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DRIVING EFFICIENCY: SOLAR PV-POWERED SRM DRIVE FOR ELECTRIC VEHICLES WITH INNOVATIVE FLEXIBLE ENERGY CONTROL"

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ABSTRACT: Electric cars are automobiles that run on electricity. Some versions feature electric power trains. You can only drive a specific distance due to the current state of battery technology. Historically, high-power permanent magnet (PM) motor drives were widely employed. PM machines do not require a field winding because the field is generated by a stationary magnet. Rare earth materials are used the majority of the time. Of course, the price is significantly higher. A solar screen can be utilized to generate power, and a switching reluctance motor can be used to drive the motor. One technique to reduce the amount of effort involved in energy conversion is to redesign the motor such that it can be charged. PV-fed electric vehicles are unique in that they use solar energy while maintaining maximum power point tracking (MPPT). This study describes a new, low-cost three-port converter that effectively coordinates photovoltaic (PV) panels, switching reluctance motors (SRMs), and batteries. The converter allows energy to flow in more flexible and cost-effective ways. There are now six operational modes, making it easier to control how much energy is transmitted.

Keywords: Electric vehicles, photovoltaic, maximum power point tracking, switched reluctance motors (SRMs).

I. INTRODUCTION

Cars with electric engines are powered by electricity. An electric vehicle (EV), often known as an electric drive vehicle, is powered by at least one driving or electric motor. An electric automobile can run smoothly because it converts fuel into electricity using either a battery or a generator. Alternatively, it can be powered by energy from outside sources via a collector system. Electric vehicles (EVs) include boats that travel on land or in water, electric planes and spaceships, and vehicles that travel by rail or road. When electricity became more widely employed to power automobiles in the middle of the nineteenth century, electric vehicles (EVs) were more comfortable and easier to use than gasoline-powered automobiles.

The production of electric vehicles is critical and appears to be a future technology. Electric automobiles use electric motors instead of internal combustion engines. Electric automobiles are particularly helpful for the environment since they emit no hazardous gases such as CO2 or N2, which contribute to global warming. Nonetheless, there are certain issues with operating electric vehicles. The current state of battery technology results in a short driving range. This reduces the likelihood that many people will purchase electric vehicles.

In the past, motor drives frequently employed high-performance permanent magnet (PM) devices. In PM machines, a fixed magnet generates the magnetic field, eliminating the requirement for a separate field winding. Rare earth materials are used the majority of the time. Of course, the price is significantly higher. When PM machines are employed, the number of electric vehicles will decrease. One solution to these issues could be to use a solar screen as the

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power source and a switching reluctance motor as the motor drive.

Installing a solar panel on the car's top is an effective technique to provide a working energy source. PV panels are ideal for battery charging because they do not provide a lot of power when utilized as motion drives. Rare earth rocks are not required for the SRM. A form of stepper motor known as a switching reluctance motor (SRM) operates via reluctance torque. Unlike other types of DC motors, this one directs power to the stator (the exterior case) rather than the rotor. Adding a switching mechanism to shift electricity to different windings complicates the electrical design. On the other hand, it simplifies mechanical design by eliminating the requirement to power a moving part. With today's technology, precise switching timing is now possible, and the SRM design is currently the best option for stepper motor. Ripple is the most serious problem with turbines.

One technique to reduce the amount of effort involved in energy conversion is to redesign the motor such that it can be charged. Battery cells' performance can be affected by how they are used and charged, as well as how they are built. Because of this, battery chargers are critical to the advancement of this technology. Chargers for batteries are basically divided into two groups:

1) The onboard type and

2) The stand-alone (off board) type.

The internal chargers should be as light, tiny, and inexpensive as possible because the car will always have them with it. As a result, it is rarely viable to have high-power chargers on board that are also galvanically isolated. Even though isolation is an excellent approach to ensure the safety of charger circuits, it is rarely used due to its high setup and operating expenses. Offboard chargers are put in a specific location. The battery's ability to receive charge restricts the amount of power it can provide. PV-fed EVs are distinguished by their usage of maximum power point tracking (MPPT) and solar energy.

A simple, low-cost tri-port adaptor may link the PV panel, SRM, and battery to function together. This allows you to transfer energy in a variety of cost-effective methods.

Conventional PV fed EV system

Because nonrenewable resources are rapidly depleting, the world urgently needs to transition to renewable energy. Vehicles powered by the sun, such as the solar car, are an effective way to conserve nonrenewable energy sources. One of the primary concepts behind a solar-powered vehicle is to use the energy stored in the battery both while the solar panels are charging and afterward. The charged batteries power the motor, which functions as an engine in this situation. People rely heavily on energy to survive on Earth. We rely on several sources of energy to suit our demands.

