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Electric Vehicle with Novel Energy Control using Solar PV/Fuel Cell Power SRM Drive

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Abstract:
Present days renewable electrical sources are used in the market as a additional source for rapidly growing of hybrid electrical needs. In this paper input used is renewable electrical sources(RES).PV cell, fuel cell and conventional grid are operated as source in proposed network and results in reliability of the supply and efficiency of the system are increased.Results are validated in MATLAB/Simulink for six modes of operation.

Keywords: *PV cell, Electric Vehicle, SRM*

I. INTRODUCTION

An electric vehicle consists of traction motors which is powered via a collector system through off-vehicle sources else it may be self -contained using a battery or generator for converting fuel into electrical energy. Electric motor is used instead of an internal combustion engine to supplyelectric vehicles. Electric vehicles are eco-friendly and prevents Global warming. But the limitation is driving range is very short because of current battery technologies which will decrease use of EVs in wide range of applications. High-performance permanent magnet (PM) machines are widely used in earlier days because there is no field winding which is replaced by permanent magnet. High cost of PM machines affect the applications of EVs and can be overcome by a photovoltaic panel and a switched reluctance motor for power supply and motor drive [1]. A suitable energy source can be achieved by locating PV panel on the vehicle top. PV panels can be used to charge batteries as they have low power density for traction drives. SRM is cheaper than PM as there is no need for rare earth materials.

Switched reluctance motor (SRM) is one of the types of stepper motorand operates with reluctance torque [3]. Power is delivered to windings in the stator instead of rotor unlike DC motors resulting in simplified mechanical design but electrical design is complicated because of power delivery switching to the different windings. This switching can be overcome by modern electronic devices and torque ripple must be overcome.

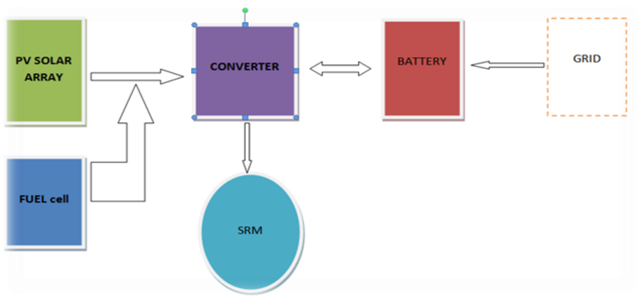

Figure1Block Diagram Representation

The redesign of motor with some onboard charging functions reduces the energy conversion processes. The design of the modules, their usage and charging

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are the factors to decide performance of battery modules. Hence, battery chargers are the key elements in the evolution of this technology [4]. Battery chargers are classified as onboard type and stand-alone (off board) type. Weight, space and cost of onboard type of chargers are to be reduced as they are carried by the vehicle always.Practically, high-power level of the onboard chargers with galvanic isolation is not possible. Isolation is avoided due to high cost even it is used in the charger circuits for safety reasons. Off board chargers are placed at a fixed locationand have limited power output of the battery. The maximum power point tracking (MPPT) and solar energy utilization are the unique factors for the PV-fed EVs. A low-cost tri-portconverter can be used for the PV panel, SRM, and battery coordination so as to save cost and flexible energy flow modes.

II. Proposed Topology

The proposed topology is a tri-port topology consisting of 3 energy terminals, PV cell/ fuel cell, battery, and SRM which are linked by a power converter having 4 switching devices (S0 − S3), 4 diodes (D0 − D3), and 2 relays J1, J2 as shown in Figure 2.

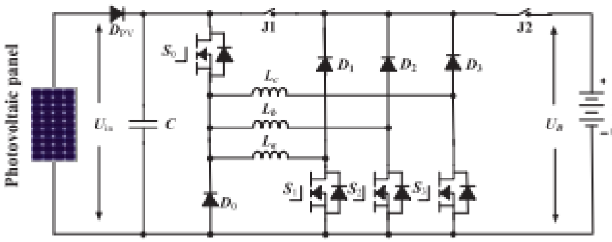

Figure2Proposed tri-port topology for PV powered SRM drive

The six operation modes are obtained by controlling the two relays J1 and J2 as illustrated in Table 1**.**

Table 1: J1 and J2 actions under different modes

Mode	J1 and J2
1	J1 turn-off; J2 turn-on
2	J1 and J2 turn-on
3	J1 turn-on; J2 turn-off
4	J1 and J2 turn-on
5	J1 and J2 turn-on
6	J1 turn-off; J2 turn-on

In mode 1, PV is the only energy source to drive the SRM and to charge the battery.
In mode 2, PV and battery are both the energy sources to drive the SRM.
In mode 3, PV is the only source and therefore the battery is idle.
In mode 4, Battery is the only driving source and therefore the PV is idle.
In mode 5, Battery is charged by a single-phase grid while both the PV and SRM are idle.
In mode 6, Battery is charged by the PV and therefore the SRM is idle.

