Performance Enhancement of SRM Drive with Plug-in Hybrid Electric Vehicle using Solar Integration

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Abstract
Enhancing the efficiency of solar energy and grid-connected PHEVs, or plug-in hybrid electric vehicles, are discussed. Due to its advantages of low carbon emissions, great fuel efficiency, and extended driving range, PHEVs are garnering an increasing amount of interest. In contrast to conventional architecture, the integrated switching reluctance motor (SRM) power train for plug-in hybrid electric vehicles (PHEVs) presented in this article holds numerous driving and battery-charging functionalities. Four driving modes can be reached in motor mode depending on the state of the road. It is possible to implement motoring and braking operations successfully. Three charging modes without additional battery chargers are implemented for the battery-charging mode. A three-channel interleaved boost converter withpower factor correction (PFC) capability is constituted by utilizing the SRM windings and integrated converter circuit to charge the traction battery from the grid. An integrated half- bridge isolation dc/dc converter is employed to charge the auxiliary battery from the generator or traction battery.
Index Terms— Onboard charging, plug-in hybrid electric vehicle (PHEV), power traintopology, switched reluctance motor (SRM).

Introduction

Since a decade ago, the transportation industry has grown quickly to meet demand, and battery-powered electric vehicles (EVs) have become increasingly important. Due to their many benefits [1–5], including their environmental friendliness, fuel efficiency, and flexibility to use GPS, GSM, or Internet of Things (IoT) based smart systems to control their speed at the lowest possible cost; electric vehicles (EVs) are outpacing conventional mechanical-gasoline vehicles. The use of AC-DC and DC-DC converters is particularly important in Battery Electric Vehicles (BEVs) to charge the battery. The battery is always essential to the effective running of an EV. Battery voltage and current, which are EV charger parameters, must be kept constant no matter how loaded the battery is or if the input supply is interrupted. Obtaining stable state EV charger response, operation of power converters in Continuous-Conduction Mode (CCM) is highly required. This can be achieved by employing proposed ABC algorithm-based BL Cuk converter fed EV.

The major concern with the conventional vehicles is its phenomenal hike global warming and the chaotic pollution due to the motor fuel usages as depicted in fig.1. So, this has led to emerge of green energy dependent automobile segment. This segment has constant research by various scientists for emerging EV fashion in the automobile industry branded under various names as TESLA INC., NISSAN, BAIC motors, etc. which are an alternative the CO_2 emitting Combustion Engines.

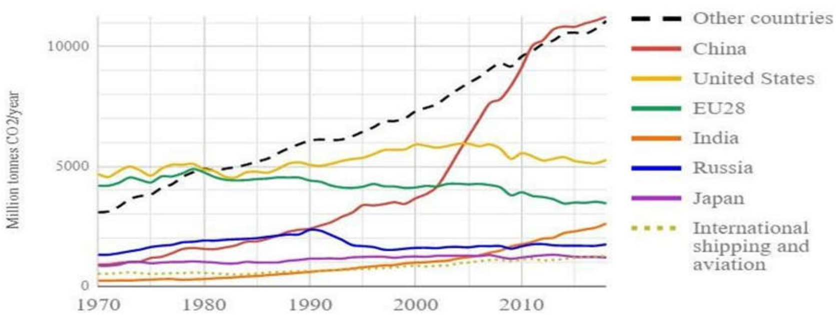

Fig.1 World CO_2 emissions from various countries

To maximize the EV usage in daily transportation, various steps have taken by Indian govt. by introducing the “ZERO EMISSION VEHICLES (ZEVs): TOWARDSA POLICY FRAMEWORK, 2018”, where it has discussed the following changes:

1. Opening of electric mobility to enter the mass India market so as to minimize the carbon emissions while providing convenient and cost-effective mobility byreducingprimary oil consumption in transportation.
2. Facilitate customer adoption of electric and clean energy vehicles.
3. Encourage cutting edge technology in India through adoption, adaptation, andresearch and development.
4. Improve transportation used by the common man for personal and goodstransportation. 5. Reduce pollution in cities.
5. Create EV manufacturing capacity that is of global scale and competitiveness.
6. Facilitate employment growth in a sunrise sector

For these changes to occur there has been a customization of Inia’s EV policy inAutomobilemarket.

