IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 1, August 2023

Performance of Induction Motor and BLDC Motor and Design of Induction Motor driven Solar Electric Vehicle (IM-SEV)

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Abstract: *The only thing pushing people toward electric automobiles is the rising cost of fossil fuels, which are slowly vanishing from nature or are likely to be and creates noise and pollutants. The several challenges that researchers are encountering with things like initial cost, battery life, and in certain cases how far an electric vehicle can drive are a focus of this research article. Although most of the electric vehicle producers employ BLDC motors, their availability is limited, and they are only appropriate for the smaller size of urban or sophisticated electric vehicles which rarely bear the heavy load and rugged situations. However, induction motors are currently being employed in heavy-duty three- and four-wheel vehicles. The author of this research article looked into and evaluated a significant amount of data before concluding that an electric vehicle's solar roof can help keep energy in a storage cell if solar rooftops are incorporated into the vehicle in the event of open-air parking. The induction of motor-driven solar-powered electric vehicles is suggested in this regard. Two electric motors a BLDC and an induction motor—and their performance are evaluated mathematically in this research article. To learn more about the structural analysis of Induction motor-driven solar automobiles, MATLAB simulations were described. The findings of this study may help researchers better understand Induction motors, which are used to boost the durability, dependability, high speed, and low maintenance costs of electric vehicles. Solar roofing might also improve the battery life and distance running of an electric vehicle.*

Keywords: Induction Motor, Charging Station, Electric Vehicle, Hybrid Electric Vehicle(HEV), Solar Automotive, BLDC Motor

I. INTRODUCTION

Globally, transportation plays a significant part in daily life, even though it also contributes significantly to environmental degradation and exhausts electric vehicle emissions. It has been noted that IC engine-based vehicles today may be a significant source of pollution. As a result of a large source of electric vehicles on emissions in the environment, researchers are working to electrify vehicles in this regard, including HEVs, PEVs, PHEVs, and NEVs.[1] The primary research area's concentration is on electric vehicles with electric motors and how well they operate. A variety of motor types play a part in the electrification of transportation, and most producers of electric vehicles employ BLDC motors because they don't require commutators. [2] The majority of manufacturers used BLDC as a major part of the electric vehicle, but they discovered it to be expensive because its magnet is a key component and it is also unsuitable for supporting big loads. [3] The BLDC, a significant player in the electric vehicle market, is less accessible and more expensive than an induction motor for urban applications. [1]. Researchers and electric vehicle manufacturers have observed that the BLDC is less effective than other prime movers for electric vehicles in terms of speed, robustness, and durability. As a result, they have looked at other alternative options that are also robust, cost-effective, and durable. The NITI Aayog is planning to fully electrify automobiles to eliminate or greatly reduce the major issue of environmental pollution. [4] This research article is divided into sections after the introduction **Section 2** describes the topic of the article Background; **Section 3** elaborates on the gaps that motivated the authors to work on this issue;

Section 4 explains the structural analysis of induction motor-driven solar-powered electric vehicles; **Section 5** provides support for induction motor-driven solar-powered electric vehicles, and **Section 6** concludes with recommendations for future research.

II. SECTION 2. BACKGROUND

Induction motors are gradually taking the place of internal combustion engines in two- or four-wheeled electric mobility. The most efficient and comfortable for passengers are electric vehicles, which also have no emissions. The lack of charging stations and the initial cost, however, are the key problems. The author is looking at the structure of an induction motor-driven solar-powered electric vehicle that has a high power density, instantaneous output, quick torque response, small and light design, high regenerative efficiency, affordable price, simple maintenance requirements, and all of these characteristics. [5] with the integration of durable, dependable, and cost-effective prime movers with solar-powered electric vehicles. When parked outside, an electric vehicle's solar roof can aid in conserving energy in a storage cell. To compare the overall performance of induction motors with BLDC motors for use in transportation applications, a MATLAB simulation has been powered electric vehicle ride out. Since the performance of an electric vehicle can only be understood in terms of the motor's power-speed or torque-speed characteristics, we anticipate great efficiency in terms of a dependable, sturdy, longer-lasting, and cost-effective electric motor. In this regard, a BLDC motor and induction motor mathematical model, along with a MATLAB simulation, were used to evaluate the performance.