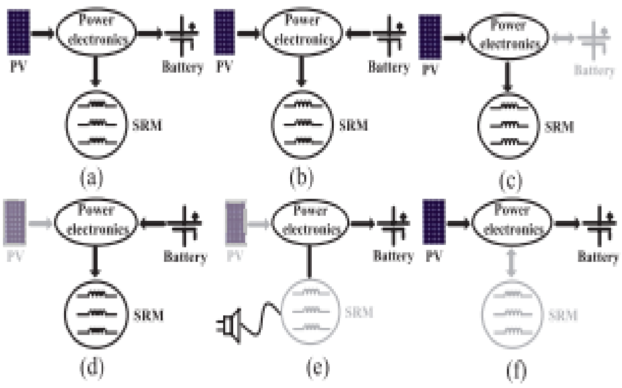

Figure3Six operation modes of the proposed tri-port topology. (a) Mode 1.(b) Mode 2. (c) Mode 3. (d) Mode 4. (e) Mode 5. (f) Mode 6.

III. Results and Discussion

Figure 4 shows the existing circuit model of the project where the PV panel is constructed using the MATLAB latest editions. Figure 5 is the extension model of the project where two renewable sources are used .A fuel cell is connected to the circuit using a NOT logic when the PV panel is not able to generate energy the fuel cell comes into action. The

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efficiency of the circuit is improved by using two renewable resources. The outputs results of both Figure 4 and Figure 5 resembles the same.

