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Torque ripples reduction for SRM drive using SVM-based converter

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Abstract:

An early electric machine, the switching reluctance motor (SRM) is old. Low production cost, durability, and streamlined design make it perfect for industrial use. The design's excessive torque ripple, noise, and control issues negate these benefits. This work minimizes torque-ripple in switching reluctance motor (SRM) drives using a torque-sharing function (TSF). The suggested method converts reference torque into a reference current waveform using an analytical formula. Torque ripple is a major shortcoming of the Switched Reluctance Motor. We start by looking at torque ripple from the basic space voltage vector, which is based on direct torque control theory. A unique torque ripple-reducing voltage vector was proposed after the analysis. We use space vector modulation to power SRMs. The SRM is powered by three asymmetrical three-phase power converter legs with two IGBTs and two free-wheeling diodes.

Introduction:

Electric devices can produce torque via electromagnetic or variable reluctance methods, dividing them into two classes.

The first type creates movement by linking two magnetic fields, one from the stator and one from the rotor. Two magnetic fields coupled together generate an electromagnetic torque that

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aligns them. Same reason bar magnets with identical poles repel and those with opposing poles attract. This is how most commercial motors work nowadays. The shape and source of magnetic fields distinguish DC and induction motors. Fields are often created by energized windings, permanent magnets, and induced electrical currents.

When the rotor-stator air gap has variable resistance, motion is generated. Energizing a stator winding creates a magnetic field that causes the rotor to seek the lowest reluctance. This phenomenon attracts iron and steel to permanent magnets like similar forces. Direct contact between magnet and metal reduces reluctance. This working principle is used by the switching reluctance motor (SRM).

Over 150 years old, the switching reluctance motor (SRM) was one of the first electric motor designs. Power semiconductors and the need for variable-speed drives have enabled switched reluctance machines "a (SR) device Switched By using "Reluctance is the New Name for an Old Feeling," defines two hardware setup aspects: After reliable power semiconductors became available, this machine emerged (a) switched | the machine must switch continuously; (b) reluctant the real reluctance machine, or double salient machine, has magnetic circuits with variable resistance in the rotor and stator. 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. SRMs, like brushless DC motors, need DC bus or AC line electrical commutation to work. The saliency of the stator and rotor, which generates reluctance torque, makes the SRM challenging to analyze and govern due to its non-linear magnetic properties. SRMs have struggled in business. The widespread use of AC and DC machines and the lack of SRM-compatible circuits explain this. However, SRMs may be cost-effective. These devices may be reliable because each SRM step is independent of physical proximity, magnetic field, and electrical current. This motor may reach far higher speeds than others since the rotor has no magnets or conductors. Better understanding of SRM mechanical design and the development of algorithms to compensate for its issues—difficulty to control, need for shaft position sensor, noise, and torque ripple—have generally been overcome.

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2. Switched Reluctance Motor:

Since the 1800s, switched-reluctance (SR) motors have been used mostly in embedded-drive systems. They function best with complicated switching control, which was too expensive until compact yet powerful solid-state power devices and integrated circuits were developed. Switched-reluctance motors may become more common in residential and industrial electronics, industry, and off-road vehicles as energy-efficient technologies become more important. DC machines have been preferred for servo applications because to their higher drive performance and low cost. AC machines outperform dc ones in torque-inertia ratio, peak torque capacity, and power density. In AC machines, commutators and brushes are unnecessary. Because of their low cost, longevity, and almost maintenance-free operation, induction machines are industry workhorses.

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.

