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# Reduced ripple in the torque output of the SRM drive by the use of the SVM-based converter

**Ch.SivaGanesh, A.V.V.S.Prasanna Kumar, G.R.S.Prudhvi, Y.Vamsi Krishna**

Department of Electrical and Electronics Engineering, Godavari Institute of Engineering and Technology (A), Rajahmundry, India.

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## ABSTRACT

***An early example of an electric machine, the switched reluctance motor (SRM) has been around for quite some time. Its low production cost, durability, and streamlined design make it ideal for use in industrial settings. These benefits, however, are offset by the high torque ripple, noise, and difficulty in controlling it that are intrinsic to the design. Based on the idea of a torque-sharing function (TSF), this work describes a method for minimising torque-ripple in switching reluctance motor (SRM) drives. By employing an analytical formula, the reference torque is converted into a reference current waveform in the suggested approach. One of the biggest drawbacks of the Switched Reluctance Motor is the torque ripple it produces. In this study, we first examine torque ripple from the perspective of the fundamental space voltage vector, which is grounded in direct torque control theory. The investigation led to the proposal of a novel technique using an improved voltage vector to cut down on torque ripple. In order to power SRMs, a space vector modulation is introduced here. Three legs of an asymmetrical three-phase power converter, each with two IGBTs and two free-wheeling diodes, provide power to the SRM.***

## 1. INTRODUCTION

Both electromagnetic and variable reluctance methods of producing torque may be used to electric devices, which leads to a categorization into one of two major groups.

In the first kind, movement is created as a result of the coupling of two magnetic fields, one produced by the stator and the other by the rotor. When two magnetic fields are linked together, an electromagnetic torque is generated that acts to align the fields. For the same reason, bar magnets with similar poles repel and those with opposing poles attract. Most modern commercial motors function in this way. The geometry and source of the magnetic fields are what set DC and induction motors apart from one another. Energized windings, permanent magnets, and induced electrical currents are all common methods of producing such fields.

When the air gap between the rotor and the stator has a varying reluctance, motion is generated. Reluctance torque is generated when a single magnetic field is created by energising a stator winding, which causes the rotor to seek for the position of lowest reluctance. Similar forces attract iron or steel to permanent magnets, and so does this phenomena. The reluctance is reduced when the magnet and metal are in direct contact. The switching reluctance motor (SRM) is an example of a machine type that uses this operating concept.

One of the first concepts for an electric motor, the switching reluctance motor (SRM) has been around for more than 150 years. Switched reluctance machines are an adaptation of the traditional reluctance machine made possible by advances in power semiconductors and the increasing need for variable-speed drives "a (SR) device Switched Reluctance is the New Name for an Old Feeling ", which is put to use by, defines two aspects of the hardware setup: This machine did not emerge until the availability of reliable power semiconductors (a) switched । the machine must be run in a continuous switching mode; (b) reluctance Having magnetic circuits with varying degrees of resistance in both the rotor and the stator makes it the actual reluctance machine, or more accurately, a double salient machine.

The SRM is the easiest electrical machine to build. The only moving part of a motor with coils is the stator. There are no conductors or magnets in the rotor. A bunch of steel sheets are placed on top of a shaft to make this. Due to its straightforward mechanical design, SRMs have been a popular area of study over the last decade because of the promise of inexpensive production costs. However, the gadget is limited in certain ways due to the simplicity of its underlying mechanical design. To operate, SRMs, like brushless DC motors, need to be electrically commutated from a DC bus or an AC line. It is also difficult to analyse and regulate the SRM because of the significant non-linear magnetic properties caused by the saliency of the stator and rotor, which is essential for the machine to generate reluctance torque. SRMs have been difficult to gain traction in the business world. This is owing to the widespread use of conventional AC and DC machines as well as to the absence of readily accessible electronics for use with the SRM. However, SRMs have some benefits and may be inexpensive. Since each step of the SRM is essentially independent in terms of physical proximity, magnetic field, and electrical current, these devices may be very dependable. Since there are no magnets or conductors on the rotor, this motor may reach far higher speeds than others of its kind. Better understanding of SRM mechanical design and the development of algorithms that can compensate for the issues that have been raised about the SRM—namely, that it is difficult to control, that it requires a shaft position sensor to operate, that it is typically noisy, and that it has more torque ripple than other types of motors—have generally been overcome.

