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A Novel High Performance H-Bridge Converter Topology for 8/6 pole SRM Drive

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Abstract: *Despite of the fact that obviously less complex, the SRM drives are these days more expensive than their formal AC drive systems. This is, all things considered brought about by the absence of an optimal power electronic converter for SRM drives, which would be accessible as a single module. Various endeavors were hence made lately to create novel power electronic converter structures for SRM drives, in light of the usage of a Four-phased voltage source inverter (VSI), it is promptly accessible as a single module. This paper takes after this line of thought and presents a novel power switching device for SRM drive, which is totally focused around the use of standard inverter legs, have their own particular favorable circumstances and weakness. The determination of a converter, in the majority of the cases, relies on the application & consistency. To encourage the choice a relative comparative analysis is intended in this paper. An arrangement of SRM formal converter topologies with a definite evaluation of proposed topology fed four phased 8/6 SRM drive worked as open circuit & closed circuit controlling scheme is executed in Matlab/Simulink software package and the relating results are introduced.*

Keywords: *Switched Reluctance Motor Drives, Asymmetric Converter topology, Proposed H-Bridge Converter Topology.*

I. Introduction

Switched Reluctance Drives have been in the center of research exertion for more than two decades [1]-[3]. These principally vary as for the amount of phases utilized, stator/rotor poles number set-up's, and the concept of torque creation. In spite of the fact that the torque is constantly produced by the doubly-salient structure of the machine, its inception may be two-fold. Torque may be created entirely because of the variation of the winding self-inductance with rotor position (nothing but short pitched SRM's). On the other hand, mutual coupling between phases (i.e. position-dependence on variety of mutual inductances) could be utilized to enhance the torque density. Contingent upon the winding distribution, two types of SRM's may come about, fully pitched and partially pitched SRM's. In fully pitched SRM's there is an unimportant variety in phase self inductance toward oneself with rotor position and torque production comes about because of variety of the mutual inductance in between neighbouring phases. As far as this subdivision, this paper focuses on the short pitched SRM's.

Various power semiconductor topologies have been created throughout the years exclusively for utilization of conjunction with SRM Drives. On a basic level, the quest has been dependably for a converter with a minimized number of switches [4]. An excellent review of various power electronic converter designs for SRM drives is accessible in [5], while some exceptionally insightful comparisons of different commonly utilized topologies might be found in [6]-[8]. Be that as it may, regardless to all the advancements in the SRM drives area, switched reluctance machine have not yet found expansive acceptance.

The low cost feasible design of switched reluctance motor, with its features of fault tolerance and capability to withstand high temperatures makes its very imperative for the automotive application. One of the principle aspects of the research in switched reluctance motor drives has been the converter design [9]-[12]. The execution and the expense of the drive are exceedingly influenced by performance of the converters. The phase independence and unipolar current necessity have produced a wide variety of converter topologies for SRM drives. Numerous diverse topologies have risen with minimized number of active switched and faster commutation time through proceeded research. There has been dependably a trade-off between gaining some of the advantages and losing some with every new topology. The decision of converter for a certain application is an essential issue [13].

The switched reluctance motor is a pivoting electric machine where both, stator & rotor have remarkable poles. The stator comprises of simple concentric windings. There are neither windings or bar wires on the rotor. Stator windings on oppositely inverse poles are connected in arrangement structure to a single phase. At the point when the stator pole pair is energized by the phase winding, the closest rotor pole pair is attracted in around the position, where the attractive magnetic path has the minimum reluctance [14]. Accordingly, by energizing the consecutive stator phases in sequence, it is conceivable to develop a torque in either direction of rotation. The fundamental working principle of the SRM is truly simple; as current is passed through one of the stator windings, torque is created by the tendency of the rotor to adjust with the energized stator pole. The direction of torque generated is a capacity of the rotor position with concerning the energized phase, and is autonomous of the direction of current flow through the phase winding. Continuous torque might be delivered by intelligently synchronizing each phase's excitation with the rotor position. By changing the number of phases, the amount of stator poles, & the amount of rotor poles, numerous diverse SRM geometrics might be realized it out. Normally, expanding the number of SRM phases diminishes the torque ripples, however at the cost of requiring more electronics with which to operate the SRM. At least two phases are obliged to guarantee starting, and least four phases are obliged to insure the starting direction.

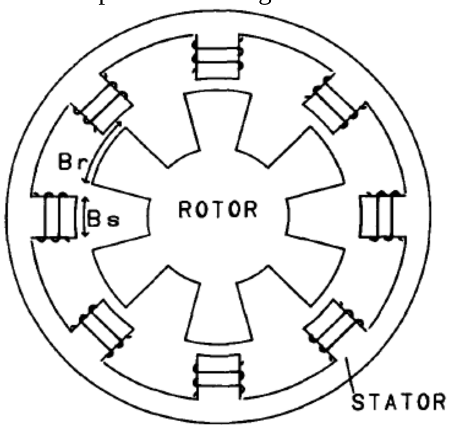


Fig.1 Basic Schematic Diagram of Four Phased 8/6 SRM

The number of rotor poles and stator poles should likewise contrast to insure starting. The accompanying Fig.1 shows the basic four phase 8/6 switched reluctance drive. It has been realized that the reluctance motors requires just unipolar currents and this offers ascent to the possibility of working with only one switching device arrangement for every phase, rather than two in series in each phase leg of an ac or BLDC drive system. The torque is directly proportional to the square of the current; henceforth the current could be unipolar to deliver unidirectional torque. Note that this is truly in spite of the case for ac machines. This unipolar currents necessity has a unique advantage in that one and only power switch is needed for control of current in a phase winding. Such a feature enormously minimizes the number of power switches in the converter and consequently makes the drive economical. A few inverter power circuits are suitable for switched reluctance motor devices are investigated and are contrasted and one another. The correlation is focused around power switches, free-wheeling diodes, size & peak appraisals of DC link components. Since converter decision depends upon motor design, converter design & analysis, determination is ruined for high speed applications [15]-[17]. This paper highlights the operation of proposed converter with minimized number of active devices & finally similarity analysis is carried out and dynamic assessment of formal asymmetrical converter & proposed H-bridge topology by using Matlab/Simulink platform.

