Single Controllable Switch Based Switched Reluctance motor drive for Low cost and variable speed applications using IGBT

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***Abstract*- The switched reluctance motor is requiring only a single controllable switch. So number of switches are reduced for the purpose of low cost and variable speed applications. In this drive, proposed converter overcomes the drawback of the original single switch based four quadrant motor drive in terms of recovery energy circulation. The drive system is realized using an asymmetric two phase switched reluctance motor, proposed converter, and controller. This paper presents operation principle, simulation, and design considerations of the converter. Simulation results are based on a non linear model of the motor drive system. The experimental results correlate well with a simulation and demonstrate a performance. This new drive system occupies lowest cost structure, packaging compactness, self starting feature, variable speed operation and four quadrant capability**.

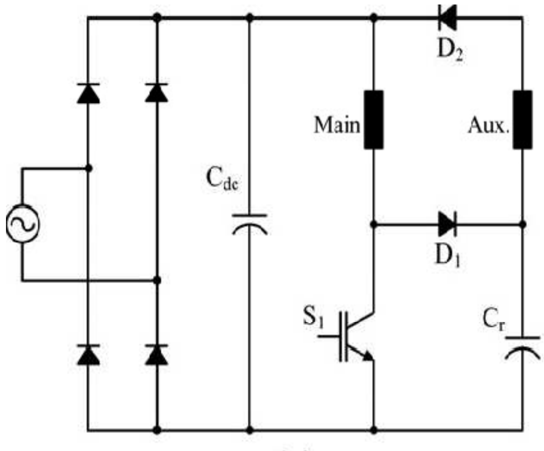
Components*: switched reluctance motor, IGBT switches, micro controller, MOSFET, Hall sensor*

I. INTRODUCTION

Growing energy and environmental concerns have increased demand for variable speed drives in low cost, low performance, high volume application such as fans, hand tools and home appliances. Currently most of these applications using simple constant speed drives. So resulting in reduced efficiency and large sized drive systems. Variable speed drive cost is high compared to fixed speed drives. Because variable speed drives have not penetrated such low cost applications. While variable speed universal motor drives with a simple one quadrant chopper may be acceptable. So resulting in low cost, low performance drives, limited lifetime, acoustic noise, brush wear contributing to electromagnetic interference and indoor air contamination and severely affect the overload capability. So it is disqualify from further consideration.
Finally search for a simple, low cost, brushless, variable speed drive has intensified with the emerging variable speed application in home appliances. Several low cost drives with reduced number of switches such as permanent magnet brushless dc motor with two switches, single phase induction motor with two switches and three phase induction motor with three switches. They are presented reasonable performance but manufacturing cost and complexity of permanent magnet brushless and induction motor remains high.
The switched reluctance motor is known to be the lowest cost motor with simplest construction having no brushes, commutators, windings, or magnets on its rotor and only concentrated windings on its stator. Converters for this motor can be simple. A single phase SRM with a two switch based asymmetric converter and a two phase SRM with two switch based split supply converter are found to be competitive for low cost variable speed applications.

II. EXISTING METHOD

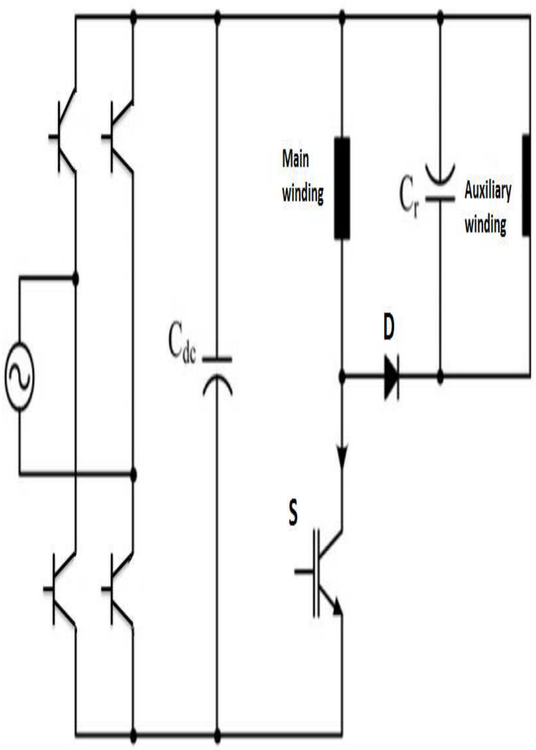
In the original converter, the recovered energy from the main winding is stored in the recovery capacitor is circulated back to the dc link capacitor.