EVs are broadly classified in three categories such battery EVs, hybrid EVs, and PHEVs, in this battery and hybrid EVs have high battery capacities ratings to drive the vehicle, more cost to overcome this PHEVs are considered [6-9]. PHEVs are operated with both electricity and fuel. Size of battery used in PHEV is low so it is more economical. Switched reluctance motor (SRM) is employed to drive the vehicle instead of brush less DC machinesand A.C machines, SRM drive has possess inherent characteristics like more starting torque, less starting current, rugged construction, wide range speed control and more fault tolerance capacity [10-12].

PHEV with SRM drive is much elaborated in the literature, It is employed withadditional LC filters, DC-DC converters to charges the battery. suffering with low power factor. These issues are effectively avoided by employed proposed converter topology. Interleaved converter improves the power factor, half bridge DC-DCconverter has a smaller number of switches, so cost optimized [13-15].

System Configuration

The structure of proposed PHEV with SRM drive is explored in fig.1

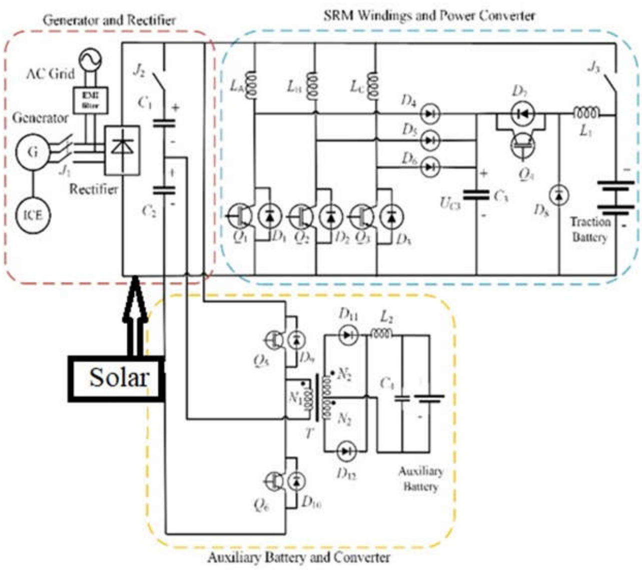

Fig.2. Structure of Proposed PHEV converter topology

Proposed network topology mainly composed with different power electronic elements to perform multi operations. Those elements are three relays ($J_1 - J_3$), four capacitors (C_1-C_4) twelve diodes ($D_1 - D_{12}$), one traction battery, auxiliary battery, six IGBT switches (Q_1-Q_6), and three inductive windings (L_A, L_B and L_C). Where inductive windings are represents the stator windings of the SRM drive, capacitors (C_1 and C_2) combination denote the DC link capacitor value. Auxiliary battery charges with reduced switches that is half bridge DC-DC converter.

Control scheme

Hysteresis control strategy is employed to operate the SRM drive at desired position. Speed regulator commands the hysteresis control to produce pulses. The closed loop of hysteresis minimizes the error between actual speed desired speed of SRM drive. The configuration of driving control strategy is explored in fig.9.

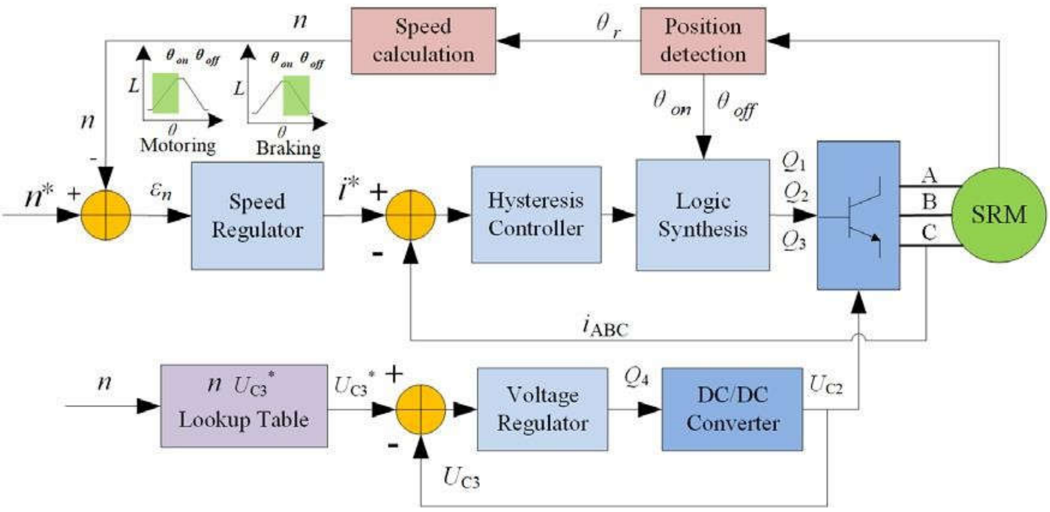

Fig.3. Schematic diagram of driving control strategy

Simple open loop PI control strategy is adopted to control the charging of traction andauxiliary battery.