II. CONVERTER TOPOLOGIES AND SPEED CONTROL OF SRM

The operation of SRM is very simple on account of its capacity to work efficiently from unidirectional winding currents, thus only one switch for every phase is sufficient yielding an extremely economical brushless drive, however in ac machine drives no less than two switches for every phase are needed. Moreover, phase winding arrangements with a switch in the SRM but the windings are not in arrangement with switches in ac drives that prompt irreparable damage in shoot through faults. This is valid for all SR converter circuits in light of the fact that there ids dependably a motor winding in series with switch with every main power switching device. Second, there is a more prominent level of independence between the phases than is conceivable in formal ac or BLDC rives [18]. A fault in one phase (whether in the motor or in the converter) normally effects that phase; other phases can keep on operating independently [19], [20].

A. Conventional Asymmetric Converter Topology

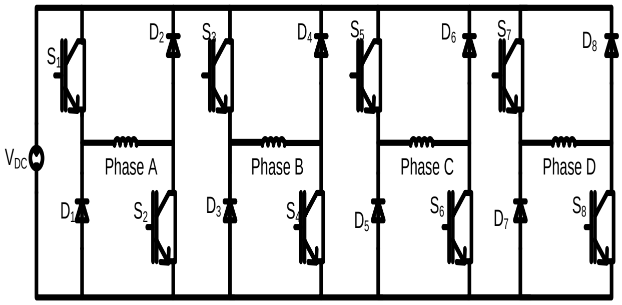


Fig.2 Asymmetrical bridge converter for four phased 8/6 pole SRM Drive system

When switches S1 & S2 are turned ON, the phase A is energized which is shown in Fig.3.

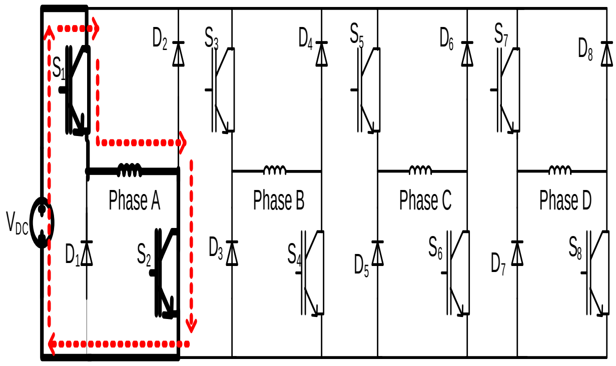


Fig 3. Current path when phase A is energized

When switches S1 & S2 are turned OFF, the diodes D1 & D2 are forward biased. In this case phase A is denergized, which is shown in Fig.4.

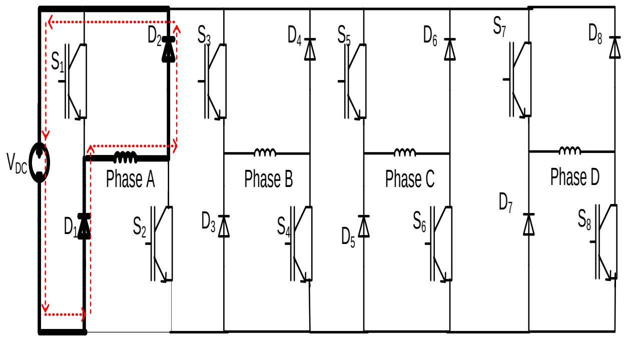


Fig 4. Current path when phase A is denergized

B. Proposed H-Bridge Converter Topology

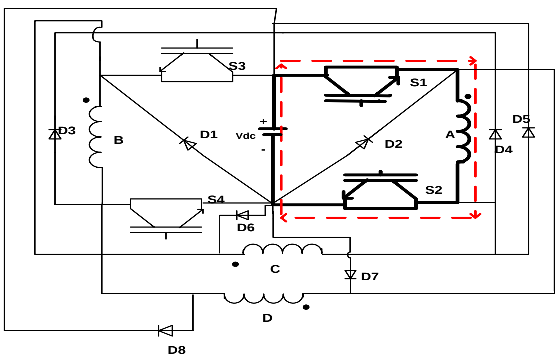


Fig.5 Proposed H-Bridge Converter Topology for Four Phased 8/6 SR Drive (Phase-A Energization)

Fig.5 shows the proposed H-bridge converter topology for 4-phase 8/6 SR drive (Ph-A Energization Mode) represents the inductor current path in phase-A excitation when the switches S1 & S2 will be conducted with respect to diode D2.

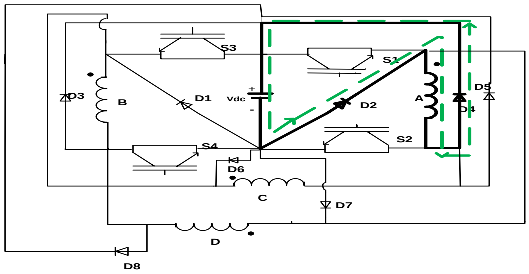


Fig.6 Proposed H-Bridge Converter Topology for a Four Phased 8/6 SR Drive (Ph-A Free-wheeling Path)

Fig.6 shows the proposed H-Bridge converter topology for Four phase 8/6 SR drive (Ph-A Freewheeling Path) represents the inductor current freewheeling path in phase-A, excitation when the switches S1 & S2 will be non-conducted with respect to diode D2 & D4 conducted and achieve the freewheeling action.