## 2. SWITCHED RELUCTANCE MOTOR:

Although switched-reluctance (SR) motors have been around since the 1800s, they have seen little use outside of embedded-drive systems. Their optimal performance requires very complex switching control, which was prohibitively expensive until the development of small but potent solid-state power devices and integrated circuits. Switched-reluctance motors may soon play a larger part in home and industrial electronics, machinery, and even off-road vehicles as a result of a shift in focus toward more energy-efficient technologies. Since their inception, servo applications have mostly favoured dc machines because to their superior drive performance and inexpensive price. The torque-inertia ratio, peak torque capacity, and power density are all areas where the ac machine excels above its dc counterpart. In addition, commutators and brushes are superfluous in ac machines. Induction machines have become the workhorses of industry because to their cheap cost, durability, and almost maintenance-free operation.

Synchronous motors of various types are utilised due to the precision with which speed may be controlled.

Due to their great efficiency and excellent performance, permanent magnet (PM) synchronous motors are widely employed in low power applications.

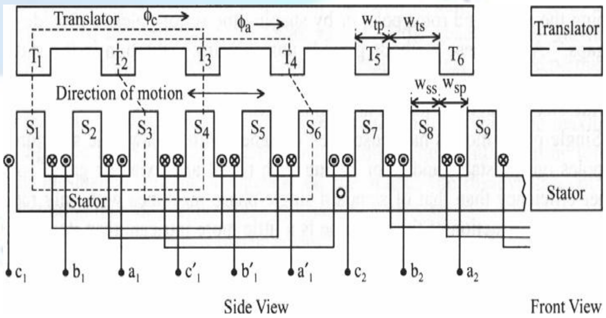


Figure 1: Three phase linear switched reluctance motor

Relationship between stator flux linkages and rotor position as a function of stator current determines torque characteristics of switching reluctance motor. Figure 2 depicts the relationship between the phase inductance and the rotor position for a constant phase current. Ignoring the fringe effect and saturation, the inductance is the same as that of a motor's stator-phase coil. Modifications to the inductance profile that are especially noteworthy are calculated based on the arc lengths of the stator and rotor and the total number of rotor poles.

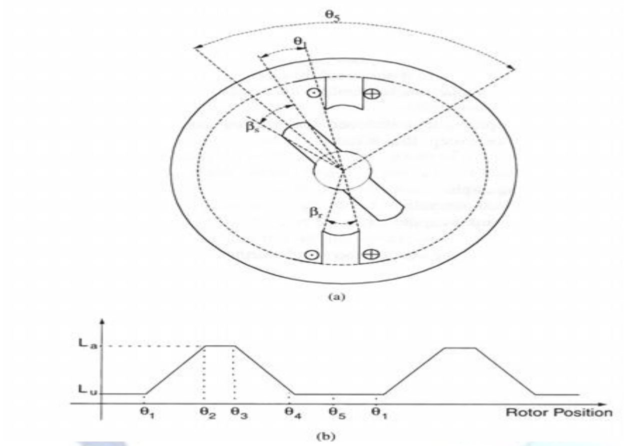


Figure 2: Inductance vs. rotor position

## 3. CONTROL METHODS OF SWITCHED RELUCTANCE MOTOR

Effective performance may be achieved by properly situating the phase excitation pulses.

- The on, dwel, and Iph settings for the controller.

Torque, efficiency, and other performance metrics are all determined by the control settings.

The asymmetric bridge converter is seen in Figure 3. By activating the two power switches for a certain phase, a current is induced in the SRM system. The switches are disabled if the current exceeds the set threshold. Because of the stored energy in the motor's phase winding, the current will continue to flow in the same direction until that energy is spent. Figure 3 shows the resulting waveforms.