Simulation Results

The output simulation results SRM motor phase current (Ia), grid current (Ig), battery current (Itb) and voltage across capacitor (Vc3) with various driving control strategies under low speed is configured in fig.4 to fig.6.

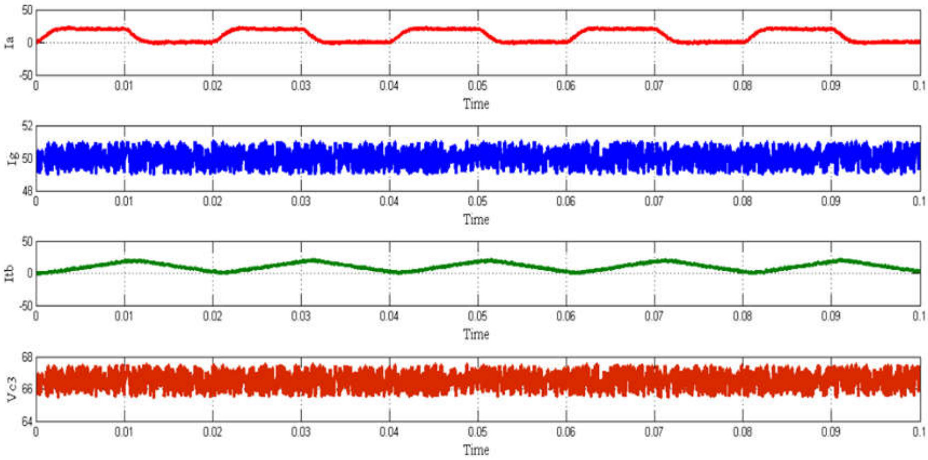

Fig.4. battery driving mode: Low speed

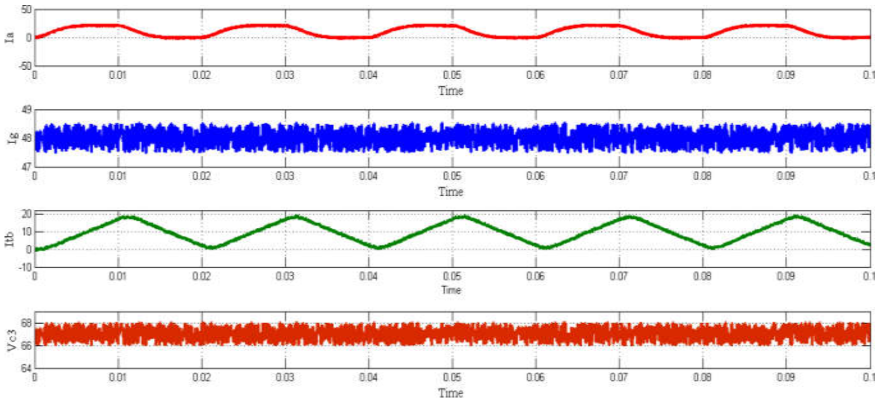

Fig.5. Generator driving mode: Low speed

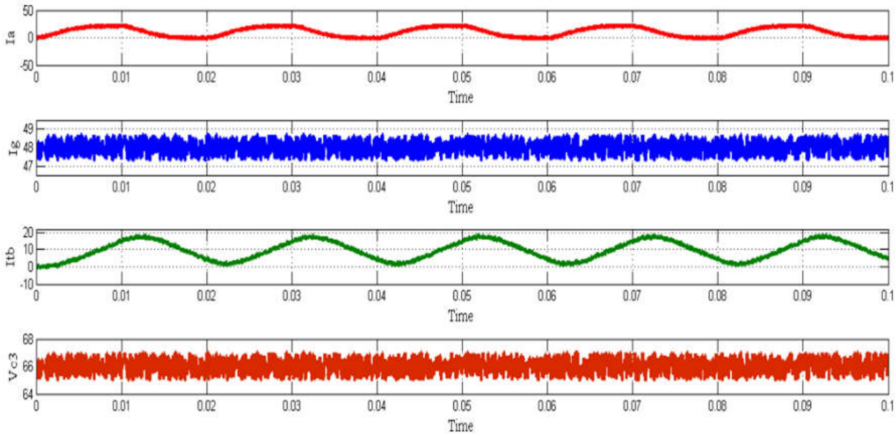

Fig.6. battery and generator driving mode: Low speed

The output simulation results SRM motor phase current (Ia), grid current (Ig), battery current (Itb) and voltage across capacitor (Vc3) with various driving control strategies under high speed is configured in fig.7 to fig.9.