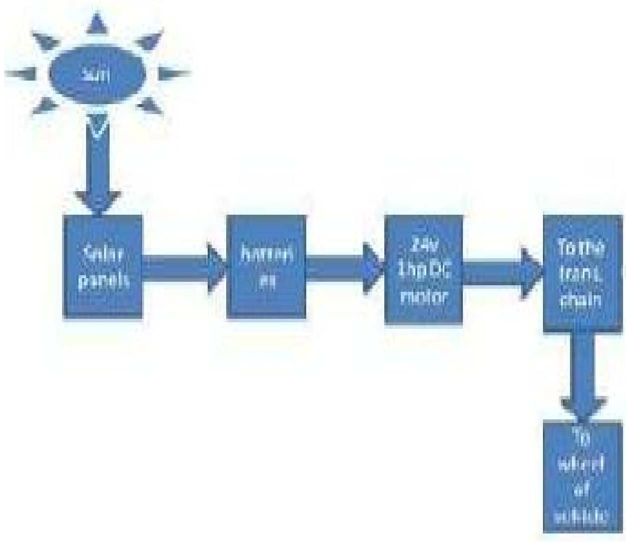

Fig.1 Basic block Diagram Representation of Solar vehicle

The illustration above depicts the entire process of how a solar automobile operates. The sun is the primary source of power for the car. Solar screens gather solar energy and convert it into electricity. The generated electrical energy is supplied to the batteries to charge them, as well as powering a set of 24 V DC high torque DC motors. A chain sprocket connects the engine shaft to the car's back wheel. The screens charge the batteries until they are full, after which they continue to charge them. This makes it easier for the battery to complete its charging and discharging cycles, which are required for the batteries to function effectively.

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Before more advanced power electronics were developed, DC motors were the best option for scenarios requiring speed changes. The primary issues are that it is inefficient (it can achieve up to 85% efficiency), expensive to maintain because the coal brushes must be replaced every 3000 hours, and lacks power in comparison to competing technologies on the market.

There is still a significant need for DC motor-powered vehicles with low to mid-power levels. In the past, motor drives were frequently built with high-performance permanent magnet (PM) devices. In PM machines, a fixed magnet generates the magnetic field, eliminating the requirement for a separate field winding. Rare earth materials are used the majority of the time. Of course, the price is significantly higher. When PM machines are employed, the number of electric vehicles will decrease.

II. PROPOSED SYSTEM

The proposed technology will help to develop adaptive and cost-effective methods of energy delivery. A low-cost tri-port converter can be used to connect the battery, solar PV panel, and synchronous reluctance motor (SRM).

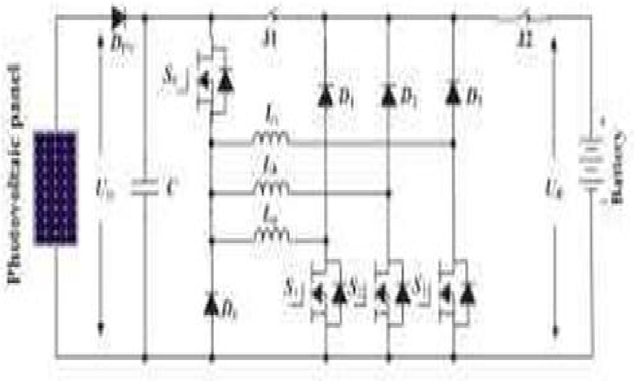

Fig.2 Proposed tri-port topology for PV-powered SRM drive

The aforementioned tri-port topology consists of three energy terminals. The energy sources include photovoltaic (PV), battery, and switching reluctance motor (SRM). As shown in the figure. The power converter that connects the three consists of four switching devices (S0–S3), two switches (J1 and J2), and four diodes.

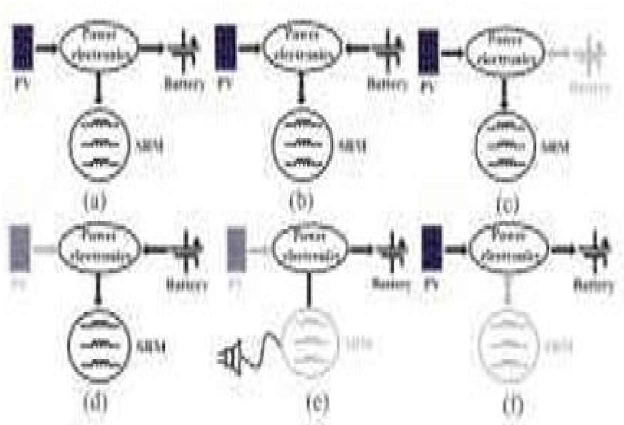

Fig.3 Six operation modes of the proposed tri-port topology. (a) Mode 1. (b) Mode 2. (c) Mode 3. (d) Mode 4. (e) Mode 5. (f) Mode 6.