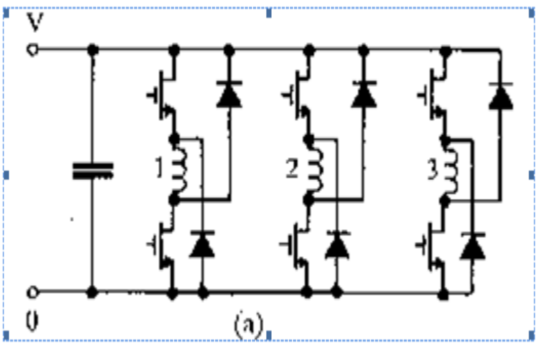


Figure 3: Asymmetric converter for SRM and operation waveforms

## C-DUMP CONVERTER:

Energy recovery circuit for the C-dump converter is depicted in Figure 4. Single quadrant chopper (Tr, Lr, and Dr) recovers magnetic energy from in and sends it back to the DC source, while some of the energy is redirected to the capacitor Cd.

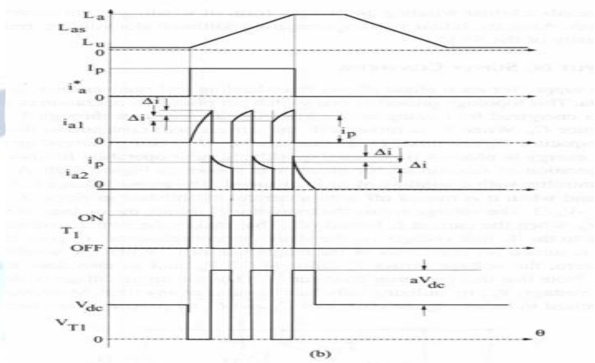


Figure 4: Bifilar type drive and operation waveforms with C-Dump

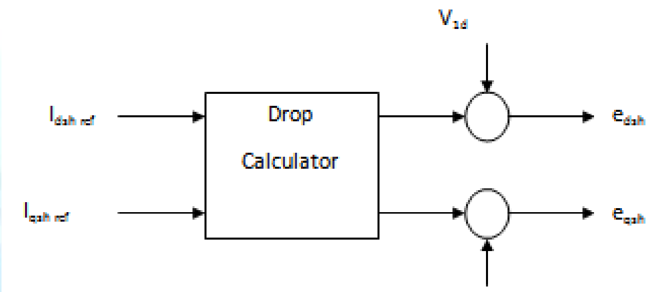


*Figure 5: Control Circuit*

The independent phase current may be controlled using minimally powered switches in this setup. The primary drawback is that there is a cap on the current commutation due to the difference in voltage between Cd, vo and the DC link voltage.

## 4. SVM TECHNIQUE FOR TWO-PHASE INVERTER

When using a three-phase inverter using the SVM method. By modifying the switching time of two zero-space vectors and determining the duty ratio for two space vectors that are next to V*, we may actualize a reference voltage vector V*. A realisation approach without zero space vectors for the SVPWM technique of a two-phase inverter is presented in this research. The reference vector Vswitching *'s timings are shown in Figure 6 as a result of altering four voltage space vectors.

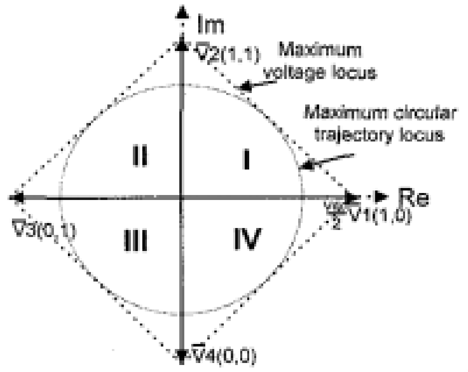


Figure 6: SVM Four possible space vectors

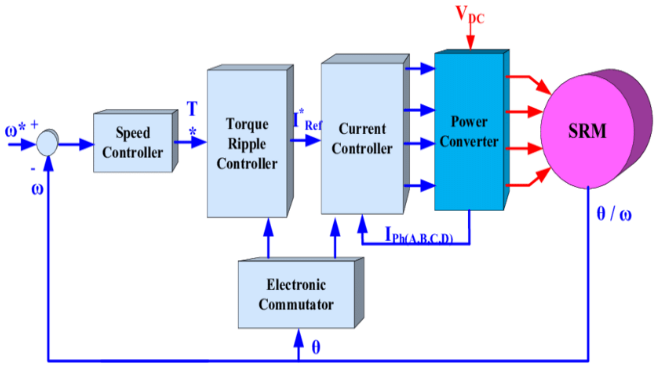


Figure 6: Block Diagram for SRM Drive

## 5. SIMULINK BLOCK DIAGRAM OF SRM:

The speed controller for SRM drive and position sensor is shown in figure 7 and figure 8 respectively.