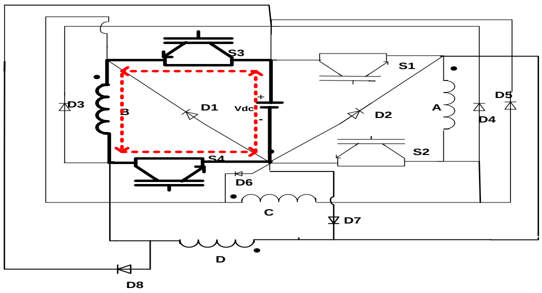


Fig.7 Proposed H-Bridge Converter Topology for Four Phased 8/6 SR Drive (Ph-B Energization)

Fig.7 shows the proposed H-Bridge Converter Topology for Four phased 8/6 SR Drive (Ph-B energization Mode) represents the inductor current path in phase-B excitation when the Switches S3 & S4 will be conducted with respect to Diode D1.

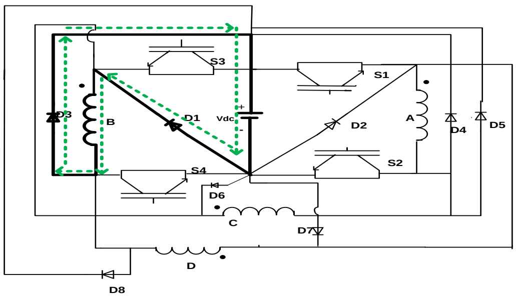


Fig.8 Proposed H-Bridge Converter Topology for Four Phased 8/6 SR Drive (Ph-B Freewheeling Path)

Fig.8 shows the proposed H-Bridge converter topology for four phase 8/6 drive (Ph-B Freewheeling path) represents the inductor current freewheeling path in ph-B excitation when the switches S3 & S4 will be non-conducted with respect to diode D1 & D3 conducted and achieve the freewheeling action.

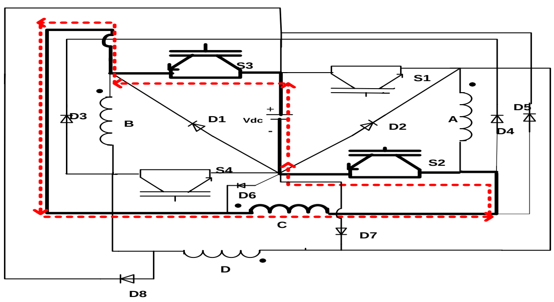


Fig.9 Proposed H-Bridge Converter Topology for Four Phased 8/6 SR Drive (Phase-C Energization)

Fig.9 shows the proposed H-Bridge converter topology for four phased 8/6 SR Drive (Ph-C Energization Mode) represents the inductor current path in phase C excitation when the switches S3 & S2 will be conducted.

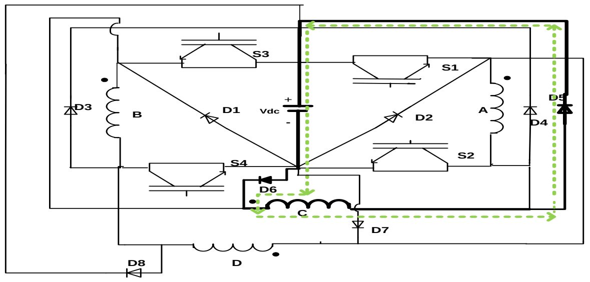


Fig.10 Proposed H-Bridge Converter topology for Four Phased 8/6 SR Drive (Phase-C Freewheeling Path)

Fig.10 shows the proposed H-Bridge converter topology for four phase 8/6 SR drive (Ph-C freewheeling path) represents the inductor current freewheeling path in ph-C excitation when the switches S3 & S2 will be conducted with Diode D5 & D6 conducted & achieved the freewheeling action.

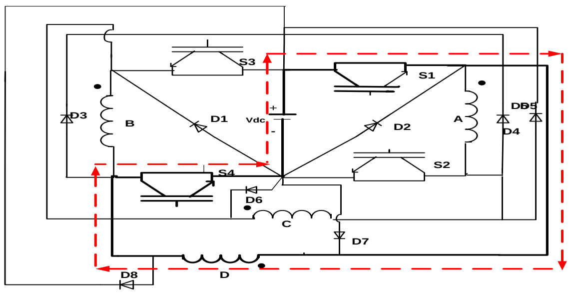


Fig.11 Proposed H-Bridge Converter Topology for Four-Phased 8/6 SR Drive (Ph-D Energization)

Fig.11 shows the proposed H-Bridge Converter Topology for Four phase 8/6 SR drive (Phase-D Energization Mode) represents the inductor current path in phase-D excitation when the switches S1 & S4 will be turns ON condition.

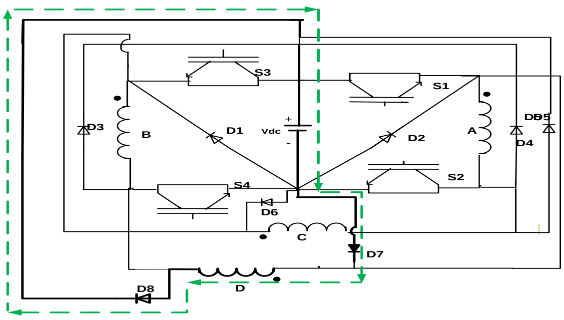


Fig.12 Proposed H-Bridge Converter Topology for Four Phased 8/6 SR Drive (Phase-D Freewheeling path)

Fig.12 shows the proposed H-Bridge converter topology for four phase 8/6 SR drive (Phase-D Freewheeling Path) represents the inductor current freewheeling path in phase D excitation when the switches S1 & S4 will be non-conducted with respect to diode D7 & D8 conducted and achieve the freewheeling action.

