# Modeling &Simulation of PV Fuel Cell Hybrid System Based Non-Isolated Multi Level DC-DC Converter Fed Split Phase Induction Motor

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*Abstract—* **In the recent years research is mainly focused on renewable energy systems because all the fossil fuels are goes on decreasing day-by-day. To increase the efficiency of the available fossil fuels and make use of the energy generated from them, many researchers concentrate their work in this area. Among all the renewable sources of energies available in the nature, Photovoltaic and fuel cells grasp more advantages because of easy installation at the consumer level with high efficiency. In this paper a split phase induction motor fed three phase inverter is proposed which is supplied by a hybrid Photovoltaic (PV) – Fuel Cell based multilevel boost – Cuk DC-DC converter. In this, multilevel Boost – Cuk DC –DC converter provides two equal and opposite polarity of dc outputs. These two outputs are added with the help of dc link capacitor and the resultant voltage is fed to the inverter. Here the inverter is a Voltage Source Converter which will convert the dc voltage to an equivalent AC value by controlling the on period of the switches using current controlled strategy. Finally the proposed system is simulated in MATLAB/ SIMULINK environment**

*Index Terms—* **Photo voltaic hybrid system, Dual output DC-DC converter, single phase full bride inverter, split phase induction motor.**

## I. INTRODUCTION

Now days, the induction motors are widely used in many fields like industries and irrigation. Even the commutator fed DC motors are replaced by converter fed induction motor drives because of their simple and robust construction. A split phase induction motor resembles a squirrel case induction motor expect there is a small change in stator winding. A split phase induction motor has only one winding on the stator where as a squirrel case induction motor has two windings.

In this paper a split phase induction motor is driven by means of a dual output dc-dc converter .The dual output converter schematic arrangement is shown in figure 1.The dual output converter is a combination of a multilevel Boost and cuk converter operated by means of Single source and a single switch. In section 2, a literature survey on various types of conventional multilevel converters is discussed. In section 3 the designing of the split phase induction motor is explained and the concerned mathematical equations are derived. The complete system analysis is discussed in section 4 which consists of a pv hybrid system, dual output DC-DC converter, single phase full bridge inverter, split phase induction motor respectively. The photo voltaic grid connected system consists of several components along with high step up converters to increase the voltage levels. Further the output obtained is fed to the split phase induction motor. The overall systems simulation results in MATLAB/SIMULINK are elaborately shown in section 5. The conclusion is stated in section 6 respectively.

## II. LITERATURE SURVEY

The electrical energy requirements of human beings are increasing day by day as it occupies first place in energy hierarchy. In the electrical energy generation, the solar energy plays a vital role as it is clean, pollution free and available at free of cost. Therefore the photo voltaic cells are employed to generate solar energy. The photo voltaic grid connected system consists of several components along with high step up converters to increase the voltage levels. In [1] different components of a PV grid connected system is discussed which consists of PV Arrays, High step up converters, grid connected inverter and AC grid respectively.

As the output obtained from the PV panels is very low, different DC-DC converters are required to boost up the voltage levels of the PV panels. The different types of conventional converters that are being used for this conversion are discussed in [1-3].
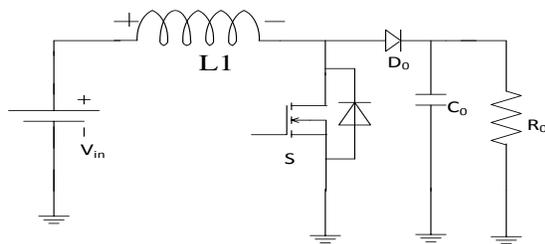


Figure 1: Circuit diagram of a conventional Boost converter

To obtain high voltage gain, a single switch Dual output DC- DC converter [4] is used but the time taken to reach steady state is very high when the input voltage is high. To avoid low voltage gain, synchronous rectification single input dual output Boost converter [5] is being used. A high efficiency low cost solution with two outputs at a fixed switching frequency is discussed in [6].

A fly back converter which uses IC TL494 which operates in master slave configuration is explained in [7]. A transformer less high switching frequency, high voltage gain, and continuous input current DC-DC converter based on pulse width modulation (PWM) is shown in [8]. In this converter, high voltage gain is achieved by using low voltage devices. A novel DC-DC converter used for various DC link applications is discussed in [9].In this converter PWM technique is used and unidirectional current flow is obtained which is very useful in PV applications.

To obtain dual output with two polarities by using single input, a novel non isolated dual output hybrid DC- DC multilevel converter is discussed in [10]. It consists of two inductors $L_1, L_2$ and a single switch. The voltage gain of the converter can be increased by adding suitable no .of switches and Diodes to the actual circuit. The converter is obtained by coupling a multilevel Cuk converter to the Boost converter. The circuit operation depends upon the duty cycle of the switch and it has two modes of operation. The complete analysis of this converter along with different operating modes is explained briefly. Further the modeling of split phase induction motor operated at various load conditions is briefly discussed in paper [11] respectively.

## III. SPLIT PHASE INDUCTION MOTOR MODELLING

A Split phase induction motor has wide ranges of applications in all the fields where cost is the major consideration. It essentially consists of main winding and auxiliary winding and there is a phase shift of $90^0$ between the main winding and the auxiliary winding. The auxiliary winding of the split phase induction motor is designed with high current density obtained by maintaining Resistance and Reactance high current ratio. The no. of turns ration on the main and the auxiliary winding are different. Because of different turns ratio, they posses different mutual reactance's .In order to have a equivalent auxiliary field transformation into an equivalent main field winding, a transformation is required.
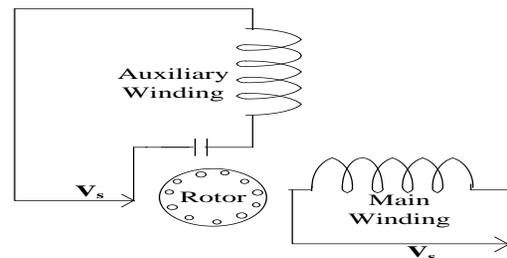


Figure2: Schematic Arrangement of a split phase induction motor

The d-q axis representation of the two windings of the split phase induction motor is as shown below.

$$\Psi_{s\alpha} = L_{s\alpha} I_{s\alpha} + L_{m\alpha} I_{r\alpha}$$
$$\Psi_{s\beta} = L_{s\beta} I_{s\beta} + L_{m\beta} I_{r\beta}$$
$$\Psi_{r\alpha} = L_{m\alpha} I_{s\alpha} + L_{r\alpha} I_{r\alpha}$$
$$\Psi_{r\beta} = L_{m\beta} I_{s\beta} + L_{r\beta} I_{r\beta} \qquad (1)$$
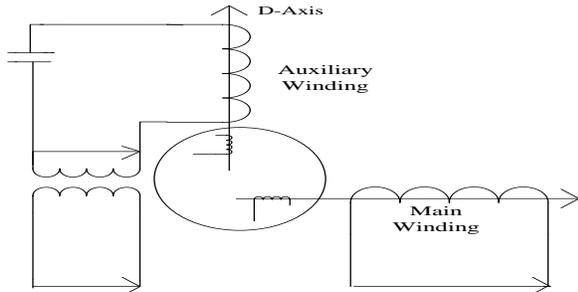


Figure 3: split phase induction motor D-Q axis transformation

## IV .BLOCK DIAGRAM REPRESENTATION OF THE PROPOSED SYSTEM

Figure 4 shows the complete block diagram representation of the proposed system which consists of hybrid PV cell, dual output multilevel DC-DC converter, single phase full bridge inverter, and a split phase induction motor. The output obtained from the PV array is fed to the multilevel Dual output DC-DC converter to increase the voltage gain of the PV panels output. Thus two output voltages obtained from the dual output converter is fed to the single phase full bridge inverter to convert it from DC to AC and the ultimate output obtained is fed to the split phase induction motor respectively.
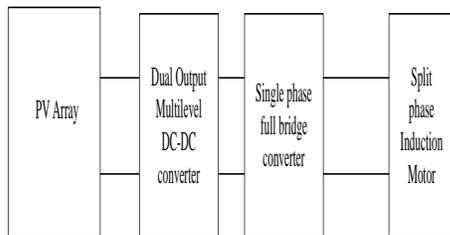


Figure 4: Block diagram representation of the proposed system

### a) HYBRID PV CELL

To serve this increased energy demand, Solar energy plays a vital role as it is pollution free, eco-friendly and available at free of cost. A photo voltaic system is a combination of several PV cells which converts the solar energy into electrical energy directly by using photo voltaic effect. All the PV panels must be connected either in series or parallel combination. But the series combination has the disadvantage of shading effect and the overall output efficiency of the system may affected when there is a short circuit fault. So parallel connection of PV Arrays is usually employed. For a temperature of $25^0$ c, and a short circuit current of 3.8A and irradiance of 1000, the output voltage obtained is 34.349v with a settling time of 0.0121s. The MATLAB simulated circuit of the hybrid PV cell is shown in figure 5 and its output is shown in figure 6 respectively.
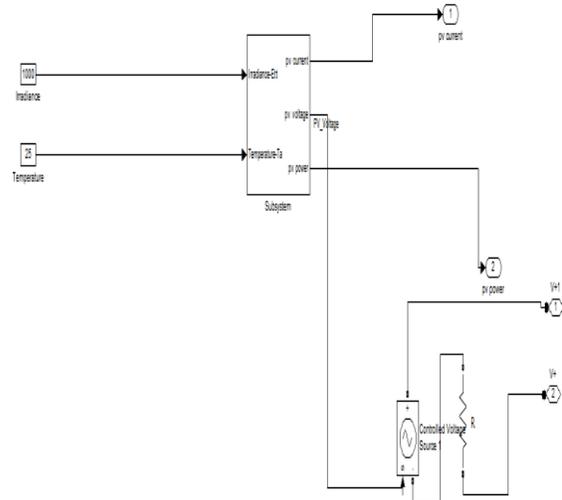