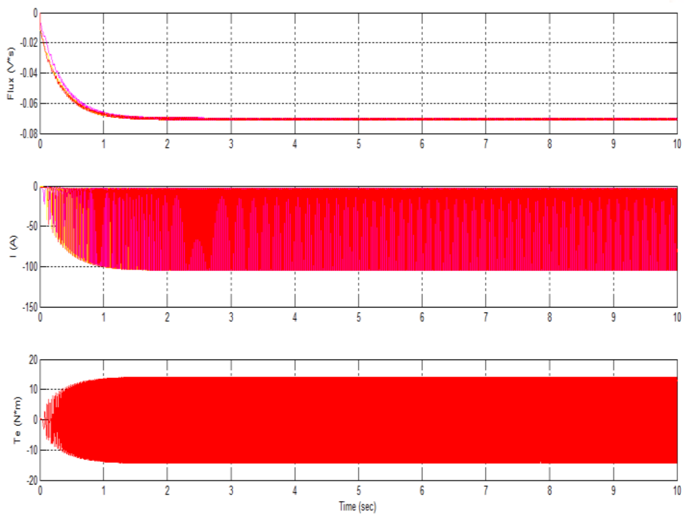

Figure 7: Simulation Waveform of SRM Parameters

In Fig. 7, we see a graph of the total torque, current, and flux. Matlab is used to model and simulate an R-dump converter. Phase A, Phase B, and Phase C are all steady states that can be deduced from Fig. 8's flux and current graph.

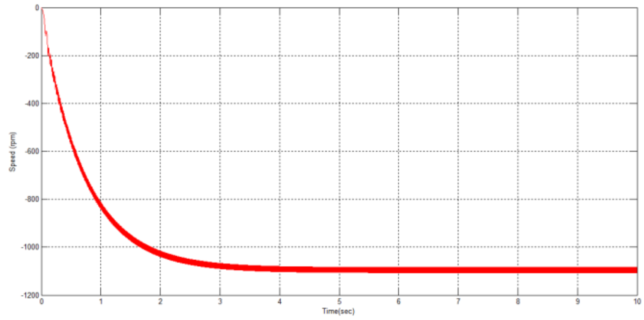

Figure 8: Simulation Waveform of SRM Speed

Figure 9 shows the simulation diagram for Controller of SRM Drive using Space Vector Modulation Technique.

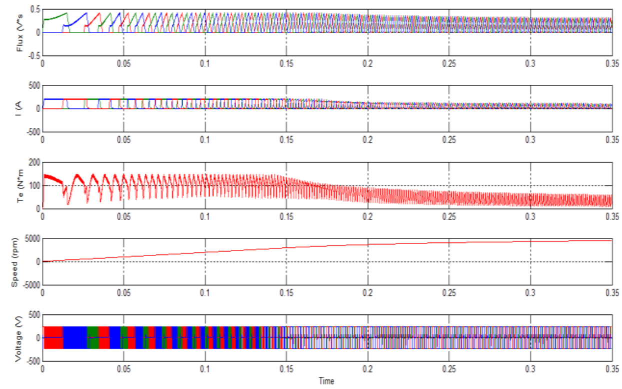

Figure 9: Simulation Waveform for SRM Parameters

The flux, currents, total torque Speed and Voltage graph, is shown in Fig. 9. R-dump converter is modeled and simulated in Matlab environment.

## 6. CONCLUSION

If you're looking for a converter for a Switched Reluctance Motor, the asymmetric type converter is your best bet. If one winding fails, the converter can still power the motor and keep it turning, although at a lower power output. The asymmetric converter type (With MOSFET) is determined to be most ideal for extremely high speed operation of SRM drive, thanks to its fast rise and fall periods of current and its low propensity to shoot through faults, as compared to other types of converter topologies. IGBT power switches, on the other hand, are chosen for medium-speed, high-power operation because of their low conduction losses and high input impedance. All of these converters will need to undergo SVM analysis in the future to evaluate the effectiveness of SRM in cutting down on torque ripple.

### Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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