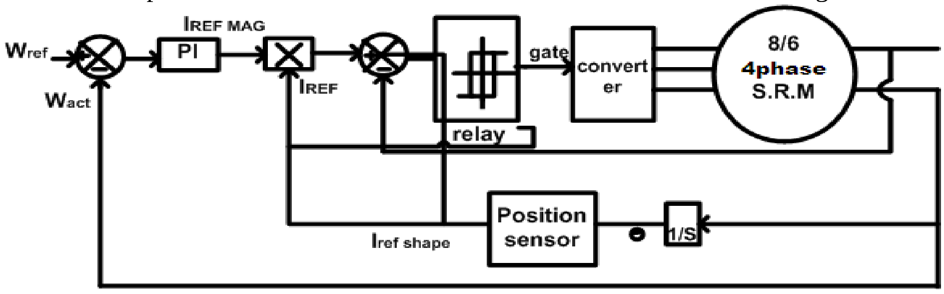


Fig. 13: Closed Loop Control of SRM Drive System

The above Fig.13 shows the closed loop control execution of SRM drive framework for getting quick transient response, the overall drive system is executed in closed manner. The actual speed of the motor is compared with the reference speed give the speed error. The speed error is connected to PI controller creates the reference current which produces the obligated gate pulses for driving the motor [20].

III. MATLAB/SIMULINK MODELLING AND SIMULATION RESULTS

Here simulation is carried out in different cases, in that

1). Conventional Asymmetrical Topology for Open Loop & Closed Loop Control of 8/6 SRM Drive. 2) Proposed H-Bridge Topology for Open Loop & Closed Loop Control of 8/6 SRM Drive.

Case 1: Conventional Asymmetrical Topology for Open Loop & Closed Loop Control of 8/6 SRM Drive

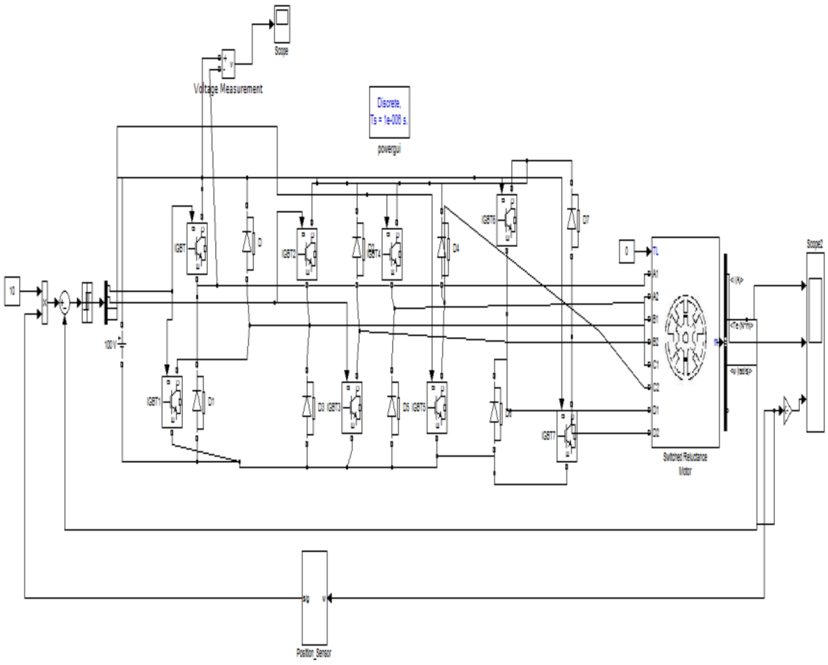
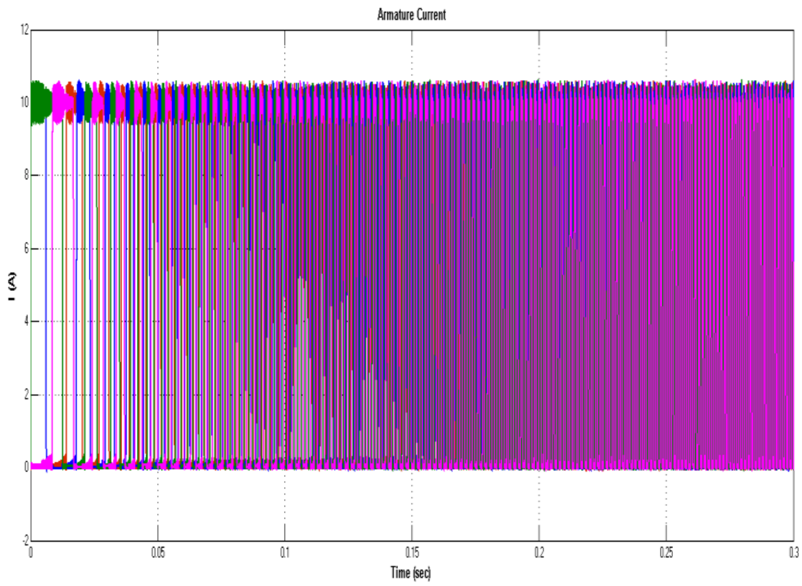
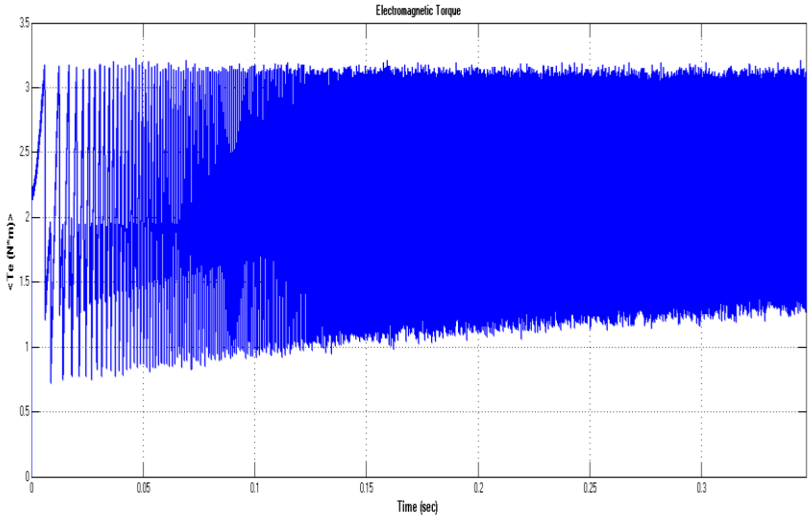


