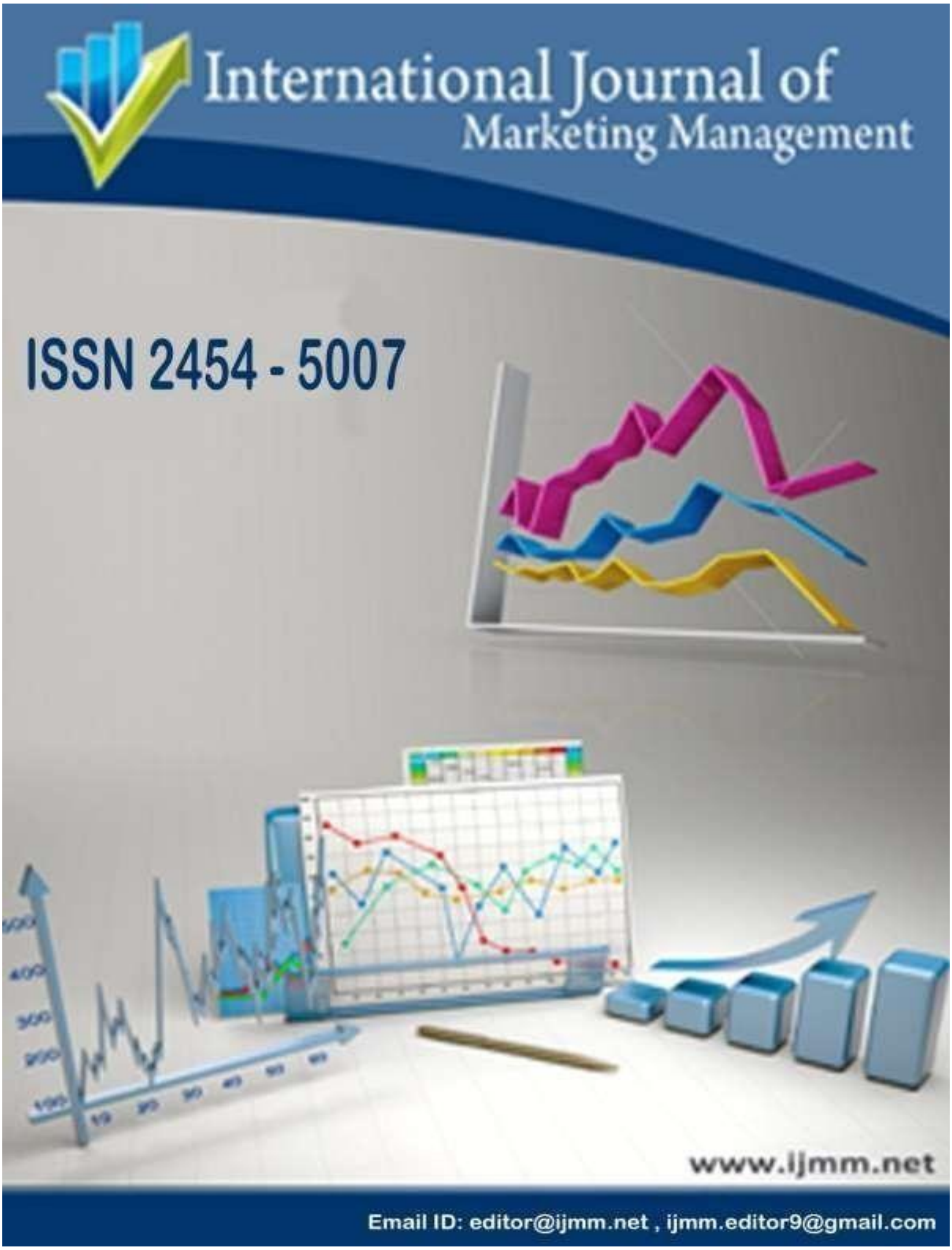
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A NEW EFFICIENT SYSTEM FOR PV FED TO BLDC MOTOR BY USING ANN CONTROLLER

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ABSTRACT

Electric vehicles (EV), including Battery Electric Vehicle (BEV), Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicle (PHEV), Fuel Cell Electric Vehicle (FCEV), are becoming more commonplace in the transportation sector in recent times. As the present trend suggests, this mode of transport is likely to replace internal combustion engine (ICE) vehicles in the near future. Each of the main EV components has a number of technologies that are currently in use or can become prominent in the future. EVs can cause significant impacts on the environment, power system, and other related sectors. The present power system could face huge instabilities with enough EV penetration, but with proper management and coordination, EVs can be turned into a major contributor to the successful implementationof the smart grid concept. There are possibilities of immense environmental benefits as well, as the EVs canextensively reduce the greenhouse gas emissions produced by the transportation sector. However, there are some major obstacles for EVs to overcome before totally replacing ICE vehicles. Industrial Motor Drives mainly deals with operations at base speed of motor. Electric Vehicle Motor Drives deals with operations that require sudden start and stop, low speed operations and base speed operations as well. The system should meet the objective of variable speed, variable torque applications like Electric Vehicles (EVs). As per studies, BLDC motor is found to be a suitable motive element for EV application based on its suitable torque speed characteristics. The system needs to implement with a suitable control mechanism that will help to operate the motor in an efficient manner.

Keywords: Electric Vehicle; Energy Sources; Electric Motors; Motor Characteristics

INTRODUCTION

PM motor drives require a rotor position sensor to properly perform phase commutation and/or current control. For PMAC motors, a constant supply of position information is necessary; thus a position sensor with high resolution, such as a shaft encoder or a resolver, is typically used. For BLDC motors, only the knowledge of six phase-commutation instants per electrical cycle is needed; therefore, low-cost Hall-effect sensors are usually used. Also, electromagnetic variable reluctance (VR) sensors or accelerometers have been extensively applied to measure motor position and speed. The reality is that angular motion sensors based on magnetic field sensing principles stand out because of their many inherent advantages and sensing benefits [9,10]. An accelerometer is a electromechanical device that measures acceleration forces, which are related to the freefall effect. Several types are available to detect magnitude and direction of the acceleration as a vector quantity, and can be used to sense position, vibration and shock. The most common design is based on a combination of Newton‟s law of mass acceleration and Hooke‟s law of spring action. Then, conceptually, an accelerometer behaves as a damped mass on a spring, which is depicted. When the accelerometer experiences acceleration, the mass is displaced to the point that the spring is able to accelerate the mass at the same rate as the casing . The displacement is then measured to give the acceleration. There is a wide variety of accelerometers depending on the requirements of natural frequency, damping, temperature, size, weight, hysteresis, and so on. Some of these types are piezoelectric, piezo-resistive, variable capacitance, linear variable differential transformers (LVDT), potentio-metric, among many others . The MEMS accelerometer issilicon micro-machined, and therefore, can be easily integrated with the signal processing circuits.

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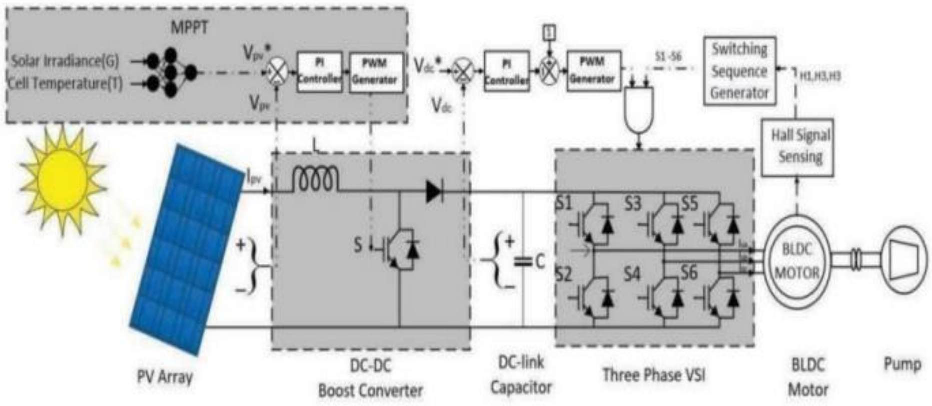

Fig 1. Proposed system block diagram

Electric vehicles (EV), including Battery Electric Vehicle (BEV), Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicle (PHEV), Fuel Cell Electric Vehicle (FCEV), are becoming more commonplace in the transportation sector in recent times [1,2]. With increase in EVs, the impact of smart charging and fast charging on the power system is explained along with its impact on the battery state of health and degradation is studied [3,4]. Most EVs are sourcing DC voltage. A direct use of DC is preferred as it avoids use of additional converter hardware. The battery performance depends not only on types and design of the batteries, but also on charger characteristics and charging infrastructure [5,6]. Combining high-energy-density batteries and high- power-density ultra-capacitors in fuel cell hybrid electric vehicles (FCHEVs) results in a high-performance, highly efficient, low-size, and light system. Often, the battery is rated with respect to its energy requirement to reduce its volume and mass [7,8]. All of the electrical motors that do not require an electrical connection (made with brushes) between stationary and rotating parts can be considered as brushless permanent magnet (PM) machines which can be categorized based on the PMs mounting and the back-EMF shape . The PMs can be surface mounted on the rotor (SMPM) or installed inside of the rotor (IPM), and the back-EMF shape can either be sinusoidal or trapezoidal. According to the back-EMF shape, PM AC synchronous motors (PMAC or PMSM) have sinusoidalback-EMF and Brushless DC motors.

LITERATURE SURVEY

The integration of photovoltaic (PV) systems with brushless DC (BLDC) motors presents a promising solution for various applications such as solar-powered water pumps, fans, and electric vehicles. To optimize the performance and efficiency of such systems, advanced control techniques are required. This literature survey explores existing research and developments in the integration of PV systems with BLDC motors, focusing on the use of artificial neural network (ANN) controllers for efficient system operation. PV systems convert solar energy into electrical energy through photovoltaic cells, while BLDC motors utilize electronic commutation to achieve efficient and reliable operation. When combined, PV systems can provide renewable energy to power BLDC motors, enabling sustainable and environmentally friendly applications across various industries. Artificial neural networks (ANNs) are computational models inspired by the biological neural networks of the human brain. ANN controllers have gained popularity in recent years due to their ability to learn complex nonlinear relationships and adapt to changing operating conditions. In the context of PV-fed BLDC motor systems, ANN controllers offer advantages such as improved efficiency, robustness, and dynamic response compared to traditional control methods.

Several research studies have investigated the integration of PV systems with BLDC motors using ANN controllers for efficient system operation. For instance, Patel et al. (2018) proposed an ANN-based maximum power point tracking (MPPT) algorithm for PV systems coupled with BLDC motors. The ANN controller dynamically adjusts the motor speed to maximize power extraction from the PV array under varying solar irradiance conditions, resulting in improved energy efficiency. Furthermore, Kumar et al. (2020) developed an ANN-based predictive control strategy for PV-fed BLDC motor drives. The ANN controller predicts the

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future operating conditions based on historical data and optimally adjusts the motor speed and torque to meet desired performance objectives. Simulation results demonstrated superior performance and stability compared to conventional control techniques. Additionally, Singh et al. (2019) investigated the use of ANN-based adaptive control for PV-fed BLDC motor drives. The ANN controller continuously adapts its parameters based on real-time system feedback to optimize energy conversion efficiency and maintain stable operation under varying load conditions. Experimental validation showed enhanced performance and robustness in practical applications.

Performance evaluation of PV-fed BLDC motor systems with ANN controllers involves simulation studies, laboratory experiments, and field trials. Simulation-based studies utilize software tools such as MATLAB/Simulink, PLECS, and PSIM to model the PV array, power electronics converters, and BLDC motor drive system. Laboratory experiments involve the development of hardware-in-the-loop (HIL) setups or prototype systems to validate the performance of ANN controllers under realistic operating conditions. Field trials may involve the deployment of PV-fed BLDC motor systems in real-world applications such as solar-powered water pumps or electric vehicles to assess their efficiency, reliability, and performance in practical scenarios. In conclusion, the integration of PV systems with BLDC motors using ANN controllers offers a promising solution for efficient and sustainable energy conversion. Through the use of ANN controllers, PV-fed BLDC motor systems can achieve optimal performance, dynamic response, and energy efficiency across a wide range of operating conditions. Simulation, laboratory, and field studies have demonstrated the feasibility and effectiveness of ANN-based control strategies in improving the performance and reliability of PV-fed BLDC motor systems. Continued research and development in this area are essential for advancing the integration of renewable energy sources with electric motor drives and accelerating the transition towards a sustainable energy future.

PROPOSED CONFIGURATION

(BLDC or BPM) have trapezoidal back-EMF. A PMAC motor is typically excited by a three-phase sinusoidal current, and a BLDC motor is usually powered by a set of currents having a quasi-square waveform 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. In the excitation of a three-phase BLDC motor, except for the phase-commutation periods, only two of the three phase windings are conducting at a time and the no conducting phase carries the back-EMF. There are many categories of sensor-less control strategies [23]. The most popular category is based on back electromotive forces or back-EMFs. Sensing back-EMF of unused phase is the most cost-efficient method to obtain the commutation sequence in star wound motors. Since back-EMF is zero at standstill and proportional to speed, the measured terminal voltage that has large signal-to- noise ratio cannot detect zero crossing at low speeds. That is the reason why in all back-EMF-based sensor-less methods the low-speed performance is limited, and an open-loop starting strategy is required.

The advancement in battery technology is a boost to the development of electric vehicles (EV). Moreover, the expedited expansion of charging infrastructure de-limits the range anxiety, which favours the adoption of EVs. Notably, the EV charger topologies are broadly categorized as single and two-stage topologies [1]. The state-of-the-art single-stage EV chargers are considered in [2]-[7]. A single-stage EV charger with high efficiency is presented in [2]. However, the effectiveness of the proposed charger is tested for charging of high voltage batteries. Further, the presented charger uses more components than the available two-stage charger in [1]. An attempt to reduce the number of components in an EV charger is carried out in [3]. In this, the authors have presented the current source converter-based EV charger. The major advantage of this topology is that it does not require a grid side filter. However, the utilization of back-to-back bidirectional switches, increases the design complexity. Moreover, this topology is derived from a full-bridge converter, therefore, it suffers from high circulating current when used with low voltage batteries. Noting this, a soft-switching technique is devised in [4]. The authors have proposed an EV charger with zero voltage switching capability. In this way, this topology has the advantage of low switching losses. However, this topology is experimentally verified for high voltage batteries only. Apart from this, to reduce the size of an EV charger, a differential interleaved boost converter-derived EV charger is presented in [5]. In this, the authors have presented an electrolytic capacitor-less EV charger.However, a step-down converter is required to make it feasible for low voltage batteries.

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Keeping a buck-boost converter-based battery charger in context to charge the low voltage batteries, a topology has been studied in [6]. In this topology, a Cuk converter-based topology is proposed. In this, the authors have presented a single-stage EV charger that significantly reduces the battery current ripples. However, the performance of the charger is verified for high voltage batteries only. For low voltage batteries, a Cuk-SEPIC-based topology is proposed in [7]. In this, the authors have presented an EV charger that satisfies the applicable standard for the grid current [7] and the battery current [8]. However, the presented EV charger is unidirectional. Noting the increased utilization through bidirectional operation, a comprehensive study is carried out on single-stage bidirectional EV chargers [9]-[10]. Notably, the authors in [9] have presented an interleaved singlestage bidirectional EV charger. Since the presented EV charger is derived from a dual active bridge converter, it has the advantage of inherent zero voltage switching, i.e. low switching losses. However, the voltage mismatch between battery voltage and the voltage across the secondary winding of the high frequency transformer creates the circulating current in the secondary side of the converter. Therefore, this EV charger is less suitable for low voltage battery charging. In this context, a single-stage bidirectional EV charger for low voltage battery charging is presented in [10]. Here a current fed topology is given. It is notable, that the back-back to bidirectional switch increases the design complexity of this current fed converter based EV charger. Further, this topology is less suitable for high voltage application, i.e., less suitable for wide voltage range operation.

SIMULATION RESULT& DISCUSSION

The aim of this project is to design microcontroller-based BLDC motor drives for electric vehicle. Based on several PWM switching schemes the performance of converter parameters will be tested and observed. Open loop and closed loop speed control of the system is done and the results are tabulated which verify the effective developed drive operation. Compared with a DC motor, the BLDC motor uses an electric commutator rather than a mechanical commutator, so it is more reliable than the DC motor. In a BLDC motor, rotor magnets generate the rotor's magnetic flux, so BLDC motors achieve higher efficiency [2]. It has become possible because of their superior performance in terms of high efficiency, fast response, and weight, precise and accurate. The BDLC motor detects the position of the rotor using Hall sensors. Three sensors are required for position information. With three sensors, six possible commutation sequences could be obtained. In the Hall sensor technique, three Hall sensors are placed inside the motor, spaced 120 degrees apart. Each Hall sensor provides either a High or Low output based on the polarity of magnetic pole close to it. Rotor position is determined by analyzing the outputs of all three Hall sensors. Based on the output from hall sensors, the voltages to the motor's three phases are switched. The advantage of Hall sensor-based commutation is that the control algorithm is simple and easy to understand. Hall sensor-based commutation can also be used to run the motor at very low speeds. BLDC motor control is to have only one current at a time. Because of which current sensor is not advised to be placed on each phase of the motor; one sensor placed in the line inverter input is sufficient to control the current of each phase. Insulated systems are not required when sensor is on the ground line. The torque and speed of motors is managed by microcontroller. A sufficient amount of processing power is required to solve the algorithms needed to generate Pulse Width Modulated (PWM) outputs for motor. By simply varying the voltage across the motor, one can control the speed of the motor. When using PWM outputs to control the six switches of the three-phase bridge, variation of the motor voltage can be achieved easily by changing the duty cycle of the PWM signal. The three-phase BLDC speed control is done by using both open loop and closed loop configurations. Open-loop control is used to control the speed of the motor by directly controlling the duty cycle of the PWM signal that directs the motor-drive circuitry.

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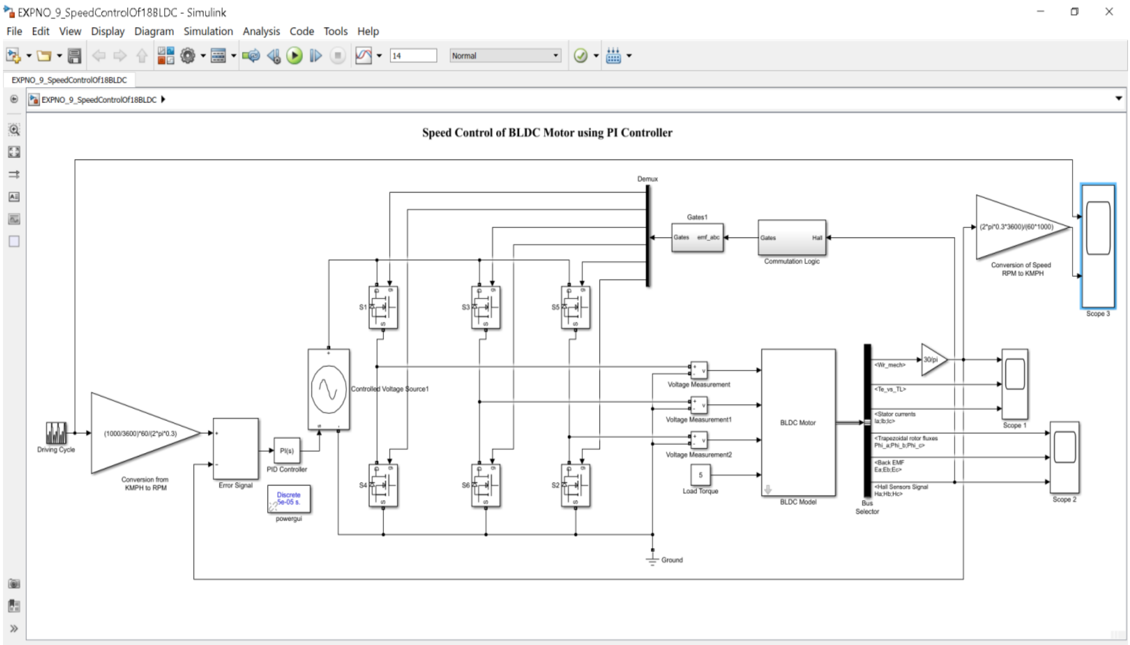
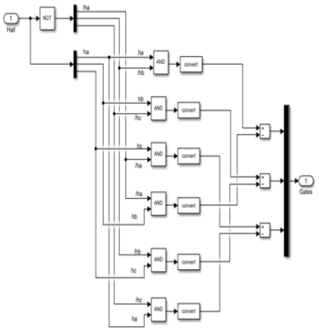


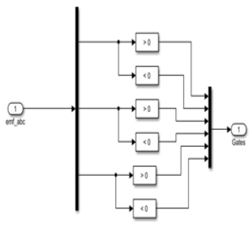
Fig 2. Shows Speed Control of BLDC using PI controller

An electric battery is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices such as flashlights, smart phones, and electric cars. When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode.[2] The terminal marked negative is the source of electrons that when connected to an external circuit will flow and deliver energy to an external device. When a battery is connected to an external circuit, electrolytes are able to move as ions within, allowing the chemical reactions to be completed at the separate terminals and so deliver energy to the external circuit. It is the movement of those ions within the battery which allows current to flow out of the battery to perform work. Historically the term "battery" specifically referred to a device composed of multiple cells, however the usage has evolved to additionally include devices composed of a single cell.



Truth Table for generation of EMF_A,EMF_B,EMF_C

Ha	Hb	Hc	EMF_A	EMF_B	EMF_C
0	0	0	0	0	0
0	0	1	0	-1	+1
0	1	0	-1	+1	0
0	1	1	-1	0	+1
1	0	0	+1	0	-1
1	0	1	+1	-1	0
1	1	0	0	+1	-1
1	1	1	0	0	0



Truth Table for generation of Pulses for Inverter

EMF_A	EMF_B	EMF_C	Q1=S1	Q2=S4	Q3=S3	Q4=S6	Q5=S5	Q6=S2
0	0	0	0	0	0	0	0	0
0	-1	+1	0	0	0	1	1	0
-1	+1	0	0	1	1	0	0	0
-1	0	+1	0	1	0	0	1	0
+1	0	-1	1	0	0	0	0	1
+1	-1	0	1	0	0	1	0	0
0	+1	-1	0	0	1	0	0	1
0	0	0	0	0	0	0	0	0

Fig 3. Proposed controller

Primary (single-use or "disposable") batteries are used once and discarded; the electrode materials are irreversibly changed during discharge. Common examples are the alkaline battery used for flashlights and a multitude of portable electronic devices. Secondary (rechargeable) batteries can be discharged and recharged multiple times using mains power from a wall socket; the original composition of the electrodes can be restored by reverse current. Examples include the lead-acid batteries used in vehicles and lithium-ion batteries used for portable electronics such as laptops and smart phones.

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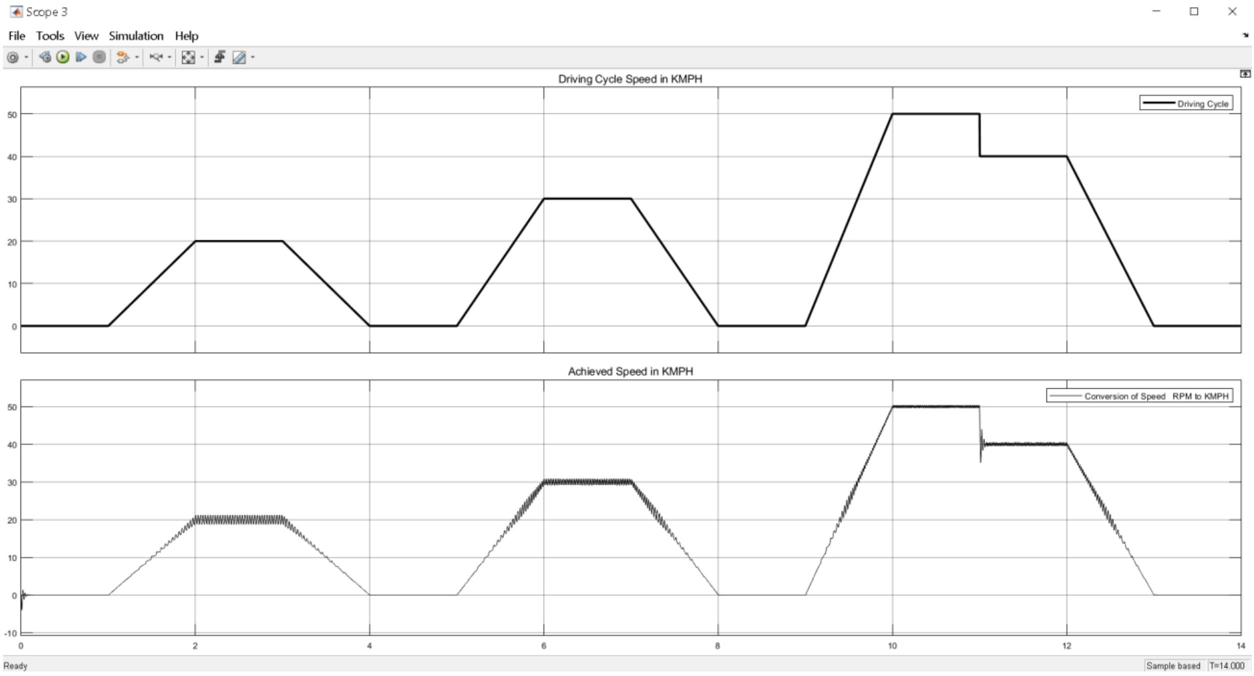

Fig 4. waveforms Represent speed of BLDC motor

Batteries come in many shapes and sizes, from miniature cells used to power hearing aids and wristwatches to small, thin cells used in smart phones, to large lead acid batteries used in cars and trucks, and at the largest extreme, huge battery banks the size of rooms that provide standby or emergency power for telephone exchanges and computer data centers. According to a 2005 estimate, the worldwide battery industry generates US$48 billion in sales each year, with 6% annual growth. Batteries have much lower specific energy (energy per unit mass) than common fuels such as gasoline. This is somewhat offset by the higher efficiency of electric motors in producing mechanical work, compared to combustion engines. Due to the fact that the software used by commercial e- Bikes is confidential, the software has been designed based on the fundamentals of BLDC motors presented in the introduction of this paper and other studies . The commutation scheme used in this design is described . By analyzing the diagram in Fig. 5, the system of equations (1) has been deduced, through which the control logic has been modeled as a combinational system. The inputs to this combinational system are the Hall position sensors signals and a master PWM, and the outputs are the PWM signals.

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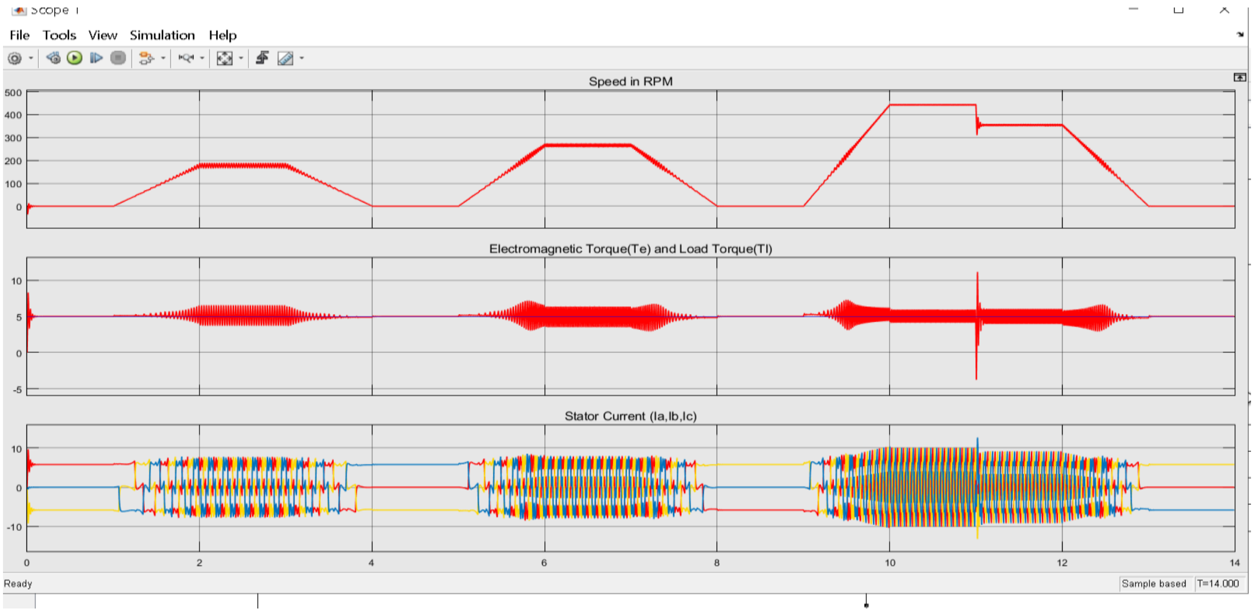

Fig 5. Waveform represents speed, torque & stator current

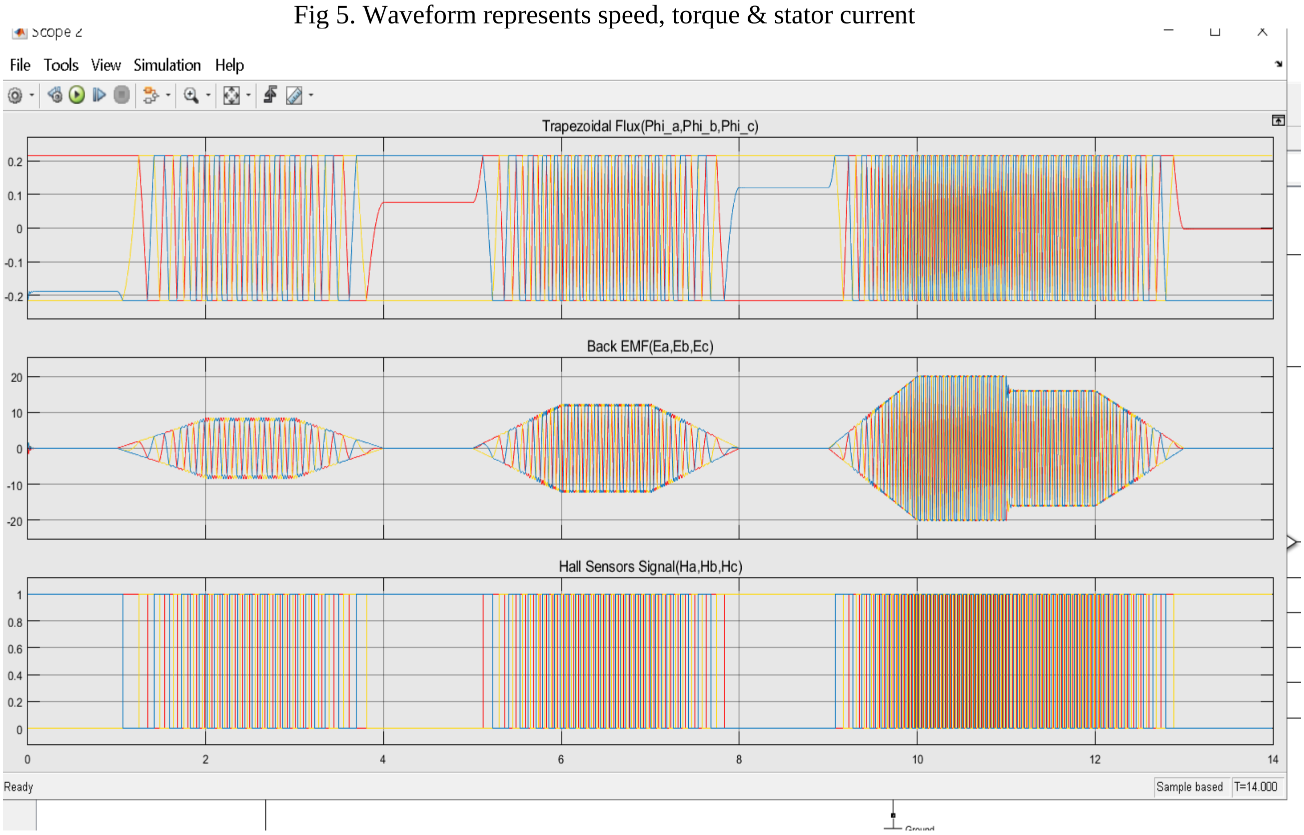

Fig 6.waveform represents the flux, emf & hall sensors

CONCLUSION

A D.C (Direct Current) drive has been used prominently in the E.V's because they provide simple speed control and ideal torque-speed requirements. The ideal torque suits the traction and terrain requirements inan E.V. Their commutator and brushes make them less reliable. So, it is not suitable for a maintenance free function. With advancements in power electronics, A.C motor drives with IM or PMSM are much more

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preferred than a D.C drive with advantages of Reliability, Greater Efficiency, Less Maintenance and High Power Density. PMSM offers overall reduction in the weight and volume for a given value of power. Owing to no rotor copper losses, the efficiency is much higher. The reliability is quite high. But the winner in this selection process for medium size electric vehicle stands out to be BLDC motor drive, which are fed by a rectangular A.C supply. With advantages like elimination of the Brushes, ability to produce a larger Torque than the others at the same values of Current and Voltage, High Power Density and Great Efficiency, P.M Brushless D.C Motor Drive an ideal choice for being used in the Electric Vehicle Propulsion System.

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