In mode 1, photovoltaic (PV) energy is the primary source. It powers the Solar Reflective Mirror (SRM) and charges the battery. Mode 2 allows the SRM to receive electricity from both the battery and the solar system. In mode 3, the battery is not used, and the solar (PV) system becomes the major power source. When in mode 4, the photovoltaic (PV) device is turned off and the battery acts as the primary power source. During mode 5, the solar photovoltaic (PV) system and the smart renewable module (SRM) are turned off. Instead, the battery is charged using a single-phase electrical grid. The PV charges the battery in mode 6, while the SRM does no action.

DRIVING MODES

The car's traction drive operates in four modes. These are modes 1 through 4.

1) Mode 1: In this state, Relay J1 switches off and Relay J2 activates. In this mode, the power generated by the PV panel powers the SRM and charges the battery.

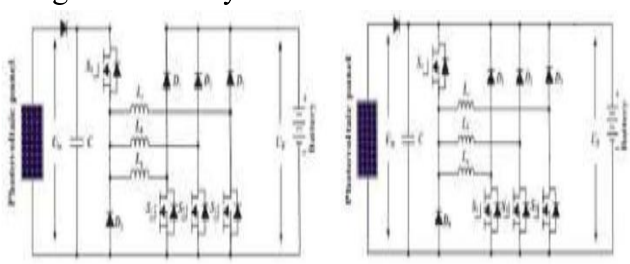

Fig: 4 Mode 1 and 2

2) Mode 2: When the synchronous reluctance motor (SRM) is under a heavy load, both the solar

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(PV) panel and the battery provide electricity to it. At the time, the J1 and J2 connectors are active.

3) Mode 3: If the battery runs out, the PV screen will be the car's primary source of electricity. At the moment, J1 and J2 alternate between on and off.

4) Mode 4: When the PV fails to generate electricity due to insufficient sunlight, the battery powers the secondary regulator. Figure 3.6 shows the relevant structure. In this configuration, both relays J1 and J2 are turned on.

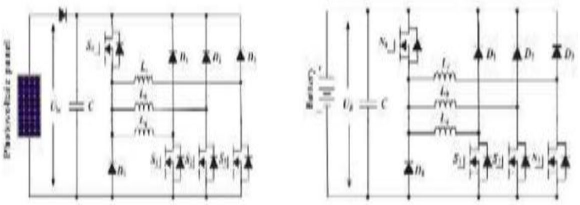

Fig: 5 Mode 3 and 4

5) Mode 5: If the photovoltaic (PV) system stops producing electricity, the battery must be recharged from another source. In this state, both J1 and J2 function. At point A, you will find the phase windings' center tap. The phase windings La1 and La2 serve as input filter inductors in this example.

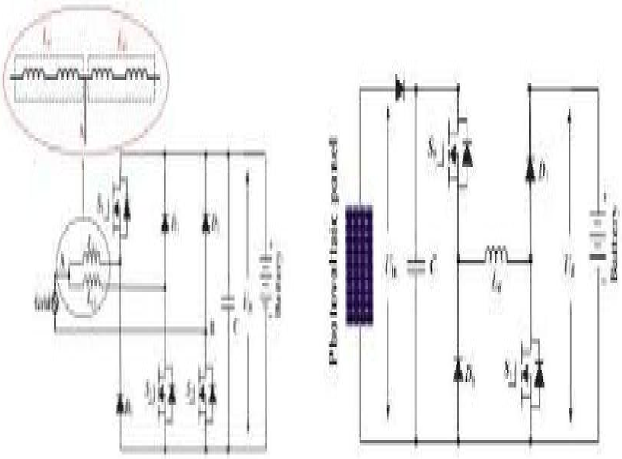

Fig: 6 Mode 5 and 6

6) Mode 6: When an electric vehicle (EV) is parked in the sun, the photovoltaic (PV) system can recharge the battery. In this situation, J1 is turned off, whereas J2 is switched on.

III. GRID-CHARGING CONTROL STRATEGY

The architecture described above can also be used for single-phase grid charging. S0 is always turned off at the start of each of the four primary charging states.

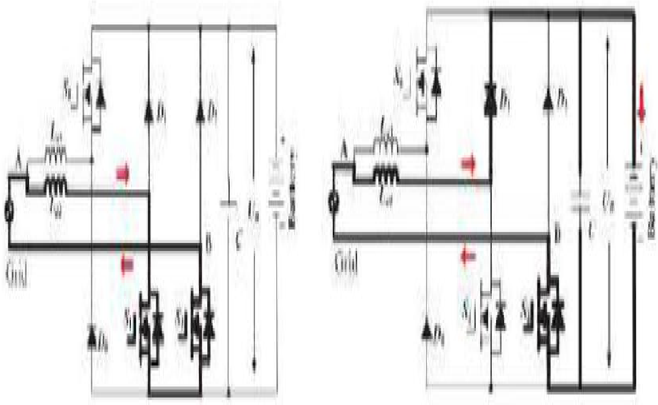

Fig: 7 Grid charging state 1 and 2

In the first stage of grid charging, energy from the grid charges LA2. Here's the equation to go with it:

Ugrid= La2 .