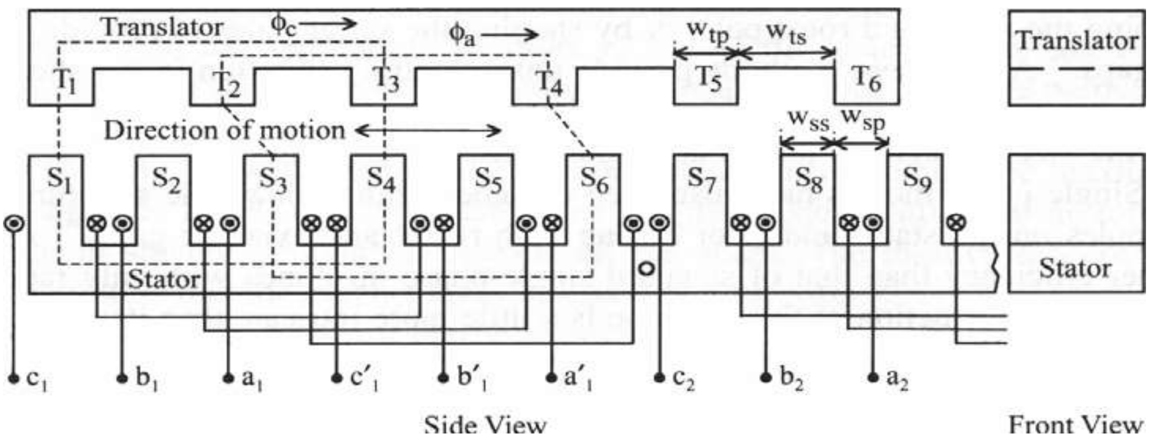

Figure 1: Three phase linear switched reluctance motor

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.

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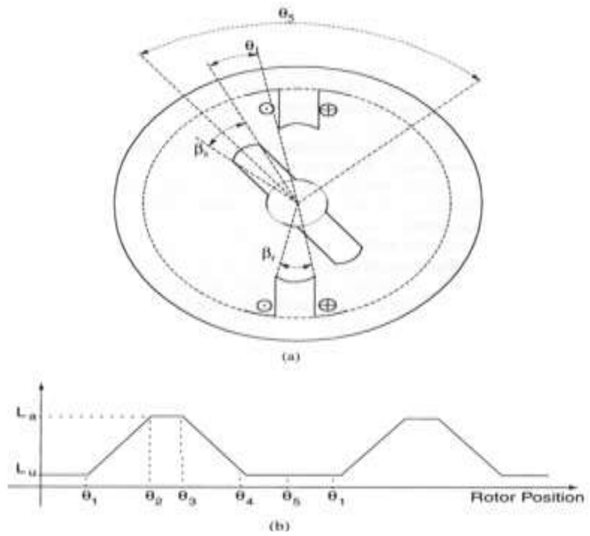

Figure 2: Inductance vs. rotor position

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.

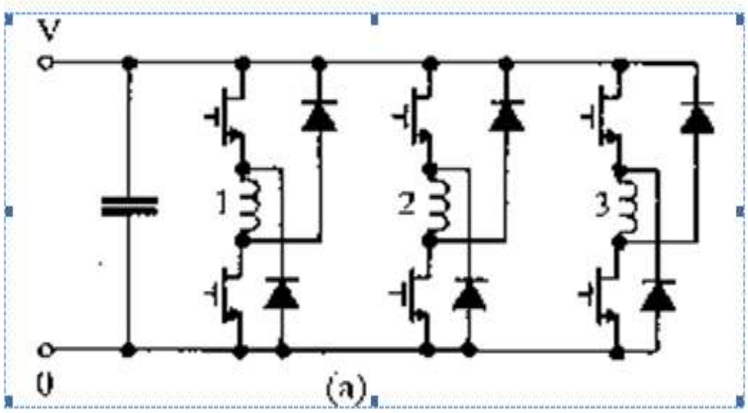

Figure 3: Asymmetric converter for SRM and operation waveforms

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4. C-Dump Converter:

Energy recovery circuit for the C-dump converter is depicted in Figure 4(a). 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.