III. SECTION 3. MOTIVATION TO WORK ON THIS ISSUE BY THE GAPS.:

Riders today deal with the following challenges in electric vehicles:

1. irregular solar light
2. The price of new electric vehicles
3. The biggest issue is EV charging stations.
4. There are serious difficulties with driving range and speed.
5. Qualified maintenance staff
6. Consumers' understanding of financial advantages is limited
7. Too little battery life

Although the majority of electric vehicle producers employ BLDC motors, their availability is limited, and they are only appropriate for small urban electric vehicles. However, induction motors are currently being employed more and more in heavy-duty three- and four-wheel vehicles.

IV. SECTION 4. THE ARCHITECTURE OF INDUCTION MOTOR-DRIVEN SOLAR-POWERED ELECTRIC VEHICLE:

A solar rooftop serves as the charging source for the proposed induction motor-driven solar-powered electric vehicle, which also has a converter/controller circuit, a battery bank, a motor, and an electric vehicle body. Figure 1 provides a detailed explanation of each component of an induction motor-driven solar automobile.

Storage Charging Source:

The energy source, which depends on the desired capacity, is crucial to the operation of the electric vehicle. An electric vehicle's weight, low energy density, longer charging periods, and battery life are all important considerations. [6] The battery of an electric vehicle, which is charged at grid-connected charging stations, stores energy that the vehicle uses as it travels. However, a researcher is working on an alternative energy source to charge the battery that should not only charge but also extend the battery life and avoid battery waste [7] by using slow and continuous charging and, to some extent, increasing the length of distance covered by the electric vehicle in the absence of charging stations. This source of energy is solar panels mounted on rooftop space. Mono-perc crystalline silicon solar panels with high efficiency are often employed in photovoltaic electric vehicle applications. While the panel efficiency was 13 percent in a month with full sunlight, it has been highlighted that there are roughly 300 sunlight days available out of which 8.29% is in India [4] On sunny days, solar energy can be utilized directly to power an electric vehicle, or it can be stored and used at night or when there is no sunlight. A single-source, the five-level inverter has the advantages of having fewer switches, less switching stress, and the capacity to be utilized with numerous strings of solar panels. [8]

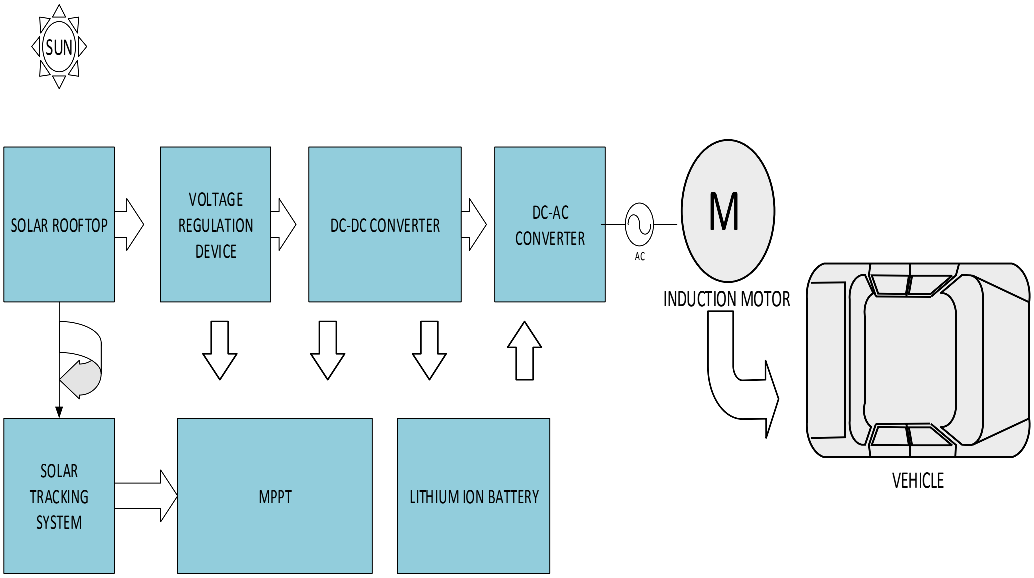

Figure 1 Induction motor-driven solar-powered electric vehicle and major parts

EV Ratings:

