# Application and Performance of Switched Reluctance motor and Induction Motor in Electrical Vehicle

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**Abstract -** *The paper mainly focuses on the efficiency of the SRM and compares it with Single Phase Induction Motor (SPIM) which is presently in use in many low-power home appliances. Analytical and Finite Element Methods (FEM) are employed which is further validated through experiment. It is clear from the results that, SRM gives better performance is energy efficient and cost effective as compared to the commonly used SPIM and hence is a better alternative for domestic applications. Torque per unit volume equations are obtained for each of the motor, related to quantities such as magnetic flux density and electric loading and the speed performances are compared by using a washing machine application, which has a wide speed range. Motors of different types are evaluated due to their torque per motor volume, torque per ampere, efficiency and etc. over a wide speed range to have an idea about the applications of these motors.*

***Key Words***: *SRM, Single phase induction motor, Torque, Motor*

## 1. INTRODUCTION

An induction motor is one in which alternating current is supplied to the stator directly and rotor by induction or transformer action from the stator. Thus each coil of the induction motor stator winding with the opposing coils of the rotor winding, may be considered a transformer and whole motor may be thought of as a series of such transformers arranged radially around the periphery. Rotor of an induction motor may be one of two types, wound rotor or squirrel cage rotor. Most induction motors are designed to operate from a three phase supply. If variable speed operation of the motor is necessary, the source is normally an inverter. The aim of this study is the comparison of four different types of motors, such as induction motor, switched reluctance motor, axial flux permanent magnet brushless DC motor and radial flux permanent magnet brushless DC motor according to their torque per unit volume and applicability to a variable speed washing machine application. It is evident that, to be able to compare the performance of these four different types of motors a framework should be set. Since it is a dimensionless quantity torque per unit volume can be used as a common basis to compare these motors. However all of these motors need to be electronically driven to achieve the desired speed range. Therefore the ratings of the switches are important from the point of view of drive cost. In this study is the comparison of four different types of motors, such as induction motor, switched reluctance motor, axial flux permanent magnet brushless DC motor and radial flux permanent magnet brushless DC motor. The Axial flux external rotor non slotted stator permanent magnet motor. Axial flux external rotor slotted stator permanent magnet motor. Axial flux internal rotor non-slotted stator permanent magnet motor. Axial flux internal rotor slotted stator permanent magnet motor.

## 1.2 LITERATURE SURVEY

1. Sonali Vidhate, Prof. Pawan Tapre , Prof. Amit Solanki "BLDC Motor Drive for Electric Vehicle Application" The system needs to implement with a suitable control mechanism that will help to operate the motor in an efficient manner. The BLDC motor provides an attractive candidate for sensor-less operation because the nature of its excitation inherently offers a low-cost way to extract rotor position information from motor-terminal voltages

2. Nasser Hashernnia and Behzad Asaei "Comparative Study of Using Different Electric Motors in the Electric Vehicles" In this paper, different electric motors are studied and compared to see the benefits of each motor and the one that is more suitable to be used in the electric vehicle (EV) applications. There are five main electric motor types, DC, induction, permanent magnet synchronous, switched reluctance and brushless DC motors are studied.

3. P.Andrada, M.Torrent, B.Blanqué "Switched reluctance drives for electric vehicle applications" This paper first tries to explain why the switched reluctance drive is a strong candidate for electric vehicle applications. It then gives switched reluctance drive design guidelines for battery or fuel cell operated electric vehicles. Finally, it presents the design and simulation of a switched reluctance motor power train

4. Asok Kumar A., Bindu G.R "Analysis of Single Phase Induction and Switched Reluctance Motor for Domestic Appliances "The paper mainly focuses on the efficiency of the SRM and compares it with Single Phase Induction Motor (SPIM) which is presently in use in many low-power home appliances. Analytical and Finite Element Methods (FEM) are employed which is further validated through experiment

5. Swaraj Ravindra Jape , Archana Thosar "COMPARISON OF ELECTRIC MOTORS FOR ELECTRIC VEHICLE APPLICATION" Electric vehicles with higher energy efficiency, low maintenance cost and pollution free operation, are offering great alternative to popular conventional IC engine vehicles. Also, with the advancement in technology, electric vehicle manufacturers are able to overcome the traditional drawbacks of electric vehicles, making it more and more suitable for modern day transportation.

## 1.3 BACKGROUND

The switched reluctance machine is basically a doubly salient structure in which concentric coils are mounted around the stator poles and rotor has neither windings nor permanent magnets on it. So that it is a doubly salient singly excited motor with different number of stator and rotor poles.