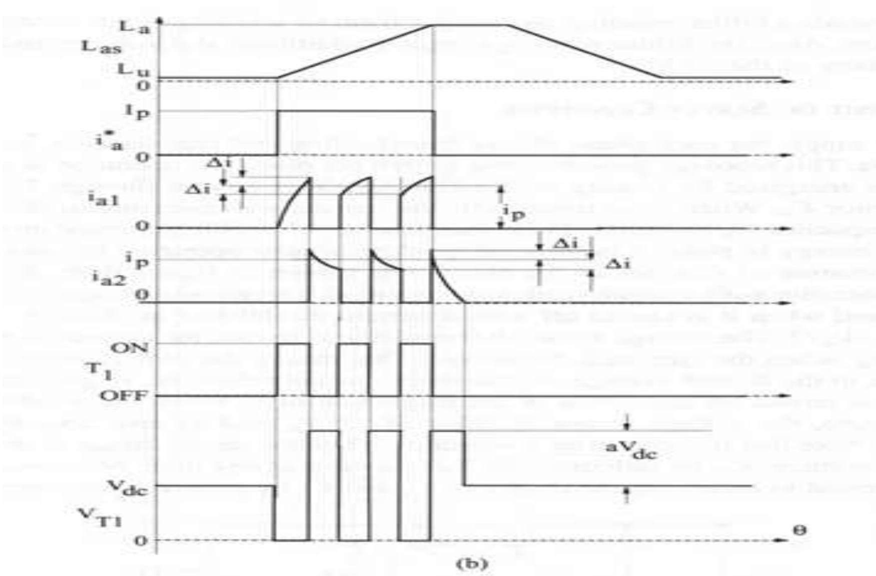

Figure 4(a) : Bifilar type drive and operation waveforms with C-Dump

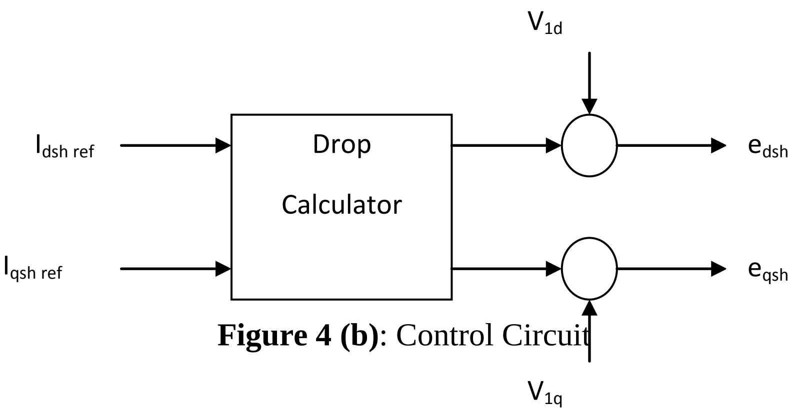

Figure 4 (b): Control Circuit

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.

5. 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

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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 5 as a result of altering four voltage space vectors.