Power (P_{max}) = 195Wp at 12 Volt
Power voltage (Vmp) =20Volt
Power current (Imp) = 8.90A
Voltage Short Circuit (Voc) = 25 V
Maximum system voltage = 995V
No. of cells = 36
Specifications are 1000w/m^2 Irradiance AM 1.5 Cell temp. 25 ^{0}C
Dimension L/W/H 1450/660/30

as well as power electronics, which is merely a converter. In solar-powered electric vehicles, the converter is essential because it enables it to lower the voltage supplied to the motor or even charge the battery which undoubtedly contributes to the electric vehicle market [9]and the battery at the same time utilizing the DG system. [10]as an alternating source of energy like non-conventional sources like fuel cells, wind turbine energy generation, and solar array mounted on the roof of the vehicle when the solar irradiation is sufficiently high and the voltage required by the motor is less than the output voltage produced by the solar panel. In another scenario, where the solar voltage is insufficient to power the motor, the converter can raise the output voltage. [2] Additionally, wind energy can be used when an electric vehicle is fully operational and traveling down the road, and a wind turbine is placed so that it can move in response to air pressure on the wings that result from it forces exerted by the electric vehicles. [11]

Power Electronics Accessories:

Here power electronics is an active player in an electric vehicle the application of solid-state electronics to control electric power is called a controller which comprises of inverter and control [12] It must eventually be transformed into the necessary amount of power. The converter of power While the sinusoidal waveform illustrated in Figure 3 can be understood as the following: a. Bidirectional Battery Charger b. Bidirectional converter topologies for plugin electric vehicles, Figure 2 has several uses in an electric vehicle that can be understood as follows. Direct conversion of an AC-DC converter for plugin hybrid vehicles. c. Bidirectional DC-DC Converter for Ultracapacitor Applications. d. Integrated Bidirectional Converters. f. A bidirectional isolated AC-DC converter for a DC distribution system. g. A bi-direction EV charger's resonance converter h. Topology of a bi-directional T-type converter for EV applications. i.

Wireless Topology for Charging EV Batteries j. Flexible charging in EV and HEV applications using split converter fed induction motor/BLDC drive.

Figure 2 Power Converter

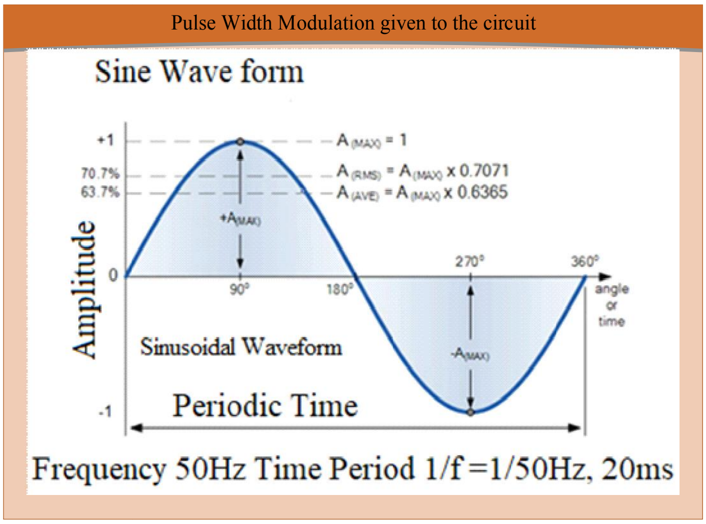

Figure 3 Pulse Width Modulation given to the circuit

Storage Battery Bank:

The total power required to run an induction motor-driven solar-powered electric vehicle is 69981.442 Watts using the following Table 1 calculation if the induction motor-driven solar-powered electric vehicle travels approximately 50 Km. This calculation is necessary to determine the total power that will be consumed by electric vehicles. To do this, we must take into account the force that the electric vehicle exerts and the weight of the electric vehicle without passengers.

Notation	Parameters	Units	Vehicle 1			
			Value	Units		
m	Weight	m	800.000	Kg		
W	Width	W	1.000	m		
H	Hieght	H	1.500	m		
μ_{rr}	Rolling Resistance	μ_{rr}	0.020			
þ	Air Density	þ	1.250	kg/m2		
Cd	Drag Coefficient	Cd	0.300			
g	gravitational Force	g	9.800			
	Speed in km		**50.000**	**kpmh**		
A	Forntal Area	A	1,400.000	m2		
v	Velocity	v	13.889	m/sec		
	Angle - Hill Climbing	Θ	40.00	degree	0.698	Rad
	Rolliong Resistance Force		156.800	Watts		
	Aerodynamic Drag Force		50,636.574	Watts		
	Hill Climbing Force		5,038.664	Watts		
F_{te}	Tractive Force	F_{te}	50,793.374	F_{RR}+F_{ad}		
	Total Power for 50Km	F_{te}	**705,463.529**	**Watts**		
	Total Power for 50Km Hill Climbing		69,981.442			