Fig.14 Matlab/Simulink Model of Conventional Open Loop Model of 8/6 SRM Drive Configuration

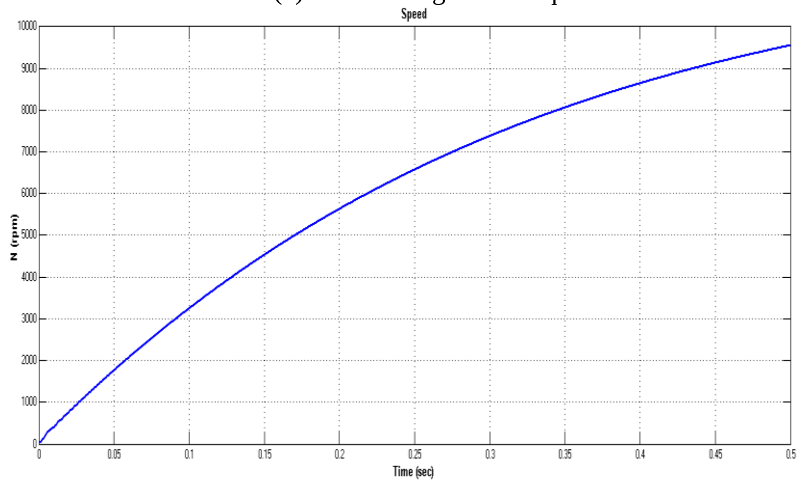
Fig.14 Matlab/Simulink Model of Conventional Open Loop Model of 8/6 SRM Drive Configuration using Matlab/Simulink Software Package.



(a) Current



(b) Electromagnetic Torque



(c) Speed

Fig.15 Current, Electromagnetic Torque, Speed of Conventional Open Loop Model of 8/6 SRM Drive Configuration.

Fig.15 shows the Current, Electromagnetic Torque, and Speed of Conventional Open Loop Model of 8/6 SRM Drive Configuration, due to open loop circuit somewhat delay to achieve steady state.

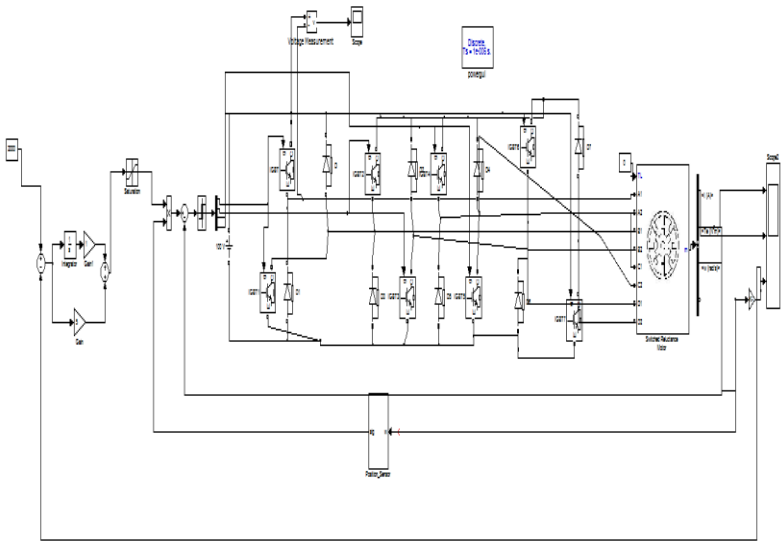
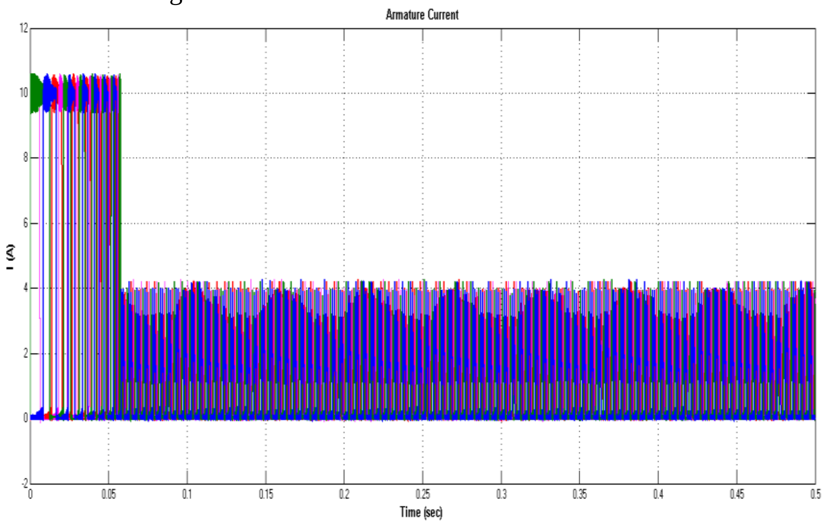
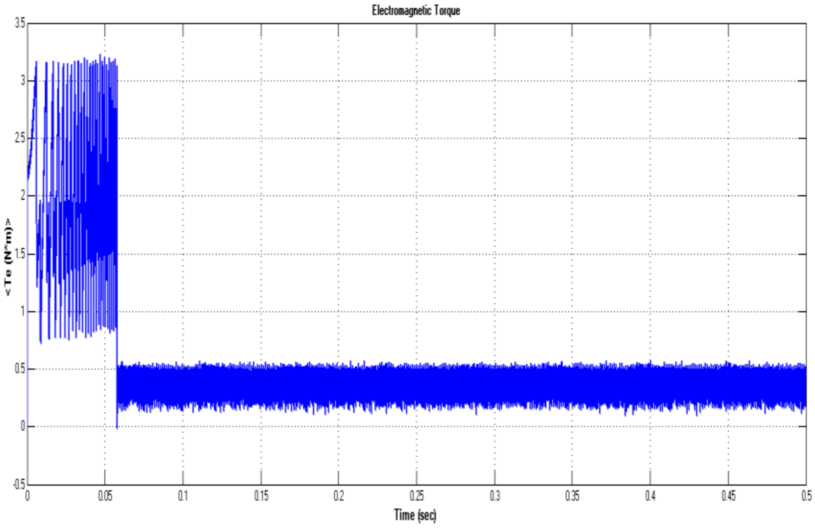