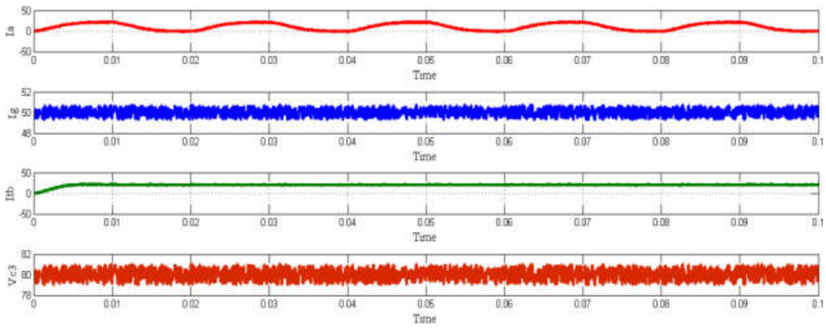

Fig.7. battery driving mode: High speed

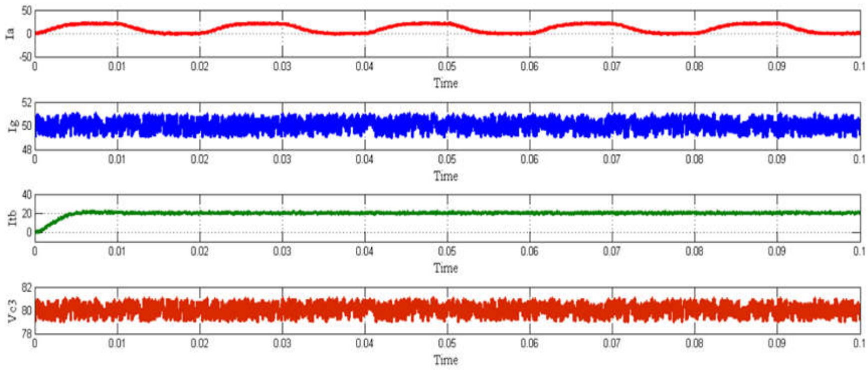

Fig.8. generator driving mode High speed

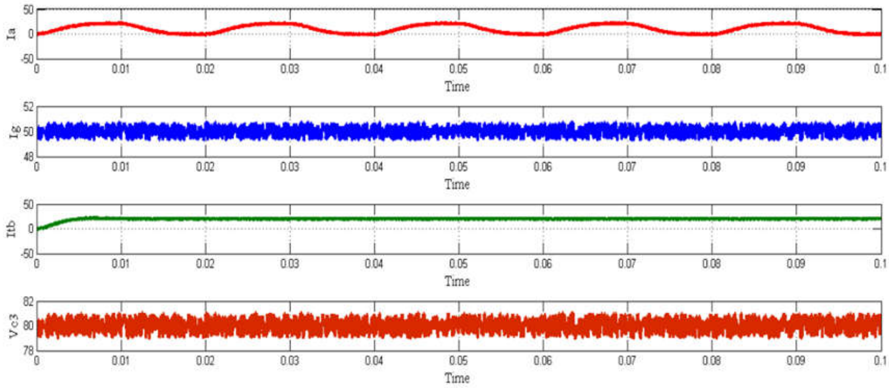

Fig.9. battery and generator driving mode: High speed

Conclusion

This article suggests a PHEV integrated SRM drive converter architecture that can perform numerous driving and charging duties without the use of additional power electronics components. The following are the article's primary contributions.

1) Compared to the conventional electrified power train for PHEV, an integrated power converter topology with fewer circuit components, such as power semiconductor devices, inductors, and capacitors, is proposed. To accomplish various driving modes and variable charging modes, only three relays are added.

2) Depending on the load circumstances, the driving mode implements four operational modes: battery driving, generator driving, generator and traction battery hybrid driving, and regenerative braking. The suggested electric driving system operates more effectively at high speeds.

3) In the charging mode, the rectifier, SRM windings, and its power converter constitute a three-channel interleaved boost PFC converter for charging the traction battery without any changes, which could reduce the input current ripple and improve the charging power quality.Three charging modes, i.e., G2T, G2A, and T2A, are achieved to improve the charging flexibility of the PHEV.

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