Table 1 Power required for an induction motor-driven solar-powered electric vehicle to run around 50 Km distance

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There are several types of batteries used in electric vehicles like Lithium-ion Batteries, Lithium Polymer, Lithium Phosphate, and Nickel Metal Hydride (NiMH) [13]. Studies have shown that a battery's failure can be ascribed to a variety of causes, including a defective cell, improper manufacturing procedures, aging, uncontrolled operating conditions, misuse, external forces, etc. For induction motor-driven solar-powered electric vehicle applications, where the solar array will be an added benefit to a slow and efficient charging process of an induction motor-driven solar-powered electric vehicle battery storage system, the battery should be routinely monitored and maintained. Another place where a battery management system should be used is to enhance the battery's performance and durability.[14]

Electric Motor used in EVs:

A variety of motor applications are used in electric vehicles, as shown in Figure 4. An electric motor's primary use is for propulsion, but it can also be used for other purposes like window sliding, front and rear wipers, seat adjustment, etc. Most of these applications can be powered by electric vehicle ride out with just a DC motor while the primary prime mover is sometimes connected across the front wheel to increase efficiency. Because a prime mover for a commercial application as a significant component is most appropriate, one of the AC motors from the Figure 5 Squirrel Cage induction Motor is taken into consideration. [15] and to increase vehicle efficiency thanks to its durability and low maintenance requirements. Although the induction motor is more favorable than all other types of motor used in electric vehicles, excess power received by the induction motor is used to move the vehicle at varying loads. Now that we have three-phase symmetrical windings and a square wave for the air gap, we need to compare the performance evaluation of BLDC and induction Motors for any electric vehicle. Armature reactions are observed as negligible but at the inner surface of the stator where they are continuously distributed in a BLDC motor.

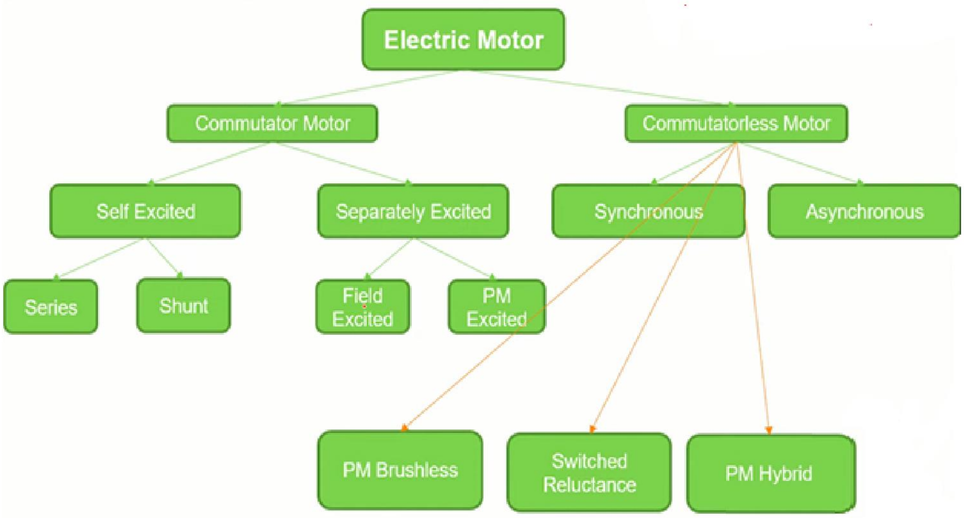


Figure 4 Categories of Electric Motor

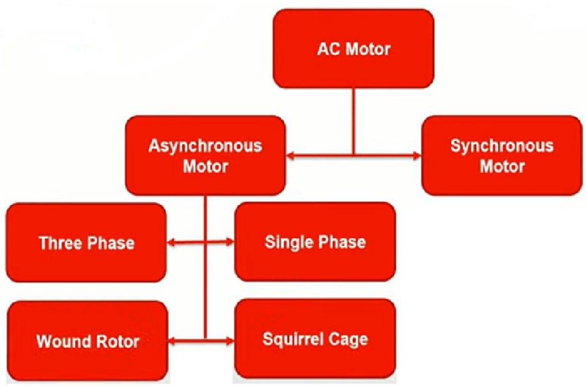


Figure 5 Types of AC type of Motors

BLDC Motor used in Electric Vehicles:

Researchers and EV manufacturers created BLDC because PMDC's commutator, which was used by 60% of manufacturers in the 1990s and is one of its major shortcomings. BLDC shares characteristics with permanent magnet DC motors. It is referred to as a brushless motor simply because it is devoid of a commutator and brush arrangement. This motor uses electronic commutation, which eliminates the requirement for BLDC motor maintenance. Among their propelling qualities are BLDC motors' strong starting torque and high efficiency. For design techniques that emphasize high power density, BLDC motors are appropriate. The most popular motors used in applications for electric bicycles and small-powered electric vehicles are BLDC motors. [5], due to their greater traction, and hybrid electric vehicles. Motor speed may be limited, and for the Indian market, durability and robustness are crucial elements. Any electric vehicle's key contribution to a dependable and effective transportation system is the choice of the prime mover. [4]

A Mathematical Model for BLDC Motor to EV propulsion applications

When examining the BLDC circuit as depicted by the equivalent circuit in Figure 6,

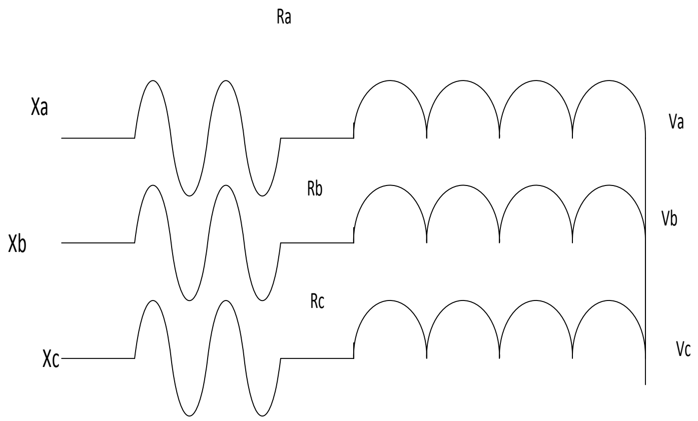


Figure 6 BLDC Equivalent circuit

The three-phase voltage is represented in the equivalent circuit above by the letters Xa, Xb, and Xc, while the current flowing through the stator's circuit is represented by the letters Ia, Ib, and Ic. The circuit back emf is also represented by the letters Va, Vb, and Vc. The three-phase stator resistance is displayed in the circuit as Ra Rb, Rc, while the inductor's inductance is displayed as A-B. so that the three-phase equations for the BLDC winding

X_a = IcRc+(A-B) dIc/dt +Va

X_b = IbRb+(A-B) dIb/dt+Vb

X_c = Ia Ra+(A-B) dIa/dt+Vc

The BLDC motor's stator has two conduction channels.

Also Xa-Xc=2RIs+2(A-B)dIs/dt+2Vs

The BLDC motor is then torqued electromagnetically.

Which is Torque(τ)=2VsIs/α

Where α angular speed

Vs=k α where k is the electromotive force coefficient

the result of the equation above is as Torque(τ)=kIs

Additionally, for the BLDC electromotive torque to X=Xa-Xb whose voltage is the line

X-2(A-B)dIs/dt=2RIs-2Vs

So that the Torque(τ)= τ_m+M α+Ld α/dt

When torque is τ and inertia is L M is the damping coefficient.

induction Motor for Electric Vehicle Propulsion Application: When running at a fixed voltage and fixed frequency, the induction motors depicted in Figure 7 don't have the same high beginning torque as DC series motors. Other control methods, such as FOC or v/f approaches, can, however, be used to alter this property. When used in vehicles, these management techniques enable the motor to start with its maximum torque. Because they require little upkeep, squirrel cage induction motors have a long lifespan. It is possible to produce induction motors with an efficiency of 95%. Therefore, it was discovered that induction motors, which are physically robust and require little upkeep, are most suited for electric vehicles, with IM with longer and larger diameter designs showing higher performance. [15] When compared to other types of motors, the induction motor is found to be suitable in all respects, including adaptability, long life, and cost-effectiveness. Some electric vehicle manufacturers, like Tesla and BMW, prefer induction motors, however, when compared to other motor types, induction motors are shown to be adequate in all areas, including adaptability, long life, and cost-effectiveness. There was an improvement in the induction motor's overall performance following the optimization of the inverted trapezoid slot. An active series filter can be used in circuits to increase the power factor, or the phase angle between current and voltage, to a desired value of unity.[16]

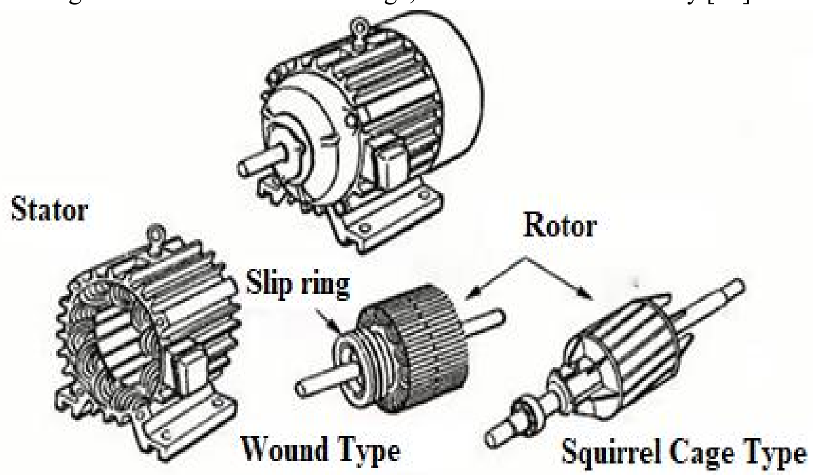
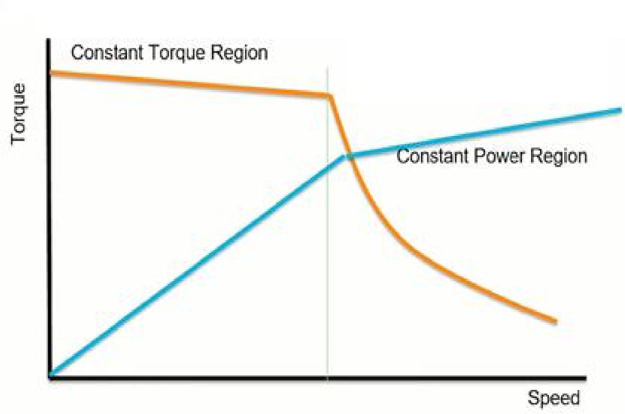


Figure 7 The induction Motor's Structure Types of wounds and squirrel cages

Motor Specification for EV application:

- Rated Power =360 Watt
- Output Speed 250 RPM
- Motor length=330mm
- Rated Voltage 24 Volt

V. SECTION 5. JUSTIFICATION OF INDUCTION MOTOR-DRIVEN SOLAR-POWERED ELECTRIC VEHICLE:



Graph 1: Display of Motor Performance Graphically

The reliability concerns, roughness, low maintenance needs, cost, and ability to function under challenging conditions of induction motors are advantages. Although direct torque control and vector control are used to increase the induction motor's efficiency. Diagram 1 describes the environment. [12] [17] It was discovered that an electric vehicle's cost might be significantly decreased while also improving its dynamic overall performance by using the RMxprt module of optimization. [18] Additionally, using hairpin stator winding and oil spray for cooling an induction motor utilized in electric vehicle propulsion applications can increase an induction motor's overall performance. [19]

The following Table 2 provides information on the overall performance of BLDC and induction motors when compared to the following parameters. view angle

S. N.	Parameters	BLDC Motor	Induction Motor
01	Rotor Magnet	A set of permanent magnets are used in BLDC motors in place of the rotor's windings.	The rotor of an induction motor is devoid of magnets.
02	Starting current	It is rated for the beginning current. It is not necessary to have a unique starter circuit.	Since the beginning current can be up to seven times the rate, the stator circuit should be powered by an electric vehicle fully chosen. Typically, a star-delta starter is used.
03	Output Power/frame	Higher	The size of the output power frame is average. Output power to power frame size is smaller than with BLDC because both the stator and the rotor must be wound.
04	Speed/ torque Characteristics	The flat is the speed/torque characteristic. It permits operations with rated loads at all speeds.	The speed/torque characteristic is nonlinear. It enables lower torque at lower speeds
05	Rotor Inertia	There is less rotor inertia. It makes certain dynamics possible.	There is more rotor inertia. This makes it possible for weak dynamical traits.
06	Slip	Between the frequencies of the stator and rotor, there is no slippage.	By slip frequency with load in the motor, the rotor runs at a lower frequency than the stator.
07	Controller	The motor must always be driven by a controller. It will also be utilized to control the motor's variable speed.	Operation at a fixed speed does not require a controller. Only the desired variable speed needs a controller.
08	Efficiency	greater effectiveness	more than BLDC, but less
09	Cost of motor	due to the permanent magnet, higher	Lower Compared to BLDC
10	Size	The BLDC motor is more compact.	greater in size than BLDC
11	Application	Electric automobiles, hybrid vehicles, DVD/CD	Lifts, cranes, hoists, large exhaust fans, driving lathe machines, crushers, etc

Table 2 Performance of BLDC and induction motor at different Parameters

The solar-powered electric vehicle has only the challenge of the limits of charging capacity which is proportional to the solar panel and the aerodynamic loss. The overall performance is directly related to the kind of friction exerted by the tire.

Here we can understand the following forces exerted by an electric vehicle as

Rolling Resistance Force (Frr)

Aerodynamic Drag Force (F aero)

Hill Climbing Force (Fhc)

Acceleration Force (Fxl)

Whereas Acceleration force can be classified as a. Linear Acceleration Force b. Angular acceleration force

Simulation Results: The performance evaluation was done using MATLAB simulations as per the parameters identified and the results found that the induction motor performs well in terms of robustness, low maintenance, high speed, reliable durable and competitive cost whereas solar rooftops can be a better option to charge an inbuilt battery

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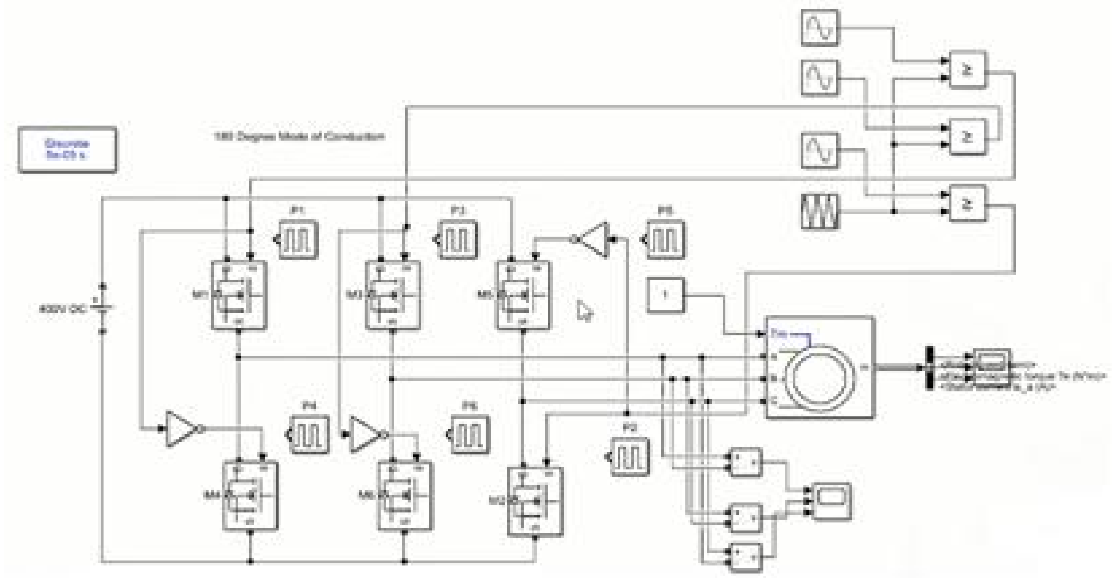
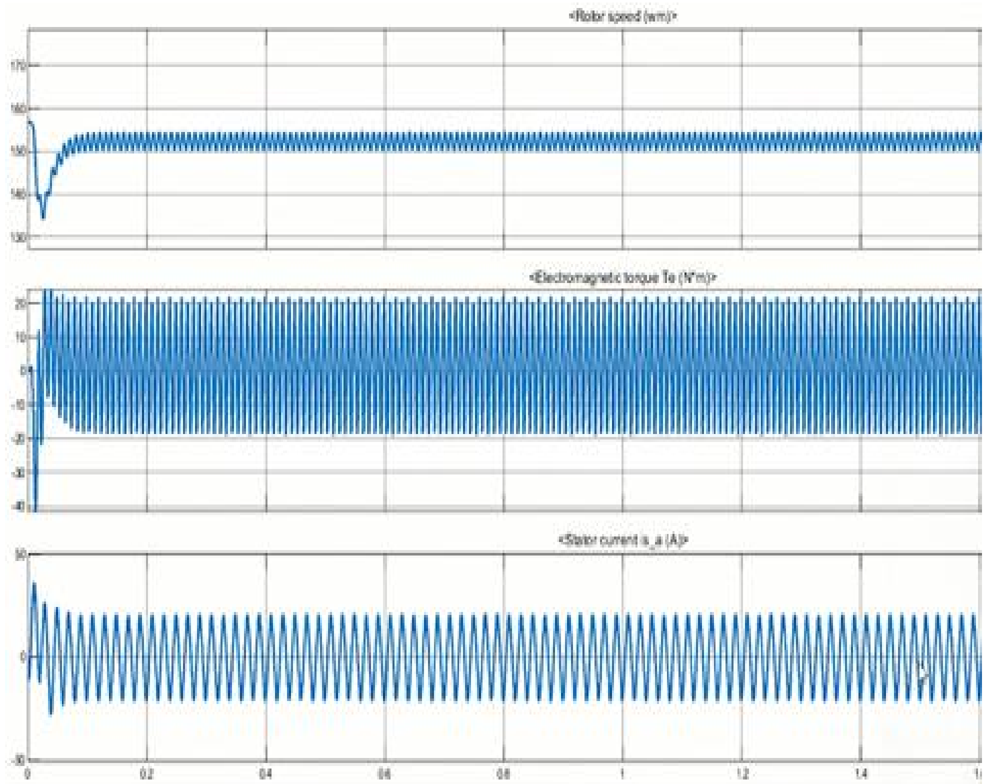
Volume 3, Issue 1, August 2023

into an electric vehicle at the time of moment when the electric vehicle parked open area of space and due to approximately 300sunlight days in India will help slow and continuous charging of the battery which will improve the performance of the battery and also extend the distance covered by the electric vehicle. At the moment the electric vehicle runs using a prime mover as an induction motor the MATLAB simulation is done the results can be seen in Simulation 1 below and the second method of PWM method we can use so that simulation results are found as



Simulation 1 MATLAB Simulation for an induction Motor for Electric Vehicle

And the sin wave result for induction motors used as a prime mover into Electric vehicles will be as



Simulation Result 1 Waveform output

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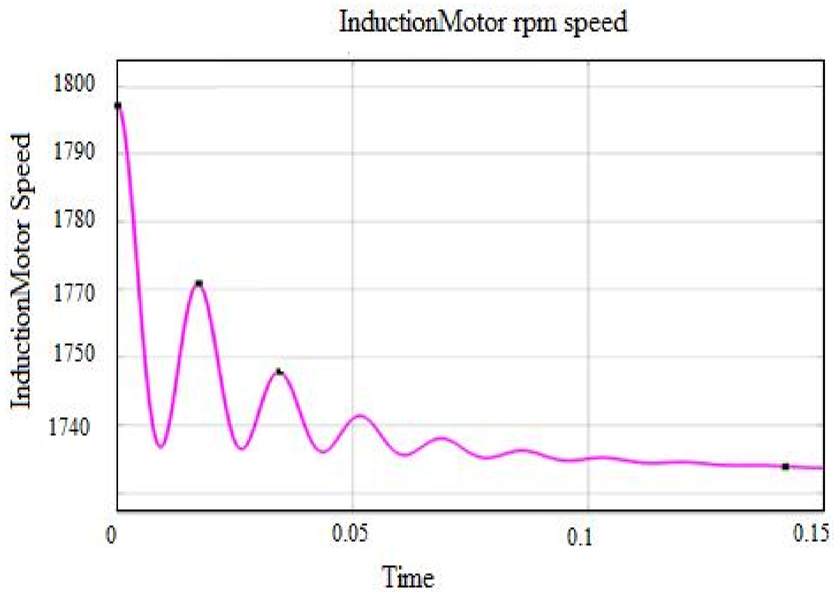

Simulation Result 2 Observation of speed using MATLAB Simulink of an induction motor connected to AC[4]
Some of the problems faced by solar rooftops vehicle is irregular sunlight. Shade also affects the performance of the solar panel.

VI. CONCLUDED WITH THE DIRECTION OF FUTURE RESEARCH WORK:

In this research, the performance of an induction motor was evaluated using MATLAB and compared to a BLDC motor. It was found that the robustness, minimal maintenance, long life, and high-speed characteristics of the induction motor make it a good prime mover for an induction motor-driven solar-powered electric vehicle and increase the efficiency of the vehicle. Additionally, it has been shown that heavy-duty three-wheel and four-wheel electric vehicles with rooftop solar arrays can assist in charging batteries when parked outside. And certainly, future research will focus on the prospect of a solar array skin type that may be used on the body of electric vehicles. It will also run a campaign to raise public understanding of government regulations for EV drivers.

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