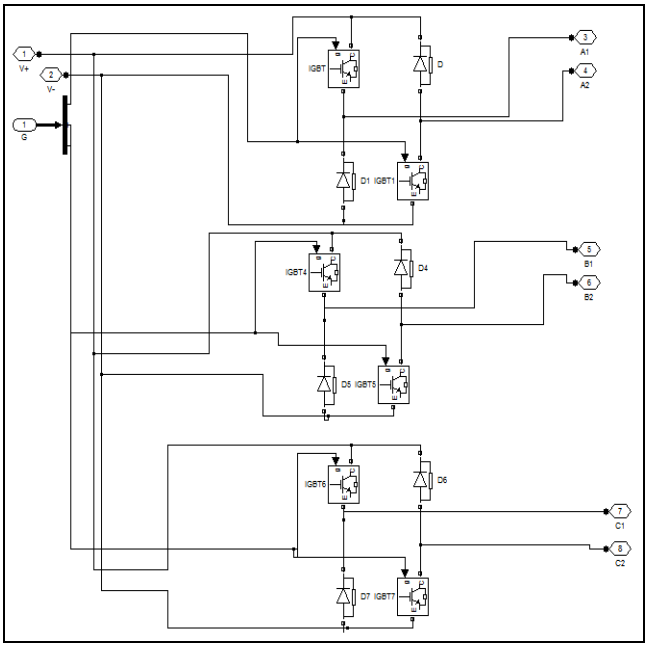

Fig 8: Double switch per phase circuit design

After designing these two types of circuits in MATLAB separately we analysed its results

4. Simulation results and discussion

The characteristic curves of the rotor flux, current, torque and rotor speed obtained by simulation of 6/4 SRM‟s model with

single switch topology given in fig.8 and fig.9.

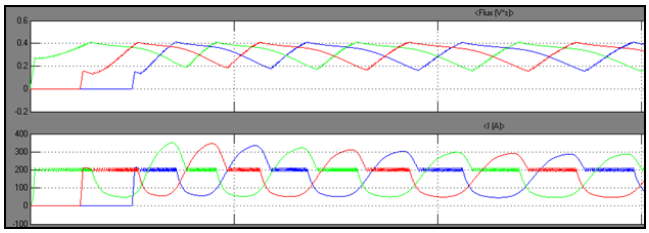

Fig 9: Flux and Current waveform for single switch topology

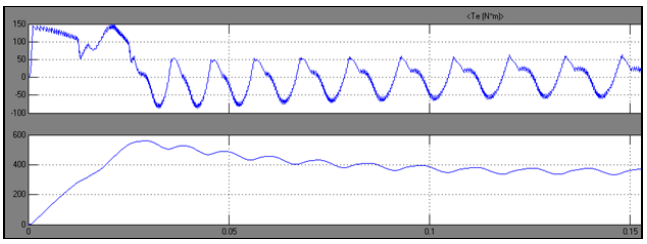

Fig 10: Torque and Speed waveform for single switch topology

And all the characteristics curves for same SRM‟s model for double switch topology is shown in fig.10 and fig.11.

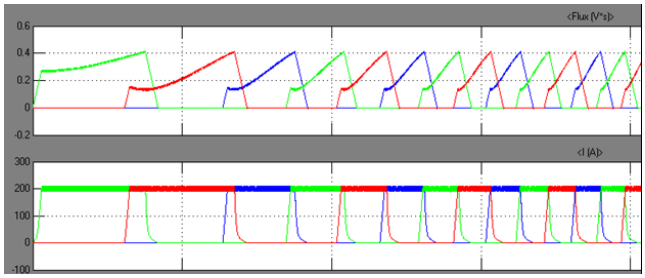

Fig 11: Flux and Current waveform for double switch topology

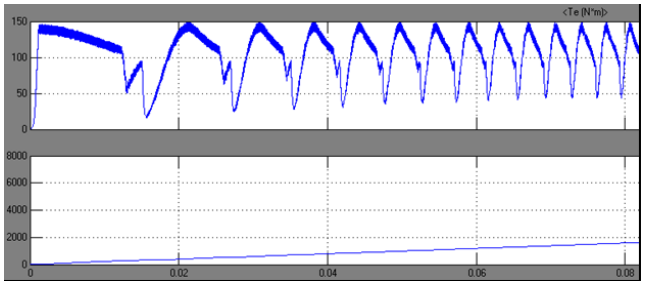

Fig 12: Torque and Speed waveform for double switch topology

We can analyse that in single switch per phase current at the time of starting as well as at steady state contains high peak value and ripples compared to double switch per phase circuit. This causes more torque ripples in single witch topology as compared with double switch topology. Because of high ripple in torque rotation of rotor is not smooth and there is vibration and noise in SRM operation.

5. Conclusion

Recently SRM is gaining importance because of its advantages compared to other motors. Low cost and maintenance free operation with windings only on stator makes SRM popular over other motor drives. Presence of torque ripples makes the system little disturbed. Torque ripples reduction is very important for SRM drive for smooth operation. This paper presents the comparative analysis of SRM drive with single switch and doubleswitch topology based on MATLAB/Simulation. Although only two types of converter is discussed here but there is a scope of other types of converter topologies to be designed for better resultslike H-bridge type converter which contains 4 switching devices for one phase.

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