Fig.16 Matlab/Simulink Model of Conventional Closed Loop Model of 8/6 SRM Drive Configuration

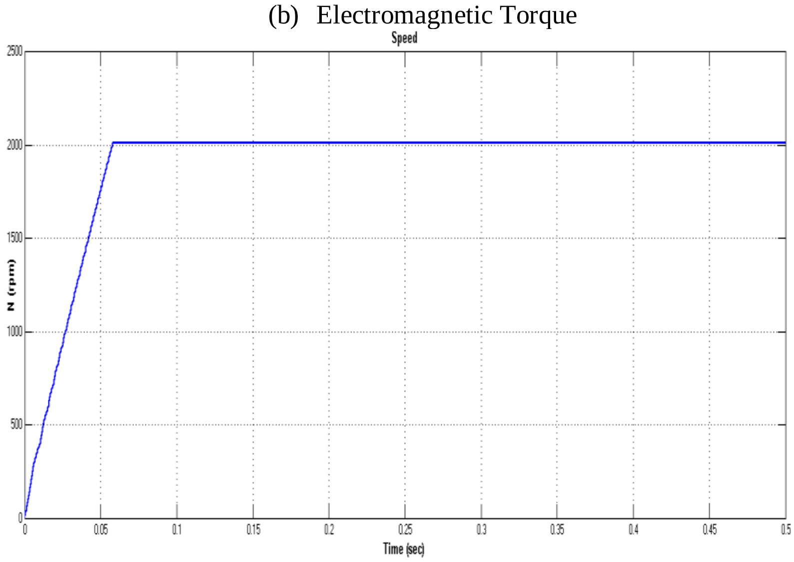
Fig.16 Matlab/Simulink Model of Conventional Closed Loop Model of 8/6 SRM Drive Configuration using Matlab/Simulink Software Package.



(a) Armature Current



(b) Electromagnetic Torque



(c) Speed

Fig.17 Current, Electromagnetic Torque, Speed of Conventional Closed Loop Model of 8/6 SRM Drive Configuration.

Fig.17 shows the Current, Electromagnetic Torque, and Speed of Conventional Closed Loop Model of 8/6 SRM Drive Configuration, due to closed loop circuit achieve fast response with low steady state error.

Case 2: Proposed H-Bridge Topology for Open Loop & Closed Loop Control of 8/6 SRM Drive.