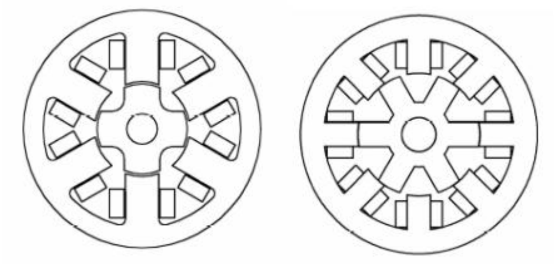

Fig 1: Different SR motor configurations

The rotor is aligned whenever diametrically opposite poles are excited. While two rotor poles are aligned to the excited two. Stator poles, other rotor poles become unaligned with respect to the other stator poles. Then another set of stator poles is excited to bring the unaligned rotor poles to align position with the excited stator poles.

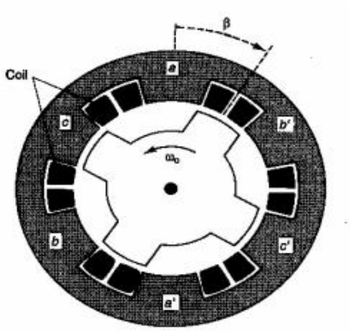


Fig2: Cross section of a SR Motor

If the coils of phase A are excited, misaligned rotor poles will be exposed to a force that acts to align the rotor poles with the phase a stator poles.

When the nearest rotor poles are aligned with the excited stator phase A poles, if the current is switched to the phase B coils, the counterclockwise force will continue acting on the nearest misaligned rotor poles. As a result rotor rotates in the counterclockwise direction by switching the stator currents sequentially through phases.

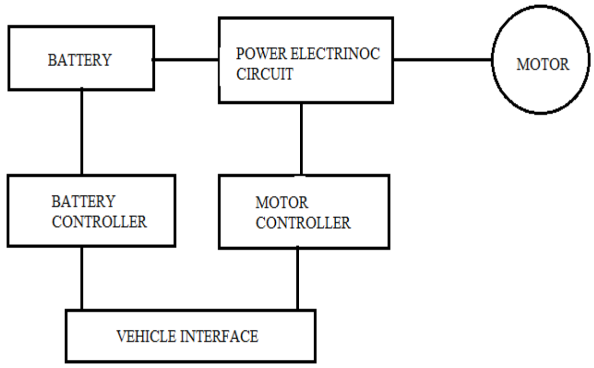


Fig 3: Block diagram

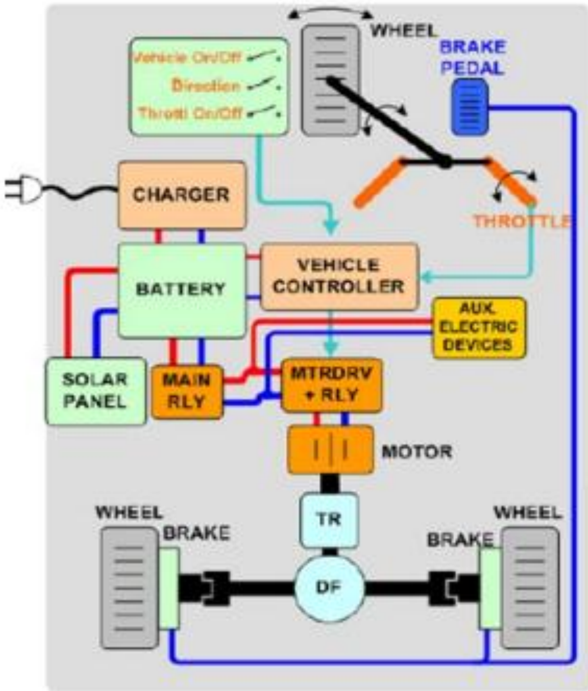


Fig 4: System Design

## 2. AIM OF THE PROJECT

The aim of this study is the comparison of four different types of motors, such as induction motor, switched reluctance motor, axial flux permanent magnet brushless DC motor and radial flux permanent magnet brushless DC motor according to their torque per unit volume and applicability to a variable speed washing machine application

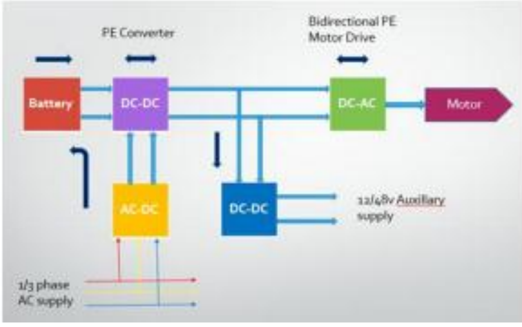


Fig 5: Power converter block diagram

## 2.1 TYPES OF MOTORS

- **Induction Motor**

The base speed of the induction motor should be chosen at such a point that the motor torque is greater than or equal to the load torque for every point in the operating speed range and hence the load torque vs. load speed characteristics fits into the torque speed characteristics of induction motor.