In grid charging state 2, the grid is connected to the phase winding to charge the battery. This occurs when S2 is conducting and S1 is turned off. Here's the math that matters:

UB - Ugrid= La2.

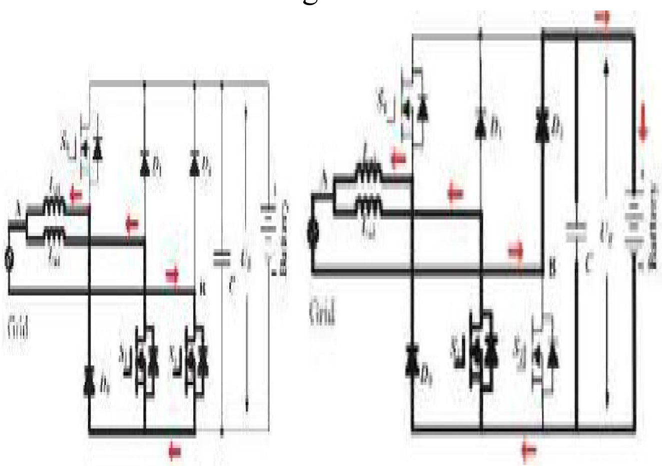

Fig: 8 Grid charging state 3 and 4

PV-FED CHARGING CONTROL STRATEGY

In this mode, the PV panel is designed to charge the battery instantaneously. The drive design incorporates an interleaved buck-boost charging technique, and the phase windings can function as an inductor.

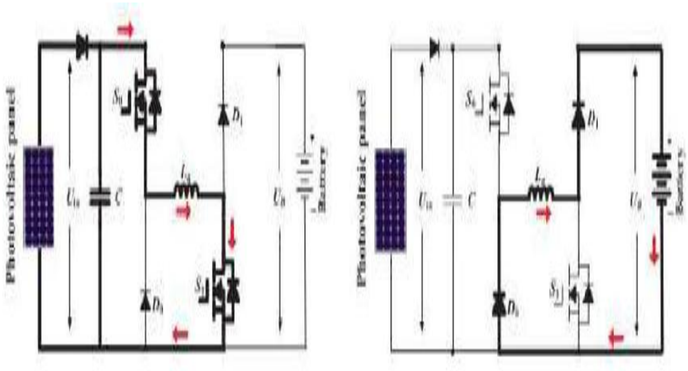

Fig: 9 PV fed charging mode

Figure 9 illustrates how a single phase can have two distinct phases. The PV panel turns on S0 and S1, which power the phase inductor. When switched off, they transfer energy to the battery. The state-of-charge (SoC) diagram depicts three processes that maximize the utilization of solar energy while maintaining the battery's integrity. Because the battery's energy is rapidly depleted in stage 1, the MPPT control approach is employed to maximize the usage of solar energy. This is the second process, in which the battery is charged using constant voltage.

IV. CONCLUSION

Combining PV panels and SRMs is thought to be the best approach to power electric cars (EVs). This will increase the range of the EVs while lowering the total costs of the system. Before more advanced power electronics were developed, DC motors were the best option for scenarios requiring speed changes. The primary issues are that it is inefficient (it can achieve up to 85% efficiency), expensive to maintain because the coal brushes must be replaced every 3000 hours, and lacks the power density of alternative technologies on the market. Coal brushes require less maintenance because private cars are rarely utilized. An substantial need remains for electric vehicles with DC motors that operate at low to medium power levels.

Historically, high-performance permanent-magnet (PM) machines were widely used as motor drives. A stationary magnet generates the magnetic field in PM machines, eliminating the need for a field winding. Minerals from rare earths are commonly used. Of course, the price is significantly higher. When PM machines are employed, the number of electric vehicles will decrease. A solar screen can be utilized to generate power, and a switching reluctance motor can be used to drive the motor. A three-port adapter connects the PV panel, battery, and SRM, allowing them to work together. There are six operating modes available for controlling the flow of energy, including driving control, driving/charging hybrid control, and charging control. To maximize the use of solar energy, a control approach is developed to improve battery charging with photovoltaic cells. This initiative will help to reduce the total cost and carbon dioxide emissions of electric automobiles. This is because photovoltaic-powered EVs are a more sustainable and environmentally friendly technology than traditional cars with internal combustion engines.

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