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Energy Management System in Electric Vehicle with PV Fed SRM System

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ABSTRACT

This project presents the switched reluctance motor (SRM) with hybrid renewable system. Switched Reluctance Motors (SRM) has a wide range of industrial applications because of their advantages over conventional AC/DC Drives. This is due to simple construction, ruggedness and inexpensive manufacturing potential. Various methods have used and applied to control SRM speed generally, the PV-fed EV has a similar structure to the hybrid electrical vehicle, whose internal combustion engine(ICE) is replaced by the hybrid system. A hybrid energy system, or hybrid power, usually consists of two or more renewable energy sources used together to provide increased system efficiency as well as greater balance in energy supply. The PV has different characteristics to ICEs, the maximum power point tracking (MPPT) and solar energy utilization are the unique factors for the PV-fed EVs. This matter is done by applying the proposed system to a multi-objective function including both speed error and torque ripple. This controller is implemented for an 8/6, 4-kW SRM. In this paper to coordinate the PV panel, SRM and battery. Hybrid renewables applied in Energy storage like battery technologies, superconducting magnetic energy, capacitors, compressed air and pumped storage, seems to be an alternative method that the operator of an electrical power grid can use to adapt energy production to energy consumption, both of which can vary randomly over time. The simulation results confirm excellent dynamic performance, reduced torque ripple and current oscillation can be achieved by using ANFIS.

KEYWORDS: *PV System, Electric Vehicle, SRM, Energy Management.*

I. INTRODUCTION

Electric vehicles are automobiles, which are powered by electrical engine and electrical energy. An electric vehicle (EV), also referred to as an electric drive vehicle, uses one or more electric motors or traction motors for propulsion [1]. An electric vehicle may be powered through a collector system by electricity from off vehicle sources, or may be self contained with a battery or generator to convert fuel to electricity [2]. EVs include road and rail vehicles, surface and underwater vessels, electric aircraft and electric spacecraft [4]. EVs first came into existence in the mid-19thcentury, when electricity was among the preferred methods for motor vehicle propulsion, providing a level of comfort and ease of operation that could not be achieved by the gasoline cars of the time [5].Due The development of electric vehicles is a very important and prospective process. Electric vehicles are powered by an electric motor instead of an internal combustion engine [6-7]. Electric vehicles are 100% eco-friendly and they do not emit any toxic gases like CO2, N2 etc. which causes Global warming. But there are some downsides in the case of electric vehicles. Due to the limitation of current battery technologies, the driving range is very short. This will reduce the wide application of electric vehicles. In earlier, in terms of motor drives, high-performance permanent magnet (PM) machines are widely used [8]. In PM machines there is no field winding and the field is provided by the permanent magnet. Most commonly rare earth materials are used [9]. But they are very costlier. So by the use of PM machines it will also reduce the wide application of electric vehicles. To overcome these issues a photovoltaic panel and a switched reluctance motor can be used for power supply and motor drive [10]. By introducing PV panel on the top of the vehicle, a suitable energy source can be achieved. PV panel has low power density for traction drives; they can be used to charge the batteries. Also the SRM need no rare earth materials. The switched reluctance motor (SRM) is a type of a stepper motor, an electric motor that runs by reluctance torque [11]. Unlike common DC motor types, power is delivered to windings in the stator (case) rather than the rotor. This greatly simplifies mechanical design as power does not have to be delivered to a moving part, but it complicates the electrical design as some sort of switching system needs to be used to deliver power to the different windings [12-13]. With modern electronic devices, precisely timed switching is not a problem, and the SRM is a popular design for modern stepper motors [14]. Its main drawback is torque ripple. Hence, it is necessary to design a hybrid fuzzy controller for SRM to get the optimum performance in the presence of the parameters variations and load disturbances. This study proposes a hybrid fuzzy controller where in discrete PI and fuzzy logic control algorithms are combined to get the desired performance of SRM [15]. This controller employs only with the speed error and changes in speed error and produces an equivalent control term. The designed hybrid fuzzy controller improves system performance in transient and steady state. Generally, the PV-fed EV has a similar structure to the hybrid electrical vehicle, whose internal combustion engine (ICE) is replaced by the PV panel. The PV-fed EV system is illustrated in Fig.1. Its key components include an off-board charging station, a PV, batteries and power converters. In order to decrease the energy conversion processes, one approach is to redesign the motor to include some on-board charging functions. For instance, paper designs a 20-kW split-phase PM motor for EV charging, but it suffers from high harmonic contents in the back electromotive force (EMF). Another solution is based on a traditional SRM. Paper achieves onboard charging and power factor correction in a 2.3-kW SRM by employing machine windings as the input filter inductor. The concept of modular structure of driving topology is proposed in paper. Based on intelligent power modules (IPM), a four-phase half bridge converter is employed to achieve driving and grid-charging. Although modularization supports mass production, the use of half/full bridge topology reduces the system reliability (e.g. shoot-through issues). Paper develops a simple topology for plug-in hybrid electrical vehicle (HEV) that supports flexible energy flow. But for grid charging, the grid should be connected to the generator rectifier that increases the energy conversion process and decreases the charging efficiency. Nonetheless, an effective topology and control strategy for PV-fed EVs is not yet developed. Because the PV has different characteristics to ICEs, the maximum power point tracking (MPPT) and solar energy utilization are the unique factors for the PV-fed EVs.