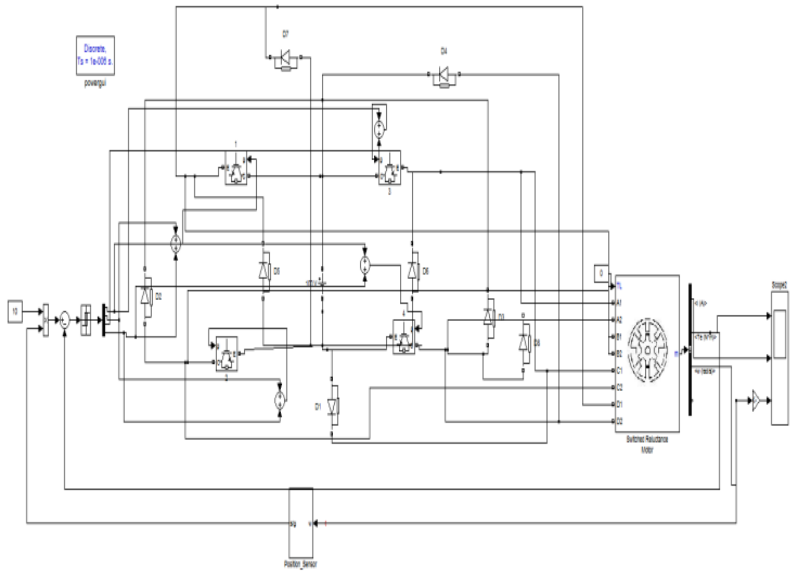
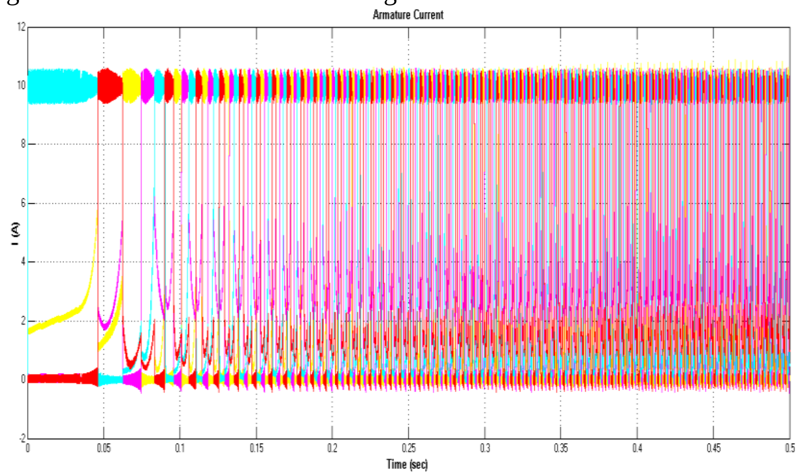
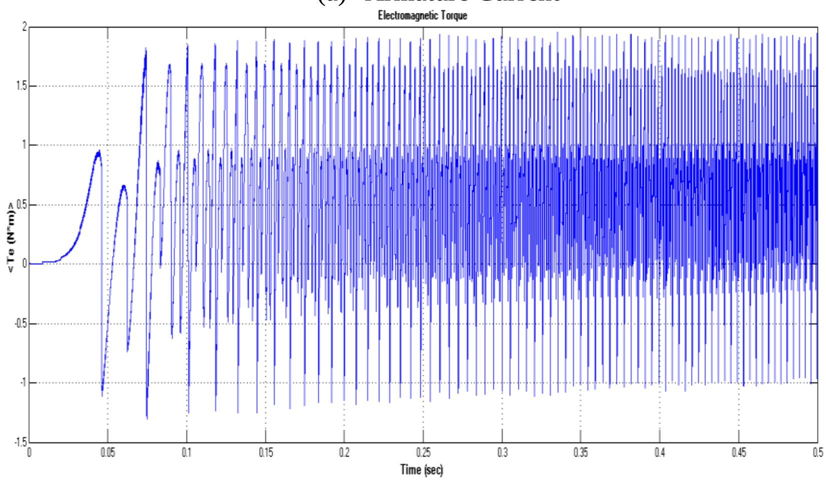


Fig.18 Matlab/Simulink Model of Proposed H-Bridge Topology based Open Loop Model of 8/6 SRM Drive Configuration

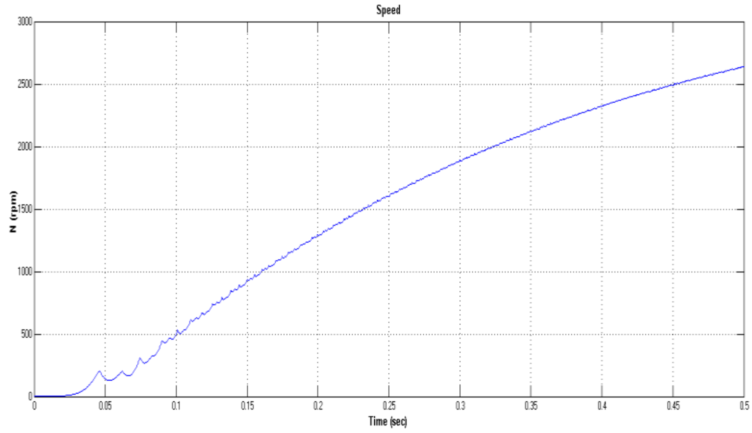
Fig.18 Matlab/Simulink Model of Proposed H-Bridge Topology based Open Loop Model of 8/6 SRM Drive Configuration using Matlab/Simulink Software Package.



(a) Armature Current



(b) Electromagnetic Torque



(c) Speed

Fig.19 Current, Electromagnetic Torque, Speed of Proposed H-Bridge Topology based Open Loop Model of 8/6 SRM Drive Configuration.

Fig.19 shows the Current, Electromagnetic Torque, and Speed of Proposed H-Bridge Topology based Open Loop Model of 8/6 SRM Drive Configuration, due to open loop circuit somewhat delay to achieve steady state.

