

Study and Implementation of a Computational Platform to Drive a Switched Reluctance Motor 8x6 for Electric Vehicles Applications

M.B.S.Pinto¹, G.P.Viajante¹, M.E.Oliveira, E.N.Chaves and M.A.A.Freitas

¹ Federal Institute of Education, Science and Technology of Goiás
Campus of Itumbiara – Goiás, (Brazil)

Phone/Fax number: +55 62 xx, e-mail: mathheusbueno@gmail.com, ghunterp@gmail.com

Abstract. This paper aims to develop a computational platform for study and analysis of a Switched Reluctance Machine (SRM) 8x6 operating as motor for electric vehicles applications. In SRM modelling it was used the non-linear approach, which includes the representation of the magnetic circuit saturation through the concept of incremental inductance. For machine drive is used the topology of the asymmetrical half-bridge converter. The proposal is to make the computational representation to simulate of the behaviour of this machine under several operations conditions, guaranteeing safety and reliability of the results. Besides the drive of the SRM, the computational platform allows the study of the various magnitudes and aspects of this machine, such as: inductance, torque, speed profile, power and efficiency. A current control is also implemented, and simulation results are presented and discussed.

Keywords

Electric vehicles, Energy efficiency, Switched Reluctance Motor 8x6.

1. Introduction

It has record that the first Switched Reluctance Machine was developed and had its application around 1838 in Scotland, and it was used in a locomotive [1]. Although its record is old, its development has been slowed down due to the electronic dependencies required to carry out its control. Due to the great advance in the latest decades of the electrical engineering, such as microcontrollers, electronic components, control systems among others; Many machines are becoming increasingly accessible, as the Switched Reluctance Machine (SRM) [2].

In this machine it is verified that its inductance varies according to the position of the rotor relative to its stator, it presents the minimum inductance when the poles are misaligned one relative to the other, and maximum inductance when the poles of them are fully Aligned. These positions can be classified as position of imbalance and equilibrium, respectively [3].

The Figure 1 shows the cross section of a motor containing the rotor and stator. Feeding the phase of the machine when it is in the equilibrium position there will be no movement, because the Poles are already aligned. However, when feeding the phase of the machine in the when it is in the position of imbalance, the rotor tended to

move either clockwise or counter clockwise seeking maximum inductance, equilibrium position.

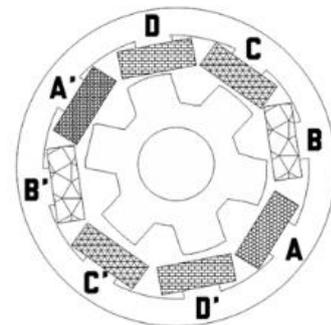


Fig. 1. Equivalent circuit for one phase.

The machine has already been used in electric vehicles, such as the Land Rover Defender 110, which was developed by Jaguar Land Rover in 2013. It replaced its diesel engine with a SRM of 70kW, powered by a 300 volt lithium-ion battery with a capacity of 27kWh that was able to have a range of 80km and can reach 110km/h with a fully charged battery [4][5].

Applications such as hybrid traction coupled with optimization techniques, aiming to optimize torque, to use power generation in braking to reduce machine losses are shown to be viable for the machine [6][7]. A promising application is its use in urban buses, as these vehicles have a high pollution index and low efficiency due to their topology of operation. This technology reduces the emission of gases pollutants and reduces the consumption of fossil fuels [8][9]. We can also use the machine generator function, by charging the batteries and providing greater autonomy for the vehicle.

2. Mathematical Model Switched Reluctance Machine

Based on the equations that describe the behavior of the engine the Switched Reluctance is used a model available in the MATLABTM/simulink[®] platform, to express the whole system of equation and activation of the same.

For the development of this mathematical modeling was considered the Switched Reluctance 8x6 operating as

Another greatness also obtained during the computational implementation and of relevance is the flow in the phases of the motor, in figure 11 we have the representation of this greatness.

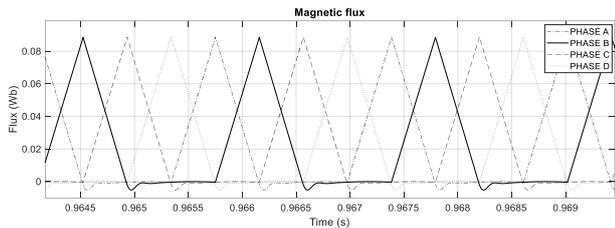


Fig. 11. Magnetic flux permanent regime.

At the end we have the efficiency of the motor by its speed. The resulting efficiency graph is shown in figure 12, demonstrating that the motor efficiency is not uniform over its operating range.