II. SRM Drive

The concept of switched reluctance motor was established in 1838 but the motor could not realize its full potential until the modern era of power electronics and computer aided electromagnetic design. SRM's are electrically commutated AC machines and are known as variable reluctance motor as studied by Lawrenson et al (1980). They are more than a high-speed stepper motor, lacking the usual expensive permanent magnets. It combines many of the desirable qualities of Inductionmotor drives, DC commutator motor drive, as well as Permanent Magnet (PM) brushless D.C systems. SRM is rugged and simple in construction and economical when compared with the synchronous motor and the induction motor. They are known to have high peak torque-to-inertia ratios and the rotor mechanical structure is well suited for high-speed applications.

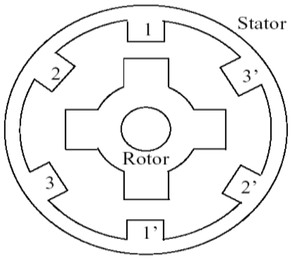

Fig.1. Switched Reluctance Motor

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A. Construction Of Switched Reluctance Motor

The switched reluctance motor has both salient pole stator and rotor, like variable reluctance motor (Nazar 1969), but they are designed for different applications, and therefore, with different performance requirements. A stepper motor is designed to make it suitable for open loop position and speed control in lower applications, where efficiency is not an important factor as shown in Fig2. On the other hand a switched reluctance motor is used in variable speed drives and naturally designed to operate efficiently for wide range of speed and torque and requires rotor position sensing. Here, the diametrically opposite stator pole windings are connected in series and they form one phase. Thus, the six stator poles constitute three phases. When the rotor poles are aligned with the stator poles of a particular phase, the phase is said to be in an aligned position. Similarly, if the inter- polar axis of the rotor is aligned with the stator poles of a particular phase, the phase is said to be in an unaligned position.

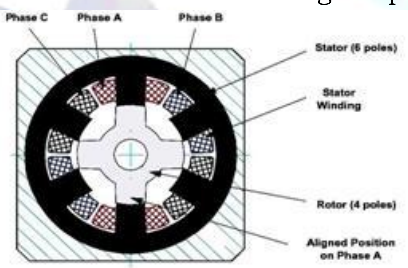


Fig.2. Three-Phase SRM.

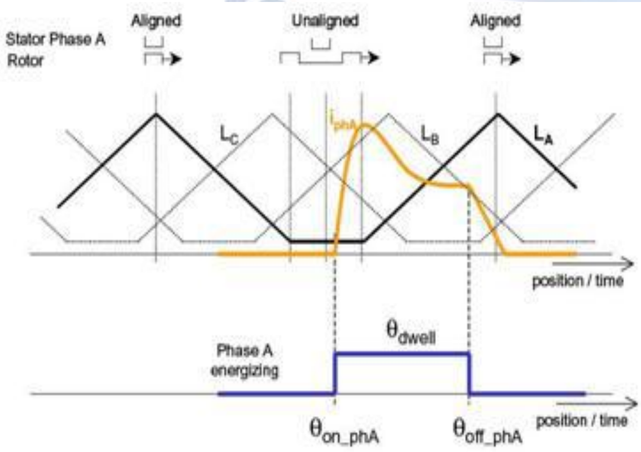


Fig.3. Phase Energizing.

B. SRM Principle Of Operation

SRM differ in the number of phases wound on the stator. Each of them has a certain number of suitable combinations of stator and rotor poles. Fig.3 illustrates a typical 3-Phase SRM with a six stator / four rotor pole configuration. The rotor of an SRM is said to be at the aligned position with respect to a fixed phase if the current reluctance has the minimum value (Corda et al 1979); and the rotor is said to be in the unaligned position with respect to a fixed phase if the current reluctance reaches its maximum value. The motor is excited by a sequence of current pulses applied at each phase. The individual phases are consequently excited, forcing the motor to rotate. The current pulses must be applied to the respective phase at the exact rotor position relative to the excited phase. When any pair of rotor poles is exactly in line with the stator poles of the selected phase, the phase is said to be in an aligned position; i.e., the rotor is in the position of maximum stator inductance (Fig.4).