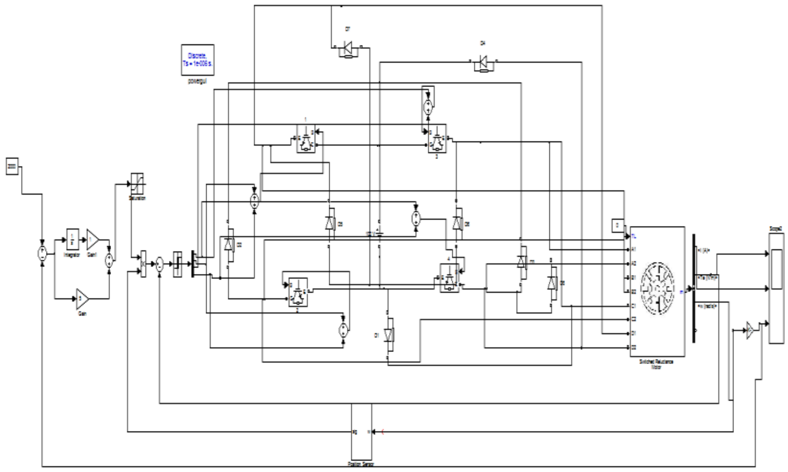
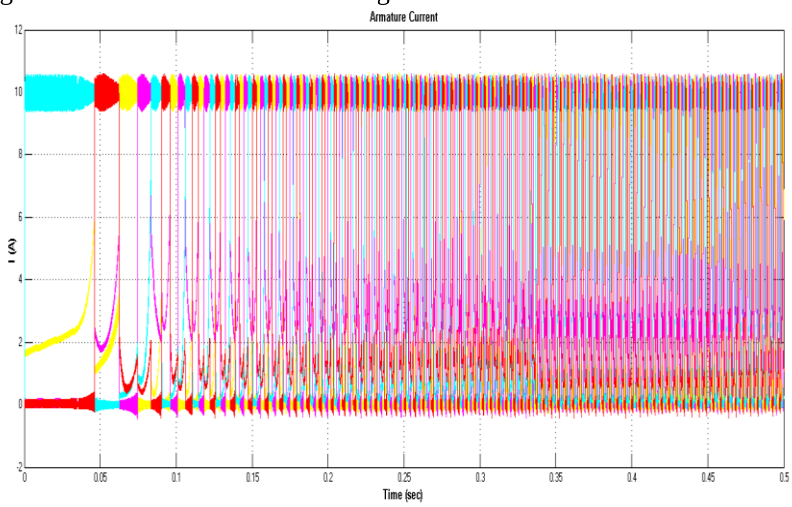
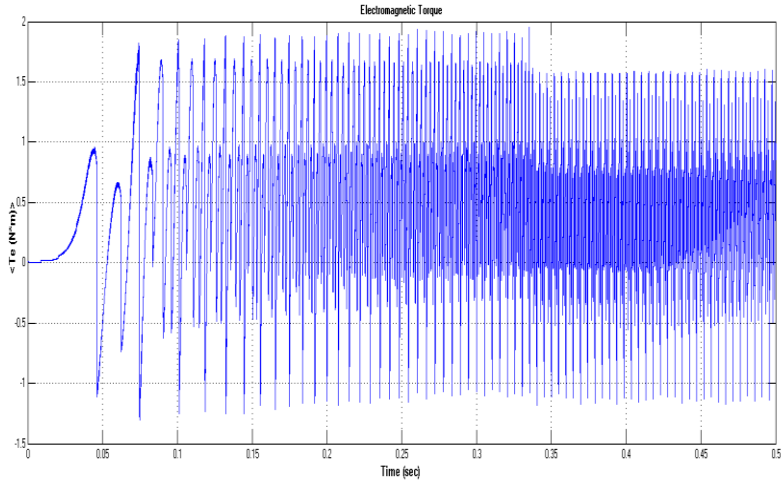


Fig.20 Matlab/Simulink Model of Proposed H-Bridge Topology based Closed Loop Model of 8/6 SRM Drive Configuration

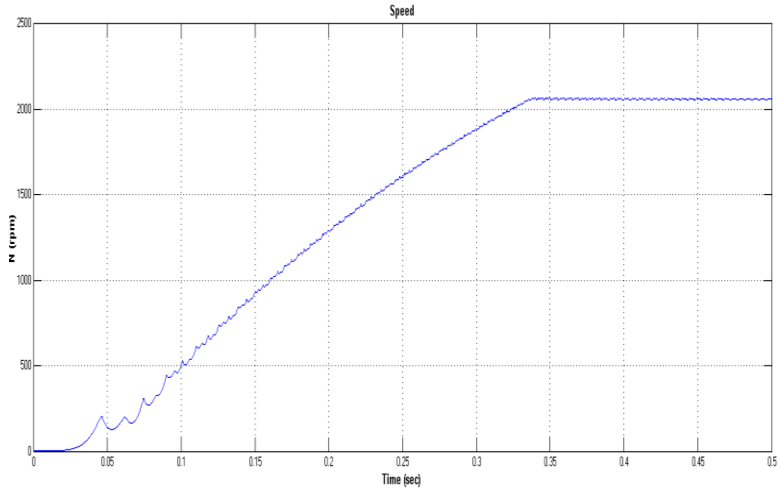
Fig.20 Matlab/Simulink Model of Proposed H-Bridge Topology based Closed Loop Model of 8/6 SRM Drive Configuration using Matlab/Simulink Software Package.



(a) Armature Current



(b) Electromagnetic Torque



(c) Speed

Fig.21 Current, Electromagnetic Torque, Speed of Proposed H-Bridge Topology based Closed Loop Model of 8/6 SRM Drive Configuration.

Fig.21 shows the Current, Electromagnetic Torque, and Speed of Proposed H-bridge Topology based Closed Loop Model of 8/6 SRM Drive Configuration, due to closed loop circuit achieve fast response with low steady state error.

Table I Comparison of Various Converter Topologies to drive Switched Reluctance Motor

S. No	Type of the Converter	Switching Devices	Active Diodes
01	Conventional Asymmetrical Converter Topology	08 Switches	08 Diodes
02	Proposed H-Bridge Topology	06 Switches	06 Diodes

Table I represents the number of switching devices & diodes required to drive the switched reluctance motor with comparison of conventional topology as well as proposed H-bridge topology requires low switches & low diodes which makes system to be required low space, low cost, low complex to design, low switching loss and high efficiency.

IV. CONCLUSION

Switched Reluctance Motor has gained momentum in the exceptionally aggressive market of adjustable speed motor drives. Basic structure and low cost are the most imperative reasons behind this frame. Despite the fact that various converters have developed through the years for SRM drives. All converters have their own disadvantages & some drawbacks. Among the disadvantages are various switching devices & diodes, high voltage ratings, necessities of auxiliary windings, low effectiveness and complicated control schemes. From the formal converter to proposed H-bridge topology has better features, reduction of active switching device, low complexity, low cost, respectively as well as voltage drops for every phase have been accomplished at the expense of the complication in the control. This paper intends the open loop & closed loop control of four phased 8/6 pole switched reluctance motor (SRM) drive. Finally a novel closed loop controller for 8/6 SRM drive is implemented in Matlab/Simulink Platform, as well as presented the results and used in many industrial applications.

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