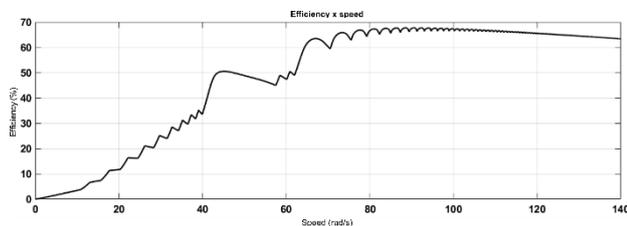


Fig. 12. Efficiency x speed.

One of the advantages of Switched Reluctance Motor, which is the possibility to operate even with phase failure. In Figure 13 the machine is shown operating at approximately 30% of the nominal load and in the half-time of the simulation a phase was broken, showing that the machine is still in operation with the efficiency undergoing a slight change. Thus, with a small oscillation.

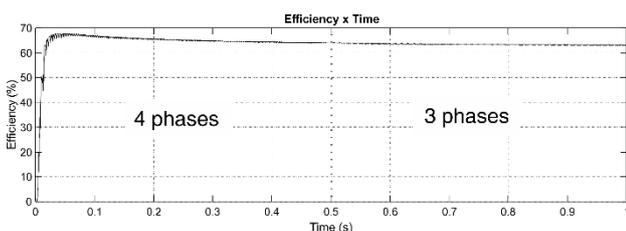


Fig. 13. Efficiency with one phase failure.

4. Conclusion

In this work a computational platform was presented for the study and drive of a Switched Reluctance Machine 8x6 operating as a motor, including its operating principle along with its elementary equations. Analysing the results obtained through the computer simulation, it was verified that the SRM 8x6, presented characteristics such as: oscillatory torque, coming from the topology of the used activation system and the constructive characteristics of the machine and quite high current requested when the machine

starts, requiring optimization the activation system in order to maximize efficiency. Looking at the scenario of energy efficiency together with renewable energies the development of a machine activation to Switched Reluctance Machine 8x6 operating as a motor shows a promising study considering its advantages as: possibility of direct power supply in direct current, tolerance to lack of phases, can be used in cars and buses in a hybrid way and also changing their behaviour as generator or motor depending on the application.

Acknowledgement

The authors would like to thank Federal Institute of Education, Science and Technology Goiás - Campus of Itumbiara for the contribution.

References

- [1] Miller, Timothy John Eastham (Ed.). Electronic control of switched reluctance machines. Elsevier, 2001.
- [2] Oliveira, D. N. Proposta e Implementação de Sistema para Caracterização Eletromecânica Estática e Dinâmica de Motores Rotativo e Linear de Relutância Chaveada. 2008. Dissertação (Mestrado em Engenharia Elétrica.) Dissertação de mestrado, Universidade Federal do Ceará-Brasil.
- [3] Moraes, Marcos José et al. Proposta de Plataforma Ppara Estudo de Motor A Relutância Variável 8/6.
- [4] Riley, Chris P. et al. Simulation based design of reluctance motors for traction applications in hybrid and electric vehicles. In: Power Electronics, Machines and Drives (PEMD 2014), 7th IET International Conference on. IET, 2014. p. 1-6.
- [5] Sun, M. et al. Design and Optimization of Switched Reluctance Motor for Propulsion System of Small Electric Vehicle. In: Vehicle Power and Propulsion Conference (VPPC), 2016 IEEE. IEEE, 2016. p. 1-5.
- [6] Nidec, <http://www.srdrives.com/land-rover.shtml>, acessado em 13/10/2018.
- [7] Drives&Controls. http://drivesncontrols.com/news/fullstory.php/aid/3872/Switched_reluct_ance_motors_power_electric_Land_Rovers.html, acessado em 13/10/2016.
- [8] Nidec, http://www.srdrives.com/green-propul_sion.shtml, acessado em 13/10/2018.
- [9] Nidec, <http://www.srdrives.com/starter-generator.shtml>, acessado em 13/10/2018.
- [10] Silveira, A. W. F. V. Controle de tensão na carga para motor/gerador a relutância variável de três fases. 2008. 165 f.. Tese (Doutorado em Engenharia Elétrica.) - Faculdade de Engenharia Elétrica, Universidade Federal de Uberlândia, Uberlândia, 2011
- [11] B. Fahimi, et. al., "A switched reluctance machine-based starter/alternator for more electric cars" Trans. Energ. Convers., vol. 19, n°1, Março 2004.
- [12] Cai, W., "Comparison and review of electric machines for integrated starter alternator applications," IEEE - IAS, 2004. Vol. 1, Outubro de 2004