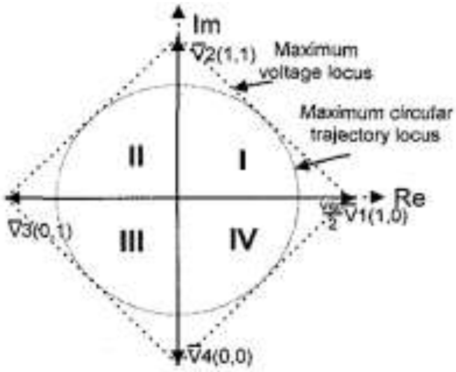

Figure 5: SVM Four possible space vectors

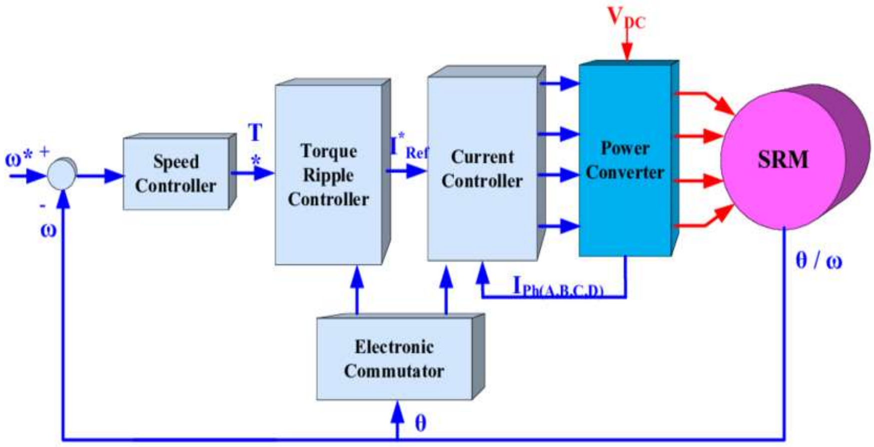

Figure 6: Block Diagram for SRM Drive

6. Simulink Block Diagram of SRM:

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

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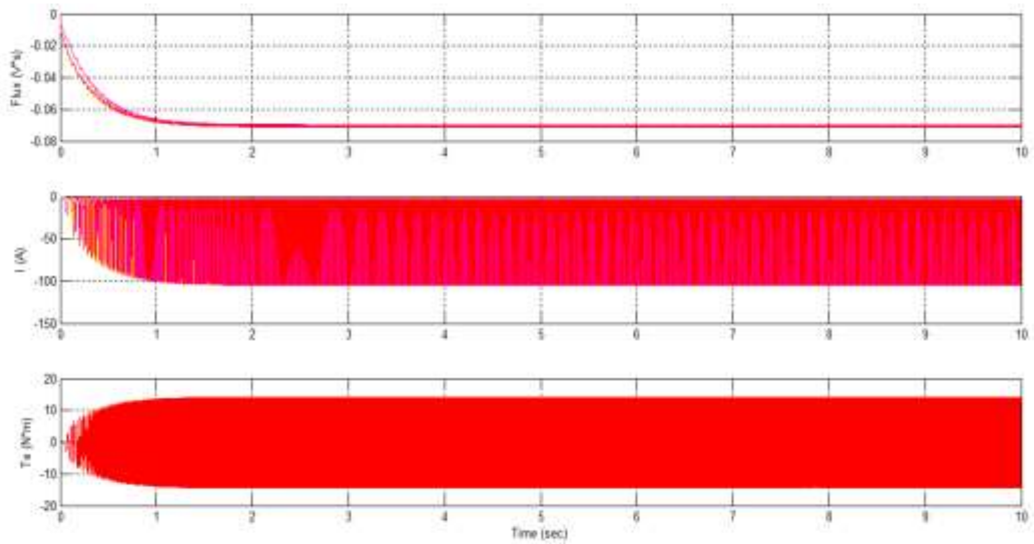

Figure 7: Simulation Waveform of SRM Parameters

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.