- The torque equation of the induction motor

$$T = \frac{1.3\pi}{4} D_i^2 LBq$$

- **Radial flux brushless dc motor**

Nearly the same procedure is applied to the RF-BLDC motor as in the case of induction motor. Again Electric loading and peak tooth flux density are taken as 28000 A/cond. And T respectively as in the case of induction motor. Since stator tooth width is assumed to be equal to stator slot width, magnetic loading "B" in equation can be determined. The air-gap flux is determined depending on the permanent magnet used on the rotor surface but the peak flux density should be limited by the saturation and should not exceed the maximum permissible value.

- The derivation of the torque equation for the RF-BLDC motor.

$$T = \sqrt{\frac{8}{3}} \pi r^2 l B_g q = \frac{\pi}{\sqrt{6}} B_g q D_i^2 l$$

- **Axial flux brushless dc motor**

"Kr" in equation (5.19) is the ratio of inner radius to outer radius and chosen to be "0.578" as the optimum value. NEOMAX-35 is used on the rotor surface of this motor. This motor is very similar to RF-BLDC motor except the flux path. So that the procedure also very similar. Same electric loading value (28000 A/cond.) is used. Knowing all the unknown values of equation, it is easy to find the outer radius of the motor to satisfy the maximum torque requirement. Then using predefined outer radius to inner radius ratio, inner radius and hence the mass and volume of the motor and stator core can be obtained.

- Torque equation of AF-BLDC motor was derived

$$T = 2\pi B_g q_i R_i (R_o^2 - R_i^2) = 2\pi B_g q_i R_o^3 K_r (1 - K_r^2)$$

- **Switched Reluctance Motor**

This torque equation is the starting point for the performance calculation of switched reluctance motor. Since the electric loading and stator pole flux density of the motor are taken as 28000 A/cond and T respectively, it is necessary to find the dimensions of the motor where it meets the maximum torque requirement (2.5 Nm washing cycle and 0.35 Nm at spin cycle). For the sake of simplicity, as in the case of the other motors considered before, stack length of the motor is taken to be equal to the bore diameter.

- The torque equation of switched reluctance motor

$$T = \frac{K}{\sqrt{3}} Bq \frac{\pi}{4} D_i^{\,2} L = \frac{K}{\sqrt{3}} Bq V_{rotor}$$

## 2.2 ADVANTAGES

- High torque ripple
- Acoustic noise generation
- High friction and wind age losses at high speeds due to the salient structure of stator and rotor
- Low Manufacturing cost

**DISADVANTGES**

- It does not have line start capability.
- The motor is a brushless machine like other AC machines.
- High Torque ripple
- High Dc bus current ripple

- **APPLICATIONS**
- wind energy systems
- electric vehicles

## 2.3 FUTURE SCOPE

These theoretical studies will be compared with the results obtained in the laboratory environment in order to see the reliability of the equations. This is achieved by using the prototype BLDC motors, SR motor and induction motor, present in the laboratory.

## 3. CONCLUSIONS

Switched reluctance motor drives emerge as one of the best candidates for powering the drive train of electric cars, mainly due to their high efficiency, extended power region, ruggedness and low foreseen manufacturing costs. The advent of various new semiconductor devices can take care of the drives to be used with SRM and hence this investigation holds relevance in the present scenario

## ACKNOWLEDGEMENT

It is indeed a great pleasure and moment of immense satisfaction for we to present a project report on "**Application and performance of switched reluctance motor and induction motor in electrical vehicle"** amongst a wide panorama that provided us inspiring guidance and encouragement, we take the opportunity to thanks to thanks those who gave us their indebted assistance. We wish to extend our cordial gratitude with profound thanks to our internal guide **Dr. Yogesh Pahariya** for his everlasting guidance. It was his inspiration and encouragement which helped us in completing our project.

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## REFERENCES

1. Sonali Vidhate, Prof. Pawan Tapre , Prof. Amit Solanki BLDC Motor Drive for Electric Vehicle Application International Journal of Latest Research in Engineering and Technology - Issue 09, September 2020.
2. Prof. Nagaraj. DC, Keerthana HN , Loka Abhiram. A3, Meghana. K4, Naveen. B Comparative Study of Using Different Electric Motors in the Electric Vehicles International Conference on Electrical Machines October 2008.
3. P.Andrada, M.Torrent, B.Blanqué, J.I.Perat "Switched reluctance drives for electric vehicle applications" RE&PQJ, Vol. 1, No.1, April 2003
4. Asok Kumar A., Bindu G.R Analysis of Single Phase Induction and Switched Reluctance Motor for Domestic Appliances International Journal of Scientific & Engineering Research, Volume 7, Issue 6, June-2016
5. Swaraj Ravindra Jape , Archana Thosar COMPARISON OF ELECTRIC MOTORS FOR ELECTRIC VEHICLE APPLICATION International Journal of Research in Engineering and Technology Sep-2017, Available @ http://www.ijret.org.

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