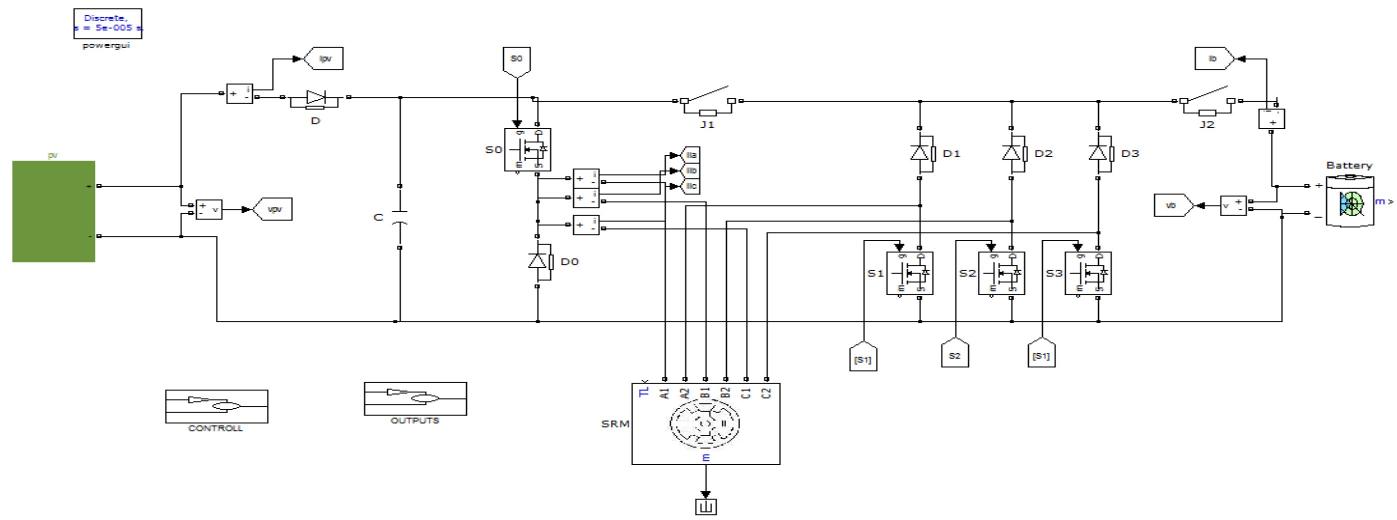


Figure4 Existing Circuit ConFigureuration

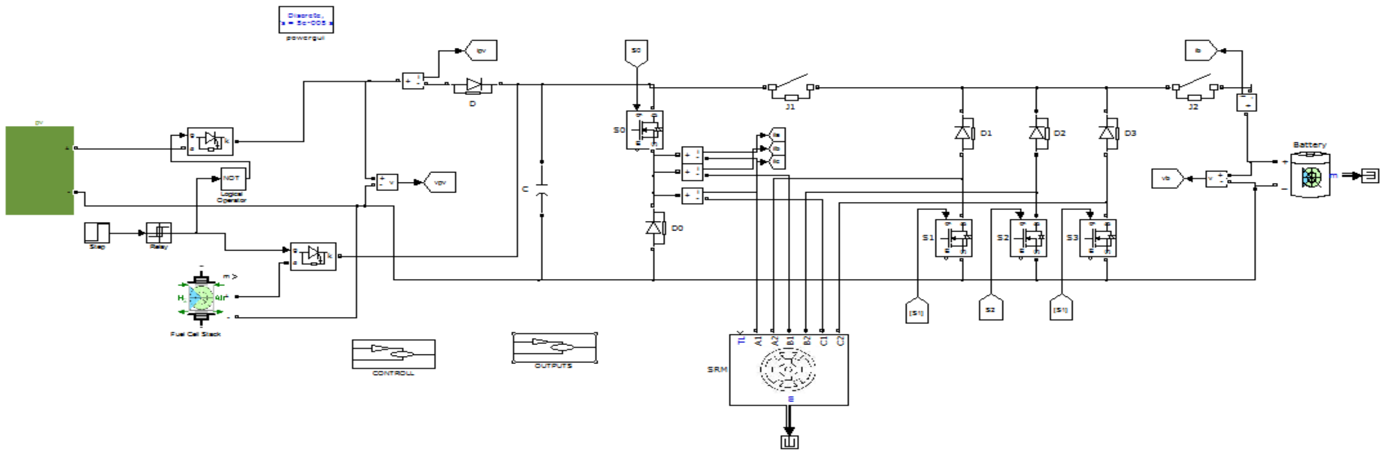


Figure5:Extension of existing circuit by adding Fuel cell

Table 2 illustrates the simulation parameters. 35 Newton-meter is the load torque and the control of PV panel voltage is done at the Maximum Power Point. Battery charging is done with the help of freewheeling current.