(a)

The energy circulation between the motor and source can cause extra losses and result in a need for a larger dc link capacitor and its reduced lifetime.

III. PROPOSED METHOD



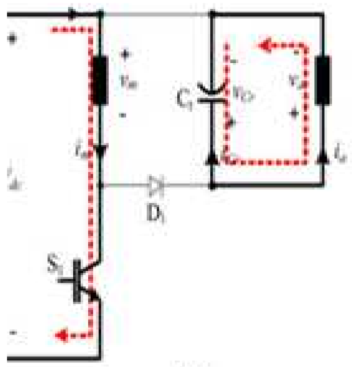
The proposed converter diagram show in the above figure. In this converter diode switches are replaced by IGBT switches for the purpose of reducing harmonics. The another change is the recovery capacitor is connected between the main and auxiliary windings.

In this new converter, the recovered energy from the main winding is retained and utilized within the motor. During the main commutation, in the original converter, -(Vcr-Vdc) appears across the main winding resulting in the range of 1.5 to 2 times Vdc; however in new converter, the voltage across the main winding equals –Vcr, resulting in Vcr being much less than Vdc. In the original converter, the recovered energy stored in Cr is returned back to the dc link capacitor and this energy exchange between the motor and source causes extra losses leading to a larger dc link capacitor. In the new converter, the recovered energy is retained and utilized within the motor windings instead of being returned to the source.

IV. MODES OF OPERATION

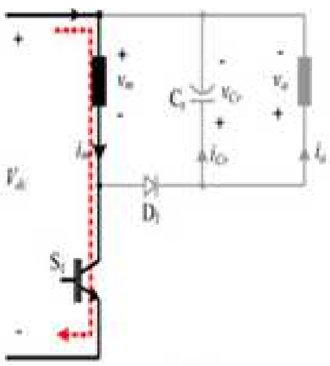
In modes of operation contains five modes.

Mode1: when S1 is turned ON, the main winding is energized with energy from dc link. The auxiliary winding also energized from Cr.



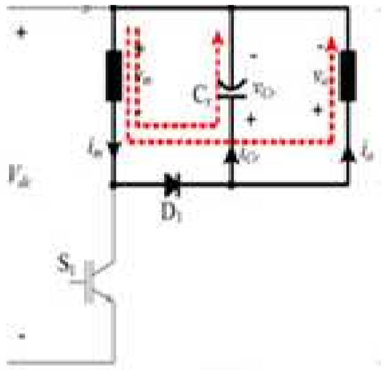
(a)

Mode2: when S1 is still turned ON, the main winding continues to energized. If Cr is completely discharged, then there is no current flow between Cr and auxiliary winding.



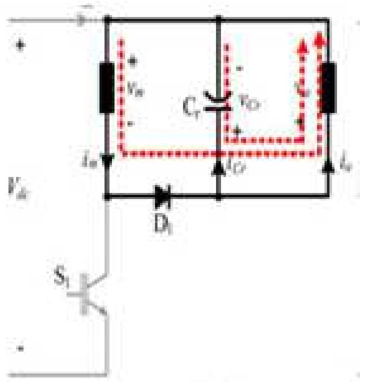
(b)

Mode3: when S1 is turned OFF, the current in main winding flows through D1 and Cr as well as auxiliary phase, hence transferring energy in part to Cr and in part to auxiliary winding.



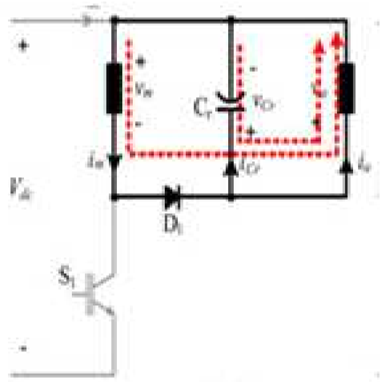
(c)

Mode 4: when S1 is turned OFF, both the main winding current and Cr supply the auxiliary winding.



(d)

Mode5: when S1 is turned OFF, and the main winding is successfully commutated, and Cr exclusively supplies the auxiliary winding.