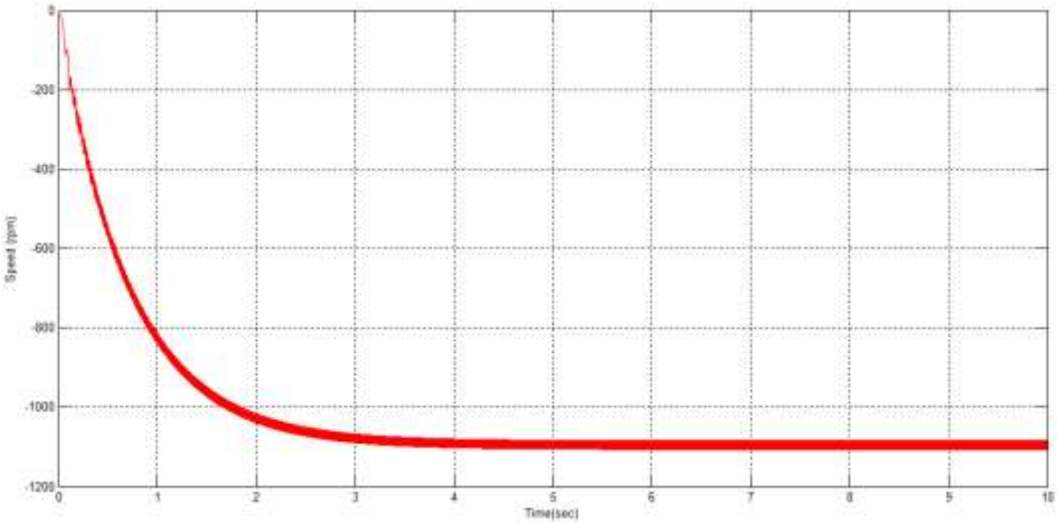

Figure 8: Simulation Waveform of SRM Speed

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

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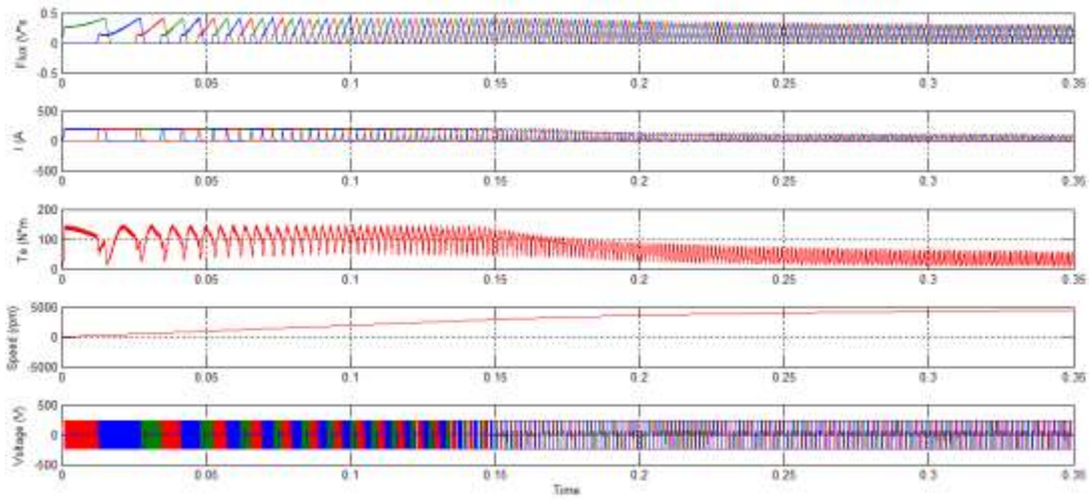

Figure 9: Simulation Waveform for SRM Parameters

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

7. 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.

References

[1] Samia M. Mahmoud, Mohsen Z. EI-Sherif, "Studying Different Types of Power Converters Fed Switched Reluctance Motor," International Journal of Electronics and Electrical Engineering, vol. I, no. 4, pp. 281-290 December 2013.

[2] T. Wichert, "Design and construction modifications of switched reluctance machines," Ph.D. thesis, Warsaw University of Technology, 2008.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 8, Issue 1, 2019

[3] Y Hasegawa, K. Nakamura, and O. Ichinokura, "Development of a switched reluctance motor made of permendur," in Proc. 2nd Int. Symp. on Advanced Magnetic Materials and Applications, Journal of Physics, 2011.

[4] Krishna Mohan Tatikonda, Udaya K. Renduchintala, Chengzong Pang, and Lin Yang, " ANFIS- fuzzy logic based UPQC in interconnected microgrid distribution systems: Modeling, simulation and implementation," 2015 The Authors. The Journal of Engineering published by John Wiley & Sons Ltd on behalf of The Institution of Engineering and Technology, https://doi.org/10.1049/tje2.12005.

[5] R. D. Doncker, D. W. J. Pulle, and A. Veltman, Advanced Electrical Drives: Analysis, Modeling, Control, Springer Press, 2011, ch. 10.

[6] E. S. Elwakil and M. K. Darwish, "Critical review of converter topologies for switched reluctance motor drives," International Review of Electrical Engineering, vol. 2, no. I, January-February 2011.

[7] 1. W. Ahn, 1. Liang, and D. H. Lee, "Classification and analysis of switched reluctance converters," Journal of Electrical Engineering & Technology, vol. 5, no. 4, pp. 571-579, 2010.

[8] Z. Grbo, S. Vukosavic, and E. Levi, "A novel power inverter for switched reluctance motor drives," FACTA Universitatis (NIS), Elec. Eng., vol. 18, no. 3, pp. 453- 465, December 2005.

[9] B. Singh, R. Saxena, Y. Pahariya, and A. R. Chouhan, "Converters performance evaluation of switched reluctance motor in simulink," International Journal of industrial Electronics and Control, vol. 3, no. 2, pp. 89- 101, 2011.

[10] P. Vijayraghavan, "Design of switched reluctance motors and development of a universal controller for switched reluctance and permanent magnet brushless DC motor drives," Ph.D. dissertation, Faculty of the Virginia Polytechnic Institute and State University, Blacksburg, Virginia, November 2001.

[11] R. Krishnan, Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design, and Applications, CRC Press 2001.