Table 2 Simulation Parameters

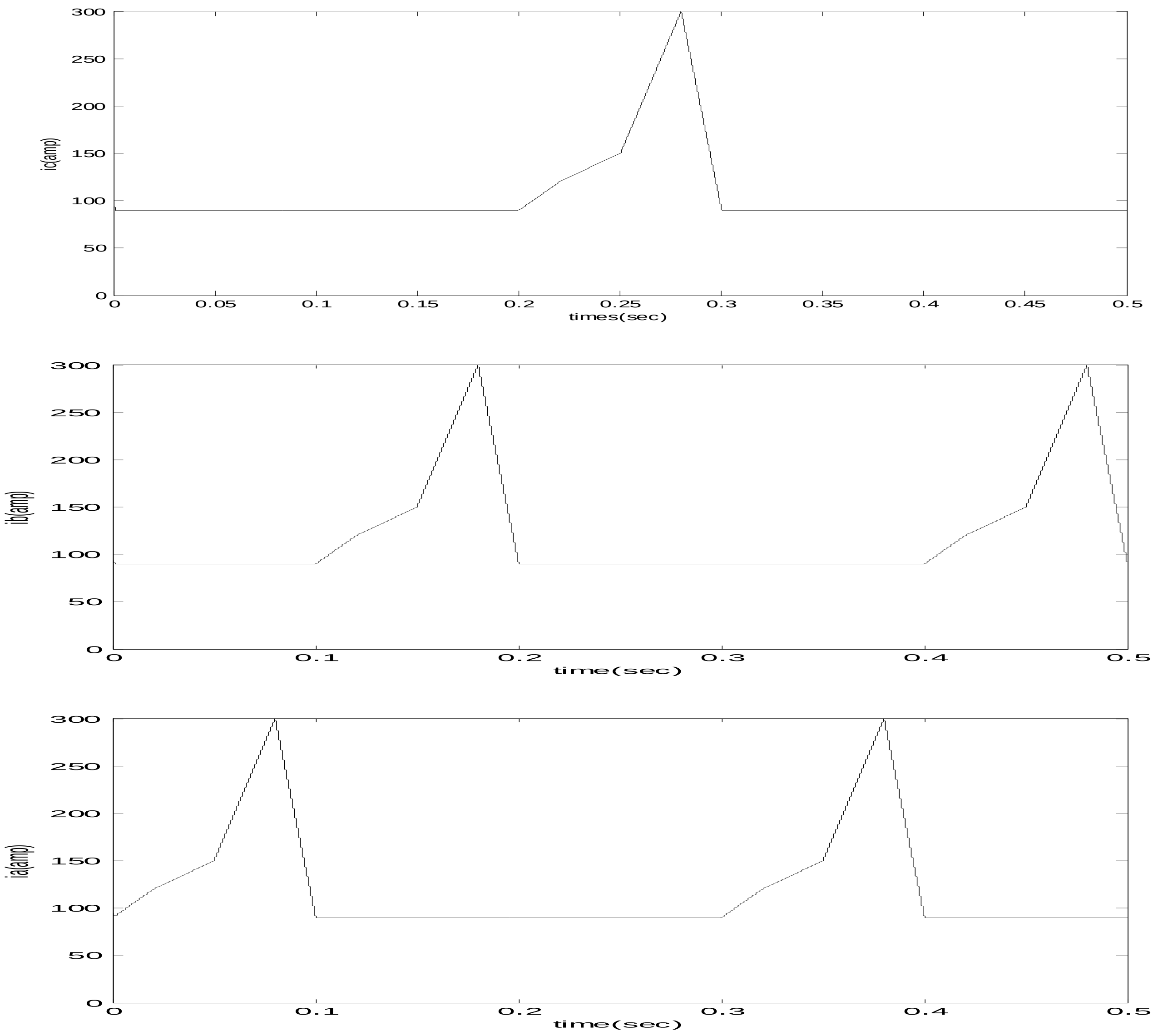
SIMULATION PARAMETERS

Parameter	Value
SRM	12/8
PV panel	
Maximum power point voltage reference voltage	310 V
Battery voltage	350 V
Constant voltage control reference voltage	355 V
Constant current control reference current	1 A
Mode 1, charging current	60 A
Mode 4, driving speed	1250 r/min
Mode 6, constant voltage charging reference	355 V
Mode 6, constant current charging reference	1 A

Figure.6. shows the simulation results at mode 1. Figure.7 shows the simulation results of single-source driving modes (modes2-4). Figure 7, Figure 8shows the simulation results of charging where

Figure 7 is for grid-charging. The current qualityis better inpositive half than the negative half which is caused due to change in inductance connected to grid.

Figure.9 and 10 is for PV-charging. Figure.9 presents the step change from stage 1 to stage 2. In stage 1, the battery is low in SOC. In order to achieve MPPT of the PV, the constant voltage control is employed and the PV output voltage is controlled at MPP (310V), as shown in Figure.9. In stage 2, a constant voltage is adopted, the reference voltage is set to 355V. As shown in Figure9, the charging converter output voltage is controlled at reference voltage in the step change from step 1 to2. In stage 3, 1-A trickle charging is also achieved, as shown in Figure.10.



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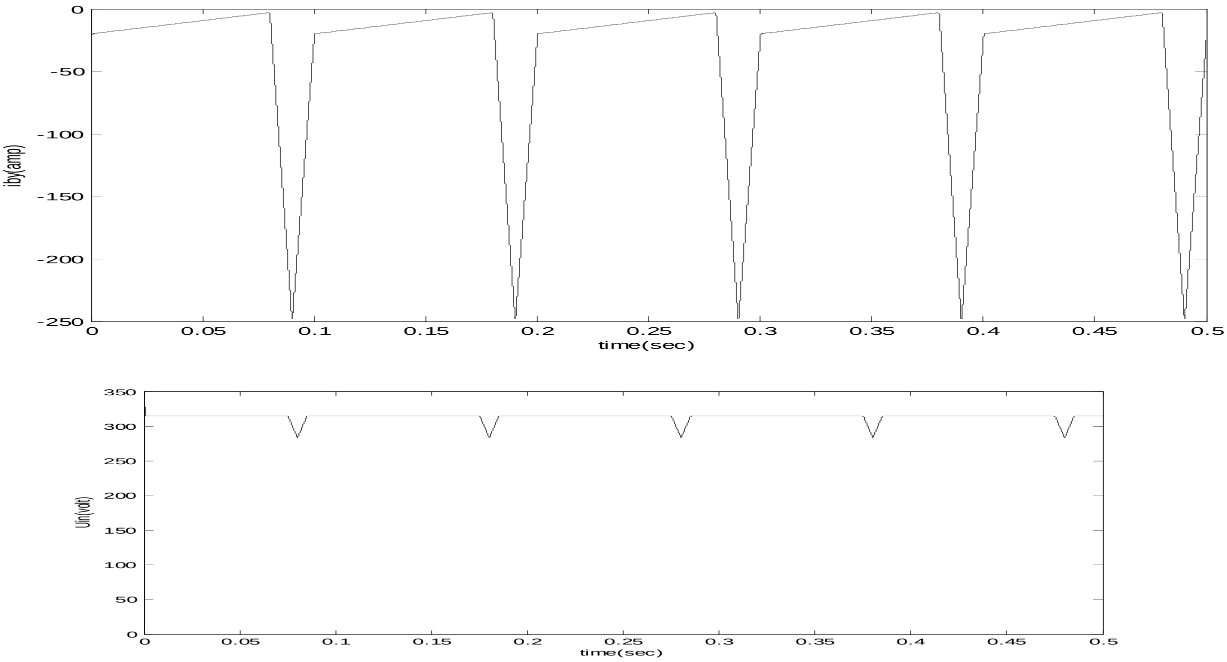
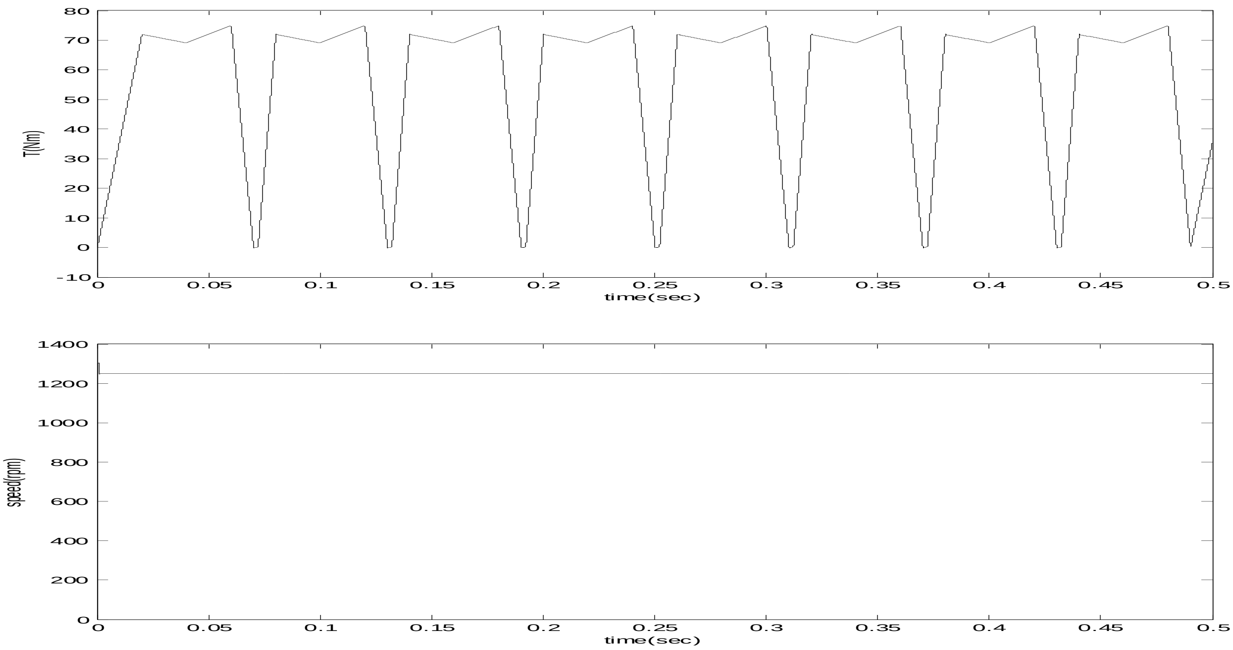


Figure 6 Simulation results of driving-charging mode (mode 1)

Figure 6 represents the simulation results of mode 1 where the energy generated is supplied to both low loads and battery. In the above U_{in} represents the PV panel generated voltage, I_{by} represents the battery current, and I_a, I_b,I_c are the line currents of the SRM motor of about 300A.



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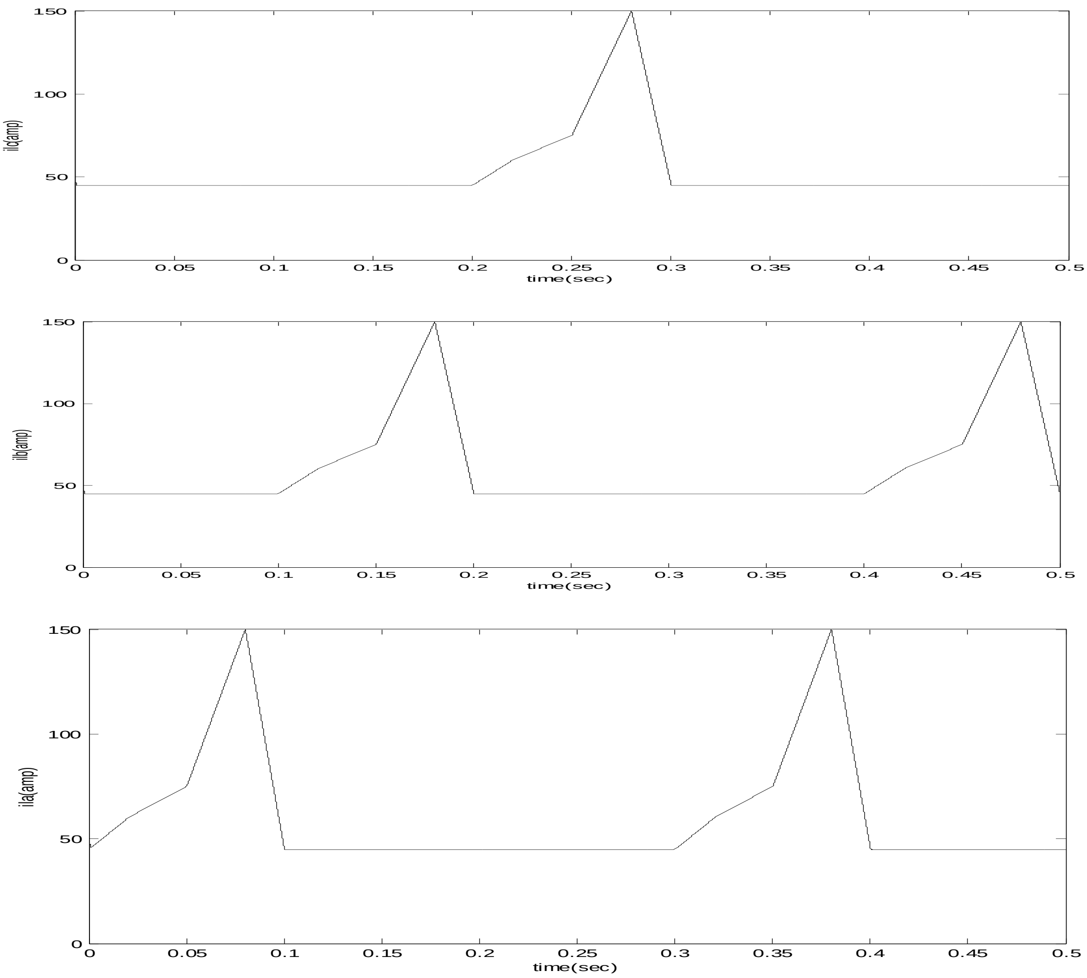
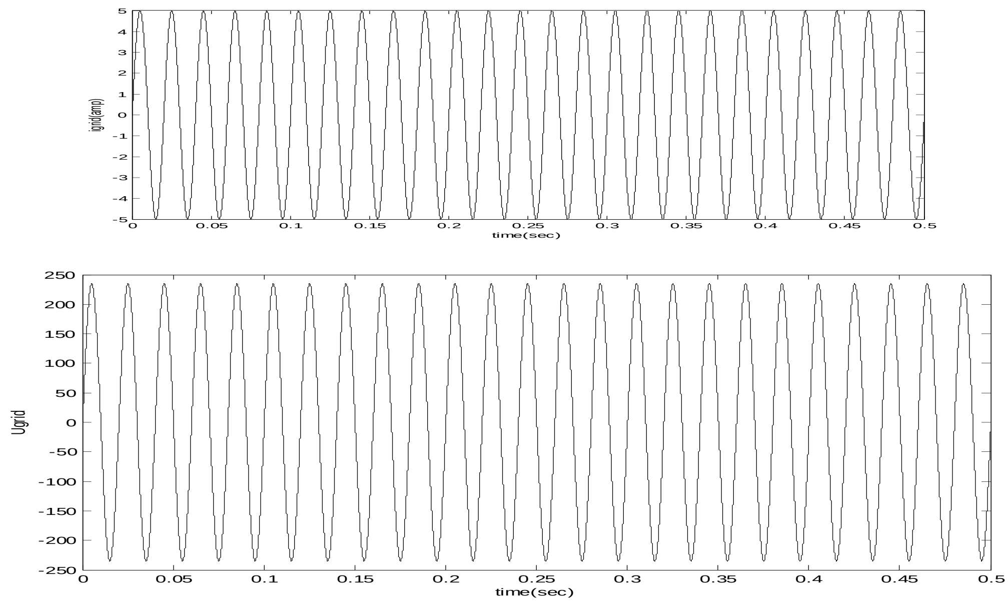


Figure 7 Simulation results of single-source driving mode (modes2-4).

Figure 7 represents the driving mode conditions from mode (2-4). In the above Figure a torque of about 70NM is achieved and the speed of the SRM is about 1300RPM and I_{La},I_{Lb},I_{Lc} are the line currents of the SRM motor.



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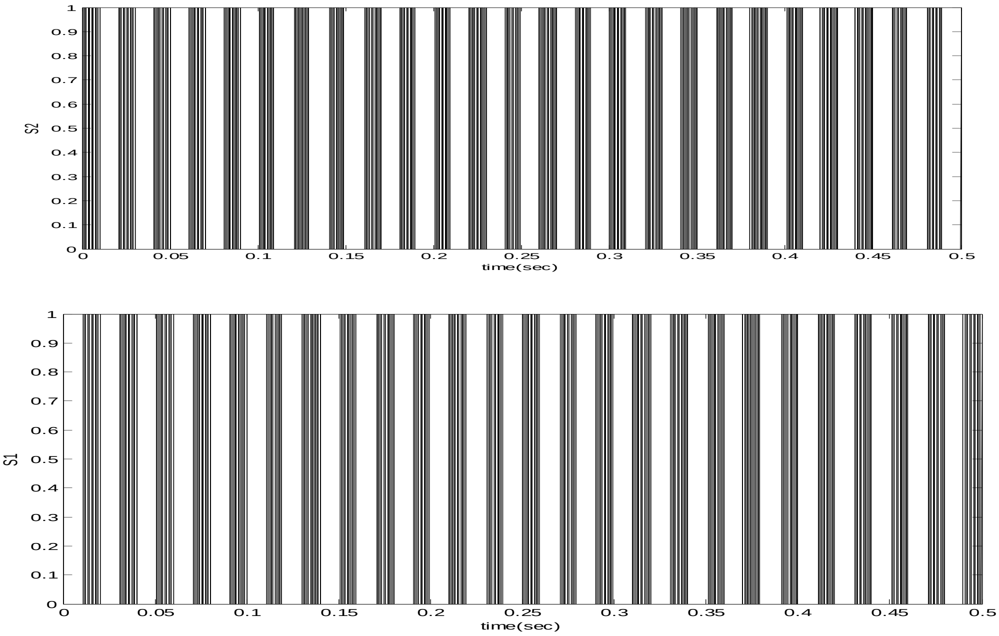

Figure 8 Grid charging (mode 5)

Figure 8 represents the grid charging method, where S1 and S2 represents the pulses of the triggering circuit and U_{grid} and I_{grid} are the voltage and currents from the grid.

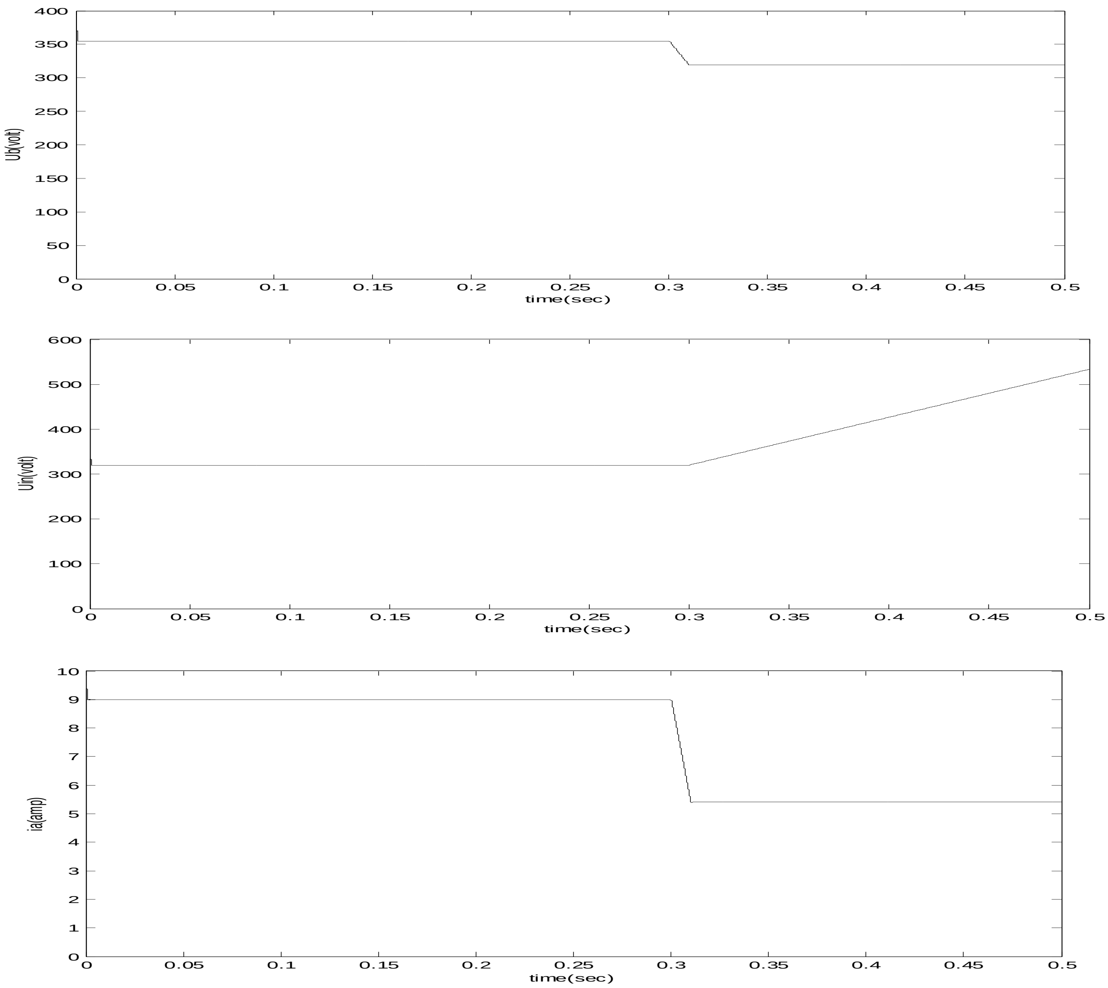

Figure 9 PV charging mode 6 (stages 1–2)

Figure 9 and Figure 10 represents the PV charging mode (1-2) and (2-3) depending upon the temperature of the PV panel they varies.

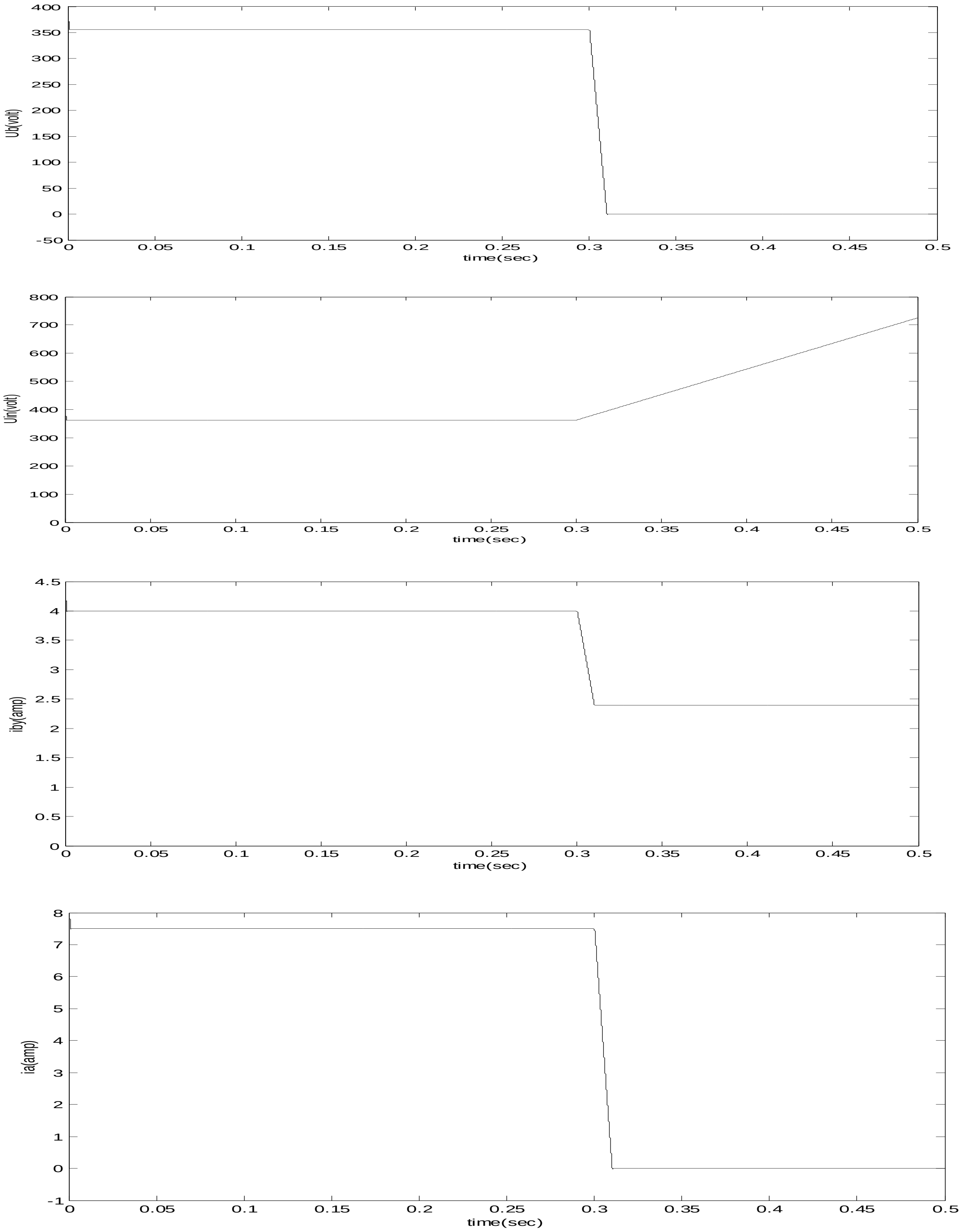

Figure 10: PV charging mode 6 (2-3)

IV. CONCLUSION

Fuel cell, Photovoltaic solar system, battery and grid connected Hybrid Electric system is developed in the proposed circuit configuration. So the reliability of the supply and the efficiency of the system get improved as a result. Total circuit is simulated in the power graphical user interfacing environment in

MATLAB software and results are analyzed infast fourier transformation analysis. SRM motor drive shows high efficiency and reliability characteristics than compare with the existing system.

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