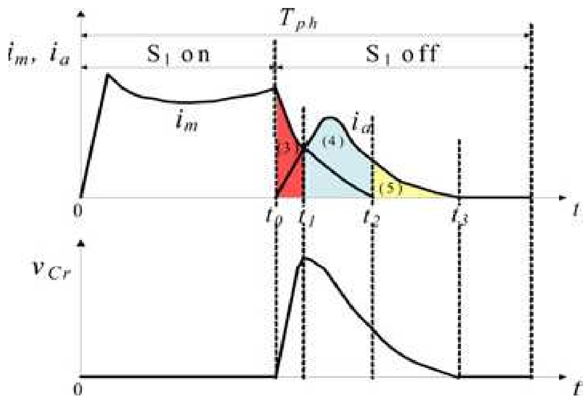


(d)

V.COMMUTATION OF MAIN AND AUXILIARY PHASE CURRENTS

The commutation of the main winding current is achieved through both the recovery capacitor and auxiliary winding. In pulse width modulation, the voltage across the main winding switches back and forth between the positive Vdc and the negative (-Vcr). Note that Vcr is not constant throughout the stroke period as it is dependent on the energy transferred from main winding and the energy drained into the auxiliary winding. The current in the main winding also circulates through the auxiliary winding, transferring energy back and forth between the main and auxiliary winding resulting in continuous conduction of auxiliary winding current. Although net torque generated by the auxiliary phase is almost zero, current in the auxiliary winding during the main phase stroke generates negative torque, thus resulting in reduced efficiency and increased acoustic noise.

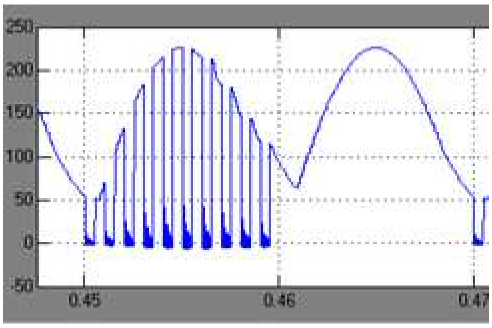
This problem is main drawback so single pulse mode is employed. The main and auxiliary winding current (Im, Ia), and the voltage of the recovery capacitor (Vcr). Once the switch S1 is turned OFF at T0, the main current flows through both Cr and auxiliary winding. Thus, Vcr and Ia increases. Once Cr is fully changed at T1, Cr starts being discharged. Thus, energy from both main winding and Cr is transferred to auxiliary winding. When the winding current decays to zero at T2, it is then only the capacitor that transfers energy to auxiliary winding. Therefore, it is of prime importance to achieve the commutation such that both main and auxiliary winding current falls to zero as soon as possible with in stroke cycle Tph to avoid negative torque generation.



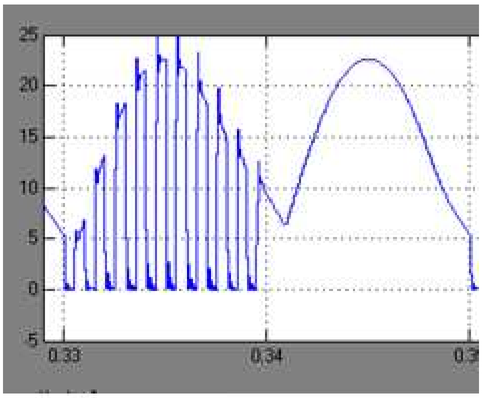
VI. SIMULATION RESULTS

The four simulation results are obtained. They are voltage and current through the main winding and voltage and current through the auxiliary winding.

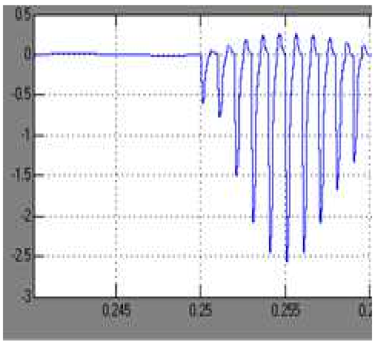
1) Voltage through the main winding



2) Current through the main winding



3) Current through the auxiliary winding



CONCLUSION

The proposed drive system with only a single controllable switch and four quadrant operation capability provides a highly cost competitive, brushless variable speed solution specifically for low cost deployment. Minimum number of controllable switches lends itself to the smallest footprint for drive electronics to reduce volume, weight, cost. Design consideration for optimal commutation of the phase currents is suited based on the analytic estimation. This is justified by both dynamic simulation and experimental results.

REFERENCES

1. Jaehyuck Kinm, “Single – Controllable – Switch – Based Switched Reluctance Motor Drive for Low Cost, Variable Speed Applications”

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