

PERFORMANCE ANALYSIS OF A NEW CONVERTER FOR SWITCHED RELUCTANCE MOTOR DRIVE WITH COMPONENT SHARING

T.Chandrasekaran, Mr. M. Muthu Vinayagam

Department of EEE
CMS College of Engineering, Namakkal
kavinnisha@gmail.com

ABSTRACT

Switched reluctance motor (SRM) has become an important alternative in variable speed drive applications. the possibility of high motor speeds, high torque-to-inertia ratio. In this paper the asymmetric bridge converter and half bridge converter topologies has been done on the basis of Phase current waveform, Fourier analysis and total harmonic distortion. The simulation of various converter topologies of switched reluctance motor drive has been done using MATLAB. The number of switches distortion and torque ripples were high in the above converters. Hence a new and cost effective converter, for switched reluctance motor drives is proposed. . The requirements of switched reluctance motor drives on converters and the operation of the component sharing converter are analyzed using Matlab/Simulink. Furthermore, the simulation results confirm the feasibility of the proposed converter, that is fall rate of the current can be reduced.

Keywords— SRM(Switched Reluctance Motor), THD(Total Harmonics Distortion), RPS(Rotor Position Sensor),HES(Hall Effect Sensor), HCC(Hysteresis Current Controller).

I. INTRODUCTION

The switched reluctance motors (SRMs) have a simple and robust structure with low inertia and direct drive capability, thus SRM drives are applicable to many industrial fields. [1] a new and cost effective converter, consisting of “half-bridge” IGBT modules and SCRs, for switched reluctance motor drives is proposed. The new method allows the sharing of the IGBT bridge to the switched reluctance motors winding, thus it significantly reduce by half of the component cost. [3], Switched reluctance motor requires a converter circuit to control the unipolar phase current in its phase windings. A converter circuit for four-phase reluctance motor, using only four switches, is described. Unlike previous circuits with one switch per phase the switches are rated at the motor voltage. Each switch is connected to two of the four-phase windings. The switching signals must be carefully derived so that independent control of the phase currents is maintained despite the common connections. Analysis is given to predict the ideal switching algorithm for the converter circuit. [4] The paper described two new inverter circuits, which were not published before, and gave a detailed design procedure for the five circuits that were considered. Of these five, only two circuits were found suitable

for industrial SRM drives supplied from 380 or 460 V ac lines. The remaining three circuits all use dual-rail topology and thus require that the inverter-active devices have a rating at least twice the motor supply voltage. Consequently, the dual-rail inverters may find applications in low-power low-voltage drives but are not suitable for industrial drives. [5] This paper describes the main considerations in the design of a single-switch-per-phase converter for a switched reluctance motor (SRM) drive with particular attention to the choice of converter topology, the type of switching devices, the normalized rating of the power devices, and input filter design. The converter uses MOSFET switches. Experimental verification is included with a 6/4 pole personal computer-controlled prototype SRM drive.

II.SRM DRIVES AND REQUIREMENT TO OPERATION CONVERTER

A controlled switch to connect the voltage source to the coil windings in order to build up the current, when the switch is turned off there should be an alternative path for the current to flow, since the trapped energy in the phase winding can be used for the other strokes. In addition to this, it protects the switch from the high current produced by the energy trapped in the phase winding. SRM has become an

important alternative in various applications both within the industrial and domestic markets, namely as a motor showing good mechanical reliability, high torque-volume ratio and high efficiency, plus low cost. As a generator SRM find its application in the aeronautical industries and in integrated applications primarily as wind generator in wind based energy generating system. In this paper the various topologies asymmetric bridge Converter with respect to voltage rating, number of switches per phase, THD and applications are compared. The phase current response with respect to time and frequency are also compared. Among these converters, it's observed that the asymmetric bridge converter is the most popular and best performed one. In this paper a new and cost effective converter topology, which is the modified asymmetric bridge topology, is developed.

With the advances in power electronics and high-tech control techniques, as well as the development of high speed microcontrollers with powerful computation capability, switched reluctance motor (SRM) drives are under consideration in various applications requiring high performance, such as servomotor drives, electric vehicle propulsion, jet engine starter-generators, etc. SRMs feature numerous merits like simple and rugged structure, being maintenance free, high torque-inertia ratio, fault-tolerance robustness and reliability, high efficiency over a wide range of speeds, the capability to run in abominable circumstances.

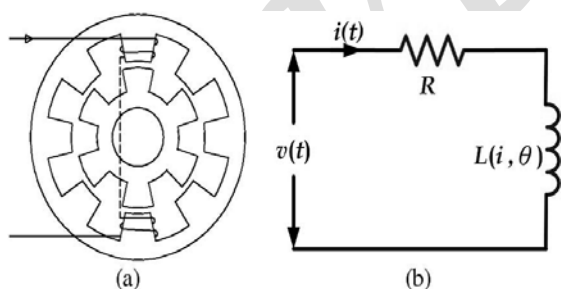


Fig. 1 (a) Cross-sectional Profile (b) Equivalent Circuit of an 8/6-Pole SRM.

III. PROPOSED CONVERTER

THD correction techniques include both passive and active solutions for eliminating harmonic distortion and improving power factor. The passive approach uses inductors, transformers, capacitors and other passive components to reduce harmonics and phase shift. The passive approach is heavier and less compact than the active approach, which is finding greater favor due to new technical developments in circuitry, superior performance, and reduced component costs. Traditional passive PFC solutions

used at the system level – where multiple subsystems or nonlinear loads are involved have proven themselves unfeasible economically as well as architecturally. Specially corrected transformers are effective only for certain harmonic frequencies and most passive filters, once installed and tuned, are difficult to upgrade and may generate harmful system resonance. As for active, they must be applied to each individual power supply or load in the system, which complicates architecture and results in high system cost. Harmonics: A sinusoidal component of a periodic wave or quantity having a frequency that is an integral multiple of the fundamental frequency. Distortion: Any corruption of the 50-hertz sinusoidal voltage or current waveform. Total harmonic distortion factor (THD) can apply to a voltage, current, or power waveform. It is the square root of the sum of the squares (rss) of the root-mean-square (rms) values of non-fundamental harmonics, divided by the rms value of the fundamental.

3.2. BLOCK DIAGRAM

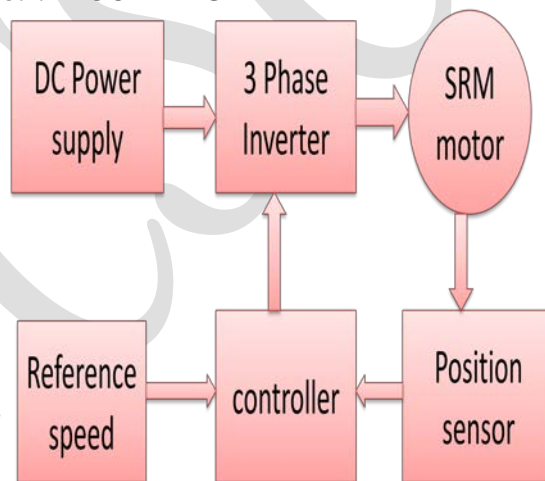


Fig. 2 Block Diagram of SRM Drive

The structure of an 8/6 switched reluctance motor. There are no windings or magnets on the rotor, thus SRM is a doubly salient and singly excited motor. The operation of an SRM drive is according to the minimum reluctance principle, which means that the rotor tries to align its poles with the position with minimum reluctance for the magnetic circuit. A position sensor is required to synchronize the stator conduction sequence by determining the rotor position. Also, the torque of an SRM drive is related to the rotor position and the inductance or flux linkage.

3.3 PROPOSED CONVERTER CIRCUIT

The component sharing converter needs four IGBT modules and eight diodes. Instead of to eight IGBT modules and eight diodes in asymmetric bridge converters. On the other hand, each phase is controlled by different switching devices. It is

helpful to reduce the temperature rise and extend the lifetime of IGBT components.

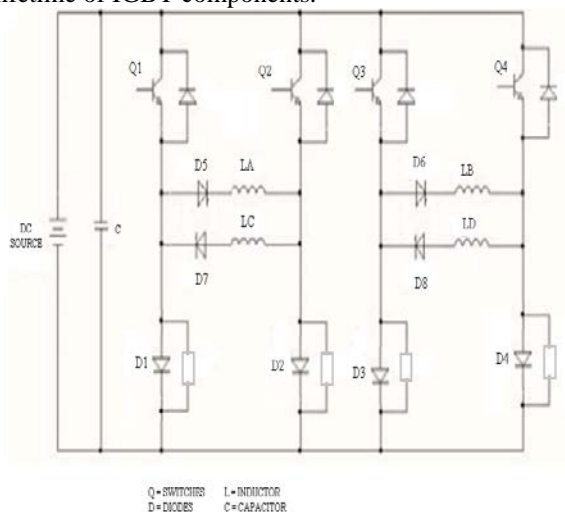


Fig. 3 Circuit Diagram of SRM Drive

IV. OPERATION OF PROPOSED SRM CONVERTER TOPOLOGY

A New Converter Topology for operation of each phase includes three modes, which are named as charging, freewheeling and discharging, respectively. For the sake of simplicity of the illustration, the operation of two phases in a group is analyzed in the following discussion the operations of phase A and Phase C in a group, respectively. The typical gate signals and corresponding current profile average rate at which the circuit develops output pulses and is determined by the frequency of the triangular waveform. performance analysis of a new converter for switched reluctance motor drive

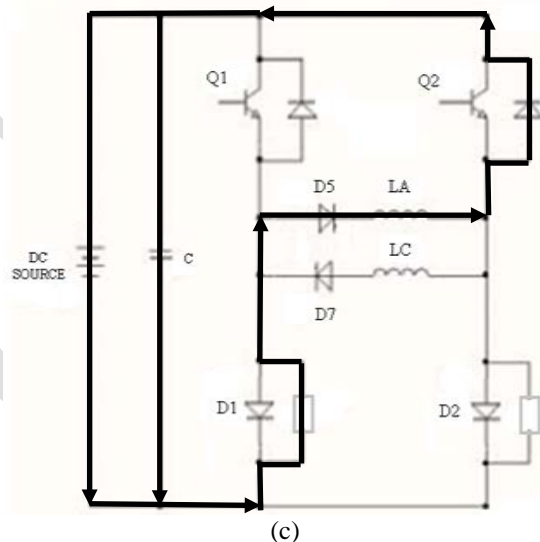
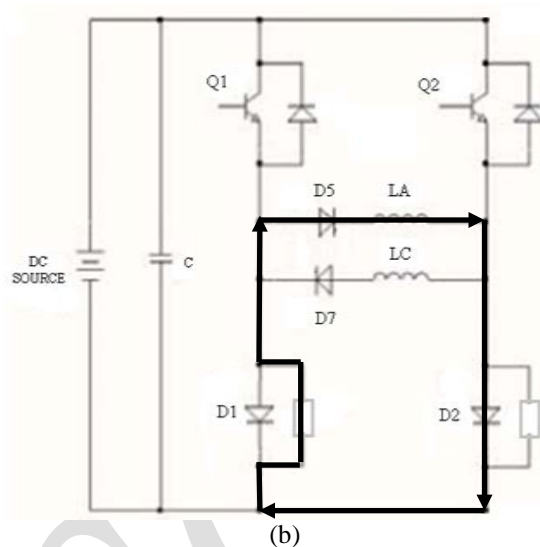
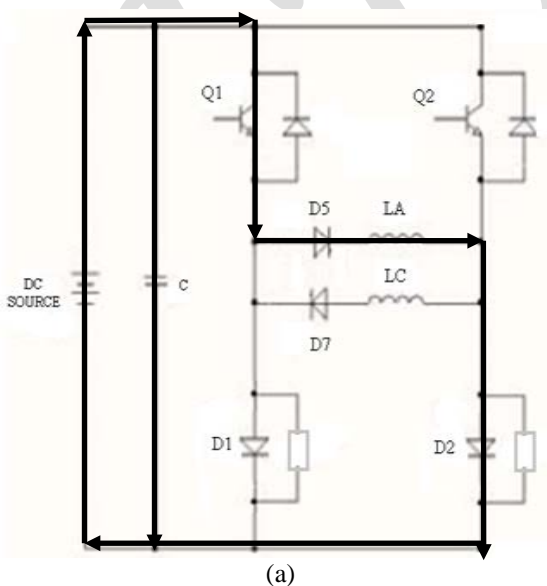
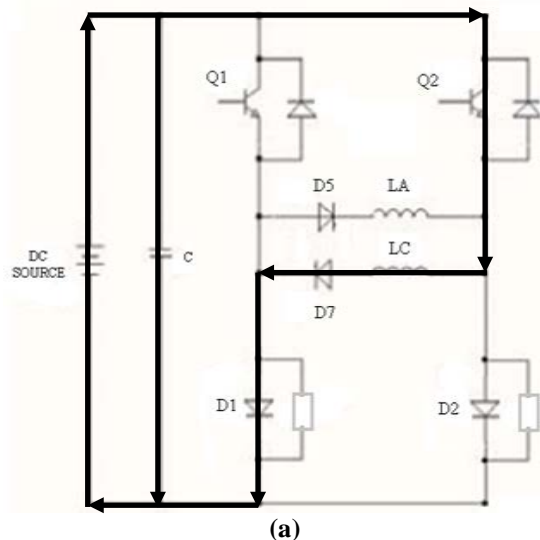


Fig.4. Mode of Operation A Phase



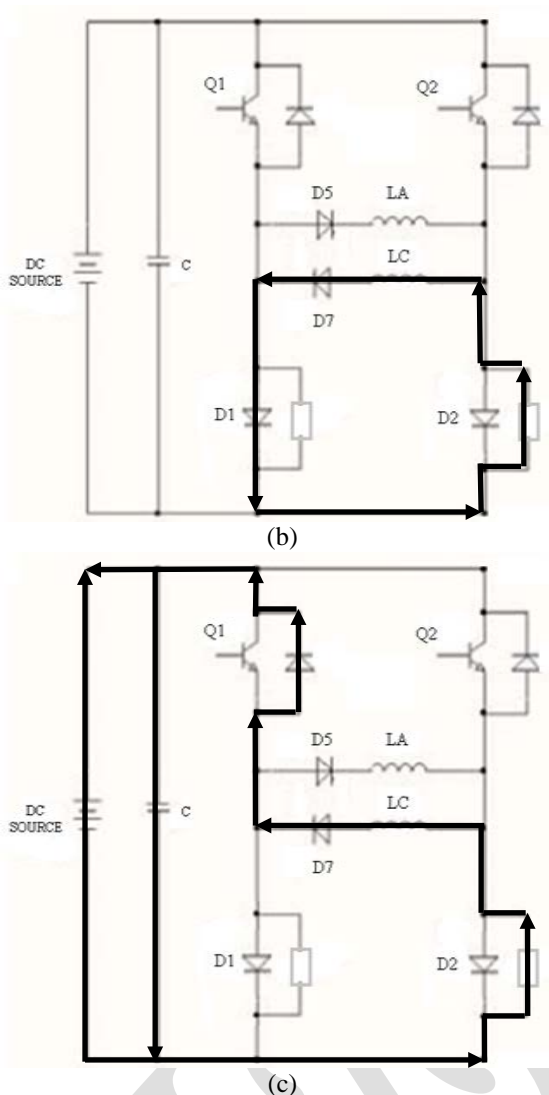


Fig.5 Modes of Operation of Phase C

Mode 1: Charging

Referring to Fig 4a, if the switching devices Q1, D2, and D5 are turned on, the DC link voltage is then applied to Phase A and the current rises rapidly in the phase winding. In the same way, seeing Fig 5a, if the switching devices Q2, D3, and D1 are switched on, Phase C is charged through the switches D1, Q2 and D7.

Mode 2: Freewheeling

It can be seen from Fig 4 b, if the switch Q1 is turned off and the switches D2 and D5 are still on, then current circulates through the switches D2, D5 and forward-biased diode D2. In this mode, there is no energy transfer between phase winding and DC source. Similarly, referring to Fig 5b, Phase C freewheels through switches D1 and D7 and the diode D4 when the switch Q3 is turned off and the switches D4 and D7 are still on.

Mode 3: Discharging

As is shown in Fig 4c, the switches Q1 and D2 are turned off and the switch D5 is still turned on in this mode. Consequently, Phase A discharges to the DC link capacitor, through D2, D3 and Q5. In the same way, from Fig 5c, Phase C discharges to the DC link capacitor through the switch Q6 and the diodes Q2 and D4 if the switches Q2 and D1 are switched off and the switch D7 is still on.

In this active filter application, the higher the relative switching frequency, the more fidelity to the reference signal is obtained. However, there are two factors that impose limit to the switching frequency of SPWM. They are switching frequency capability of the IGBT, and the increase in switching losses, which is proportional to high switching frequency. The switching losses will reduce the circuit efficiency. Hence, there must be a compromise between fidelity and efficiency.

V. COMPONENT SHARING CONVERTER

In order to verify the proposed converter for SRM drives, the simulation based on . To use the same basic parts used in Different manufacture Even in models from different manufacture is called component sharing, the gate signals of Phase A and C are illustrated, and the corresponding current profiles of Phase A and C are depicted in, respectively. As for Phase A, for example, the phase current rises rapidly when the switches Q1, D2 and D5 are turned on firstly. Then, the switch Q1 is turned on or off during the hysteresis current control. The Diode D5 shares the gate signal with the switch D2 and both switches are always turned on during the hysteresis current control to provide the path for freewheeling. Finally, the switches Q1 and D4 are switched off when the conduction angle reaches the specified value. The energy stored in Phase A discharges to the DC link capacitor through the switch D5 and the diodes Q2 and D3, and the phase current declines to zero fast. The measured phase current waveform can be observed that the simulation, measured and theoretical current waveforms demonstrates that the proposed converter for SRM drives can be used to implement the hysteresis current control. In the same way, the single-pulse voltage control and the PWM voltage control are also accomplished in the proposed converter.

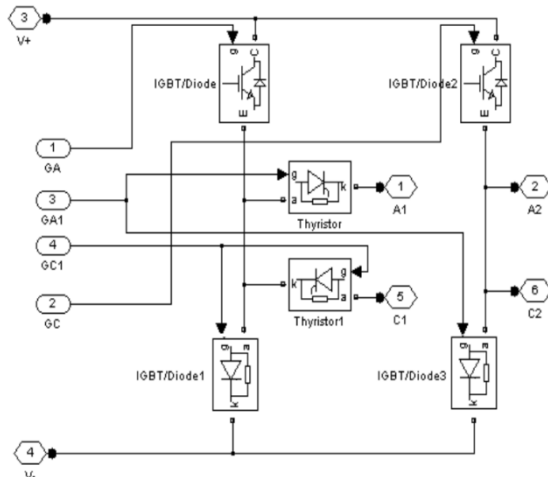


Fig. 6 Component sharing converter

The energy stored in Phase A discharges to the DC link capacitor through the switch D5 and the diodes D2 and Q3, and the phase current declines to zero fast. The measured phase current waveform It can be observed that the simulation, measured and theoretical current waveforms demonstrates that the proposed converter for SRM drives can be used to implement the hysteresis current control. In the same way, the single-pulse voltage control and the PWM voltage control are also accomplished in the proposed converter.

VI. PROPOSED SIMULATION CIRCUIT

In this circuit, a DC supply voltage of 240 V is used. The converter turn-on and turn-off angles are kept constant at 45 deg and 75 deg, respectively, over the speed ranges. The reference current is 200 A and the hysteresis band is chosen as ± 10 A. The SRM is started by applying the step reference to the regulator input. The acceleration rate depends on the load characteristics. To shorten the starting time, a very light load was chosen. Since only the currents are controlled, the motor speed will increase according to the mechanical dynamics of the system. The SRM drive waveforms (phase voltages, magnetic flux, windings currents, motor torque, motor speed) are displayed on the scope. As can be noted, the SRM torque has a very high torque ripple component which is due to the transitions of the currents from one phase to the following one. This torque ripple is a particular characteristic of the SRM and it depends mainly on the converter's turn-on and turn-off angles. In observing the drive's waveforms, we can remark that the SRM operation speed range can be divided into two regions according to the converter operating mode: current-controlled and voltage-fed.

Fig. 7 Simulation of proposed Circuit(SRM)

VII. SIMULATION OUTPUT Output of Existing System

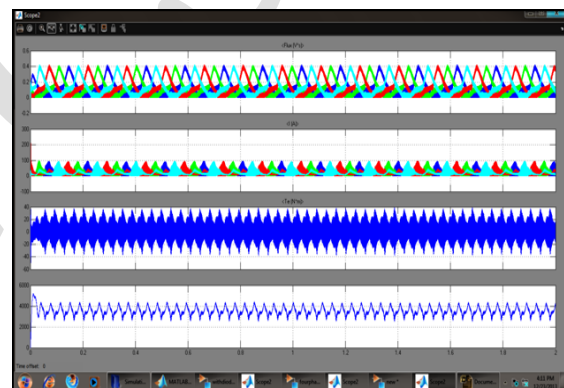
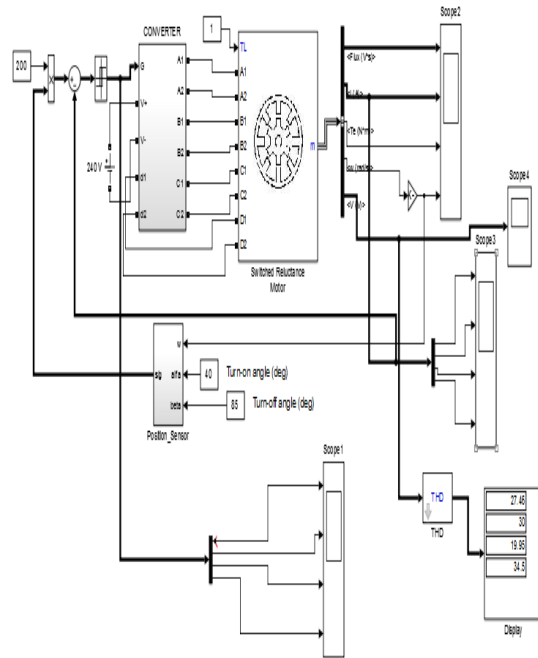


Fig. 8 Asymmetric Converter Waveforms

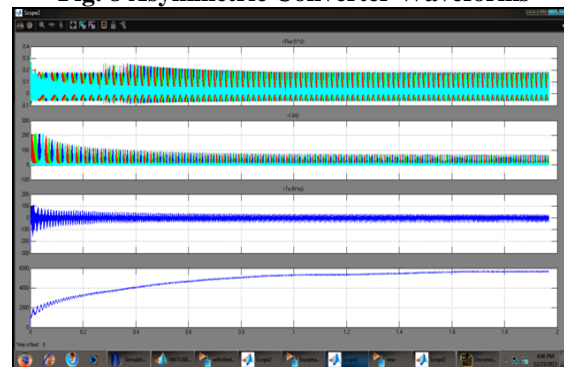


Fig.9 Half Bridge switch Converter Waveforms

The **flux** linkage of SRM based on the asymmetric converter, where the variations of flux

linkage in the stator winding is plotted with respect to time. In the graph shown, there is no initial delay and output is stable the drawbacks on conventional system has been solved. The stator **current** of switched reluctance motor drive. It shows a maximum value of 200A for a short interval of time. The graph shows a high starting current and will attain steady value.

The developed **torque** characteristics depend on the flux linkages and the position of rotor as a function of time. It shows a maximum torque of 100N-m initially and decreased to attain the stable position. The initial distortions present as in the conventional system has been solved. The rotor **speed** of the SRM drive observed that the speed varies initially but becomes constant after a certain point. The maximum speed obtained is approximately 5000rad/s.

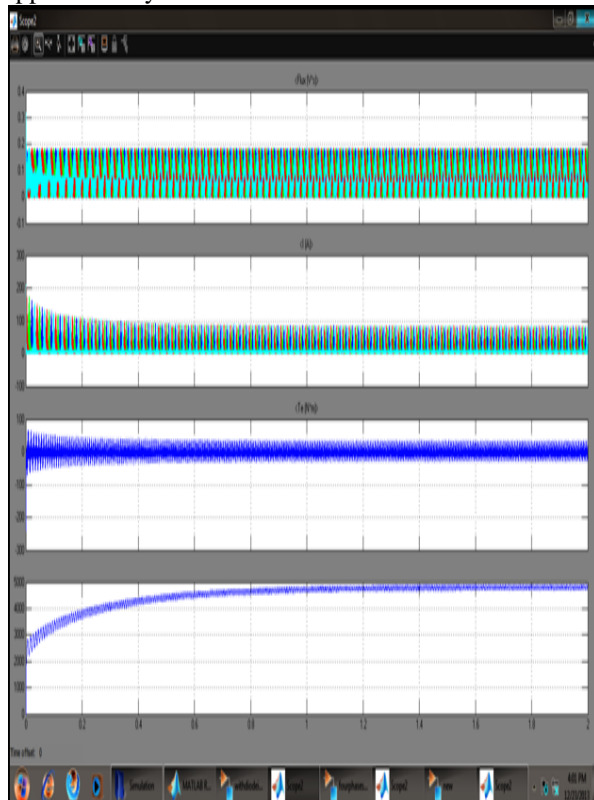


Fig. 10 simulation output of Proposed System

VIII. COMPARATIVE ANALYSIS OF CONVERTERS AND THD VALUES

Harmonics are sinusoidal voltages or current having frequency that are integer multiples of the fundamental frequency. Non-linear load draws harmonic currents, there for the system may get distorted. The dynamic behaviour of industrial loads such as rolling mills, arc furnaces, traction loads and large fluctuating single-phase loads draw wildly fluctuating amounts of reactive power from the

supply systems. These loads cause unbalance on the system and leads to wide fluctuations in the supply voltage and effects like incandescent light flicker and computer equipments etc. The THD analysis of the existing system and proposed are shown in table no 8.,

Table No. 5.1 Comparison of THD Values (10:1)

Systems	THD		
	Phase A	Phase B	Phase C
Existing system			
Half bridge converter (Switch)	11.90	15.41	13.32
Asymmetric converter	6.17	11.7	4.24
Proposed System			
Half bridge converter (Diodes)	2.7	3.0	1.91

IX. CONCLUSION

In this particular system a new and cost effective converter topology for switched reluctance motor drives has been proposed. Compared to the conventional asymmetric bridge converter, the proposed one using half-bridge diode modules is more compact and has higher utilization of power and lower cost, without degrading in performance. The new converter has three conventional operating modes that are charging, freewheeling and discharging modes. Hence, the single pulse voltage control, the hysteresis current control and the PWM voltage control are implemented in the developed converter.

The simulation in Matlab/Simulink has demonstrated the proposed converter. As a result, this study provides the valuable converter for SRM drives in industrial applications. The proposed new method arrangement allows the reduction in circuit components by nearly half and mainly the main performance of the motor drive. The method can be applied for all the even number of phases of the switched reluctance motor drive. And also the THD is reduced.

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