III. Proposed Topology and Operational Modes

The proposed Four-port topology has four energy terminals, PV, battery and SRM. They are linked by a power converter which consists of eight switching devices (S0~S7), four 8 diodes

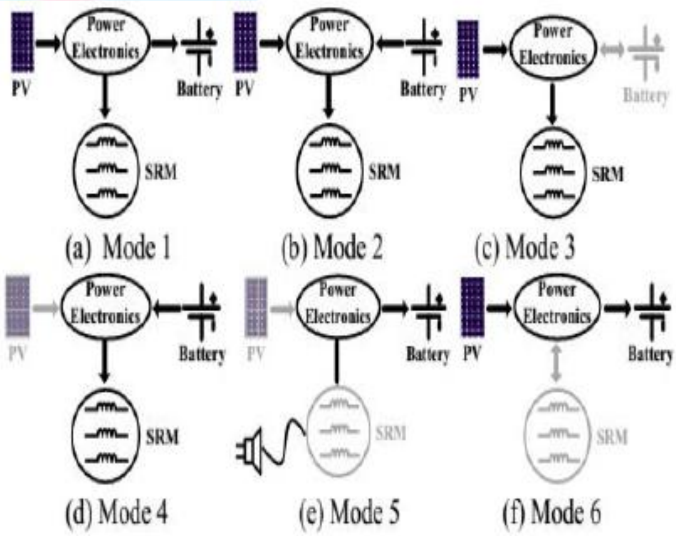


Fig.4. Six operation modes of the proposed topology

Operating modes 1–4 are the driving modes to provide traction drive to the vehicle.

Mode 1: At light loads of operation, the energy generated from the PV is more than the SRM needed; the system operates in mode 1. The corresponding operation circuit is shown in Fig. 5(a), in which relay J1 turns off and relay J2 turns on. The PV panel energy feeds the energy to SRM and charges the battery; so in this mode, the battery is charged in EV operation condition.

Mode 2: When the SRM operates in heavy load such as uphill driving or acceleration, both the PV panel and battery supply power to the SRM. The corresponding operation circuit is shown in Fig. 5(b), in which relay J1 and J2 are turned on.

Mode 3: When the battery is out of power, the PV panel is the only energy source to drive the vehicle. The corresponding circuit is shown in Fig. 5(c). J1 turns on and J2 turns off.

Mode 4: When the PV cannot generate electricity due to low solar irradiation, the battery supplies power to the SRM. The corresponding topology is illustrated in Fig. 5(d). In this mode, relay J1 and J2 are both conducting.

Mode 5: When PV cannot generate electricity, an external power source is needed to charge the battery, such as ac grid. The corresponding circuit is shown in Fig. 5(e). J1 and J2 turn on. Point A is central tapped of phase windings that can be easily achieved without changing the motor structure. One of the three-phase windings is split and its midpoint is pulled out, as shown in Fig. 5(e). Phase windings La1 and La2 are employed as input filter inductors. These inductors are part of the drive circuit to form an ac–dc rectifier for grid-charging.

Mode 6: When the EV is parked under the sun, the PV can charge the battery. J1 turns off and J2 turns on. The corresponding charging circuit is shown in Fig. 5(f).

IV. Grid Charging Control Strategy

The proposed topology also supports the single-phase grid charging. There are four basic charging states and S0 is always turned off. When the grid instantaneous voltage is over zero, the two working states are presented in Fig. 6(a) and (b). In Fig. 6, S1 and S2 conduct, the grid voltage charges the phase winding La2, the corresponding equation can be expressed as (7); in Fig. 7, S1 turns off and S2 conducts, the grid is connected in series with phase winding to charges the battery, the corresponding equation can be expressed.

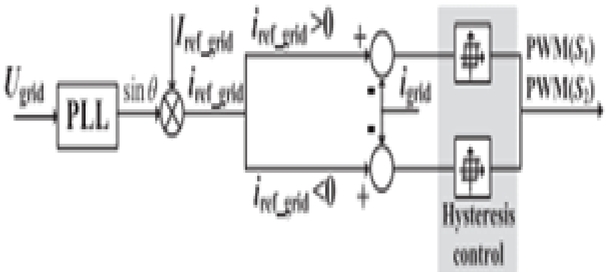
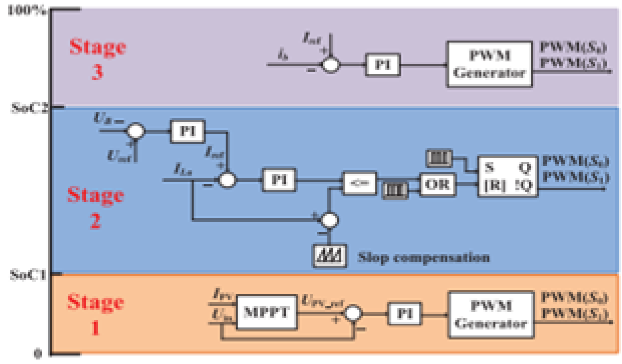


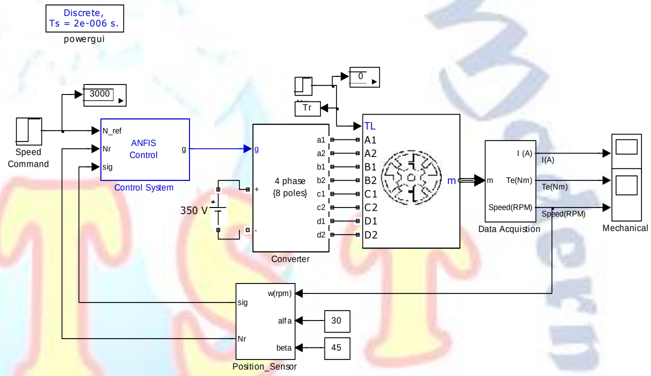
Fig.5. Grid-connected charging control (mode 5).



(c)

Fig.6. Mode 6 charging states and control strategy. (a) Phase inductance charging. (b) Battery charging. (c) Charging control strategy.

V. Simulation Results



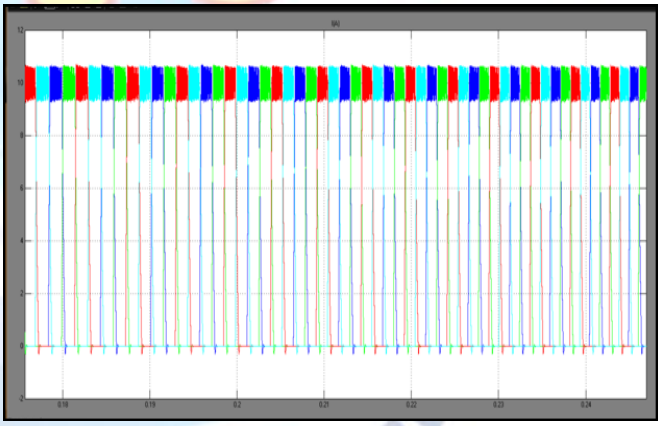


Fig 7: Current waveform of SRM Drive

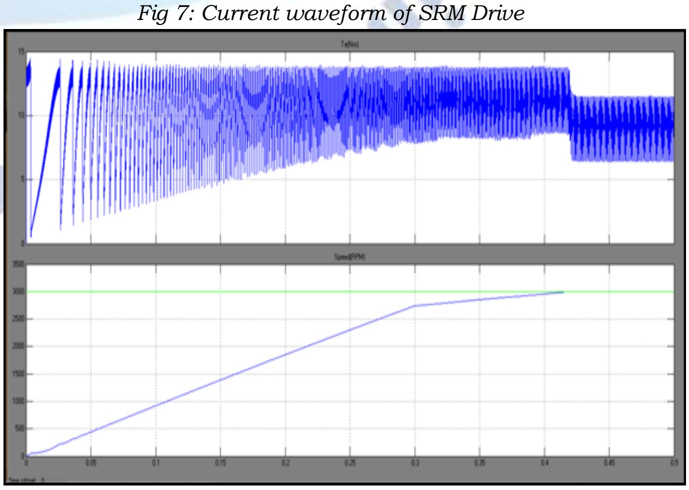


Fig 8: Torque and Speed

VI. Conclusion

In this project in order to tackle the range anxiety of using EVs and decrease the system cost, a combination of the PV panel and SRM is proposed as the EV driving system. In this paper 8/6, 4-kW SRM is used Six working modes are developed to achieve flexible energy flow for driving control, driving/charging hybrid control and charging control. A novel grid-charging topology is formed without a need for external power electronics devices. A PV-fed battery charging control scheme is developed to improve the solar energy utilization. Since PV fed EVs are a greener and more sustainable technology than conventional ICE vehicles, this work will provide a feasible solution to reducing the total costs and CO2emissions of electrified vehicles. It is shown that the presented hybrid controller for SRM drive has fast tracking capability, less steady state error and is robust to load disturbance. The complete speed control scheme of the SRM drive incorporating the hybrid control was implemented. From the above results it is clearly observed that the proposed controller despite of its simple structure has good speed response, high precision speed controller (Hybrid fuzzy) for operating in the whole of speed range and for any loading and environmental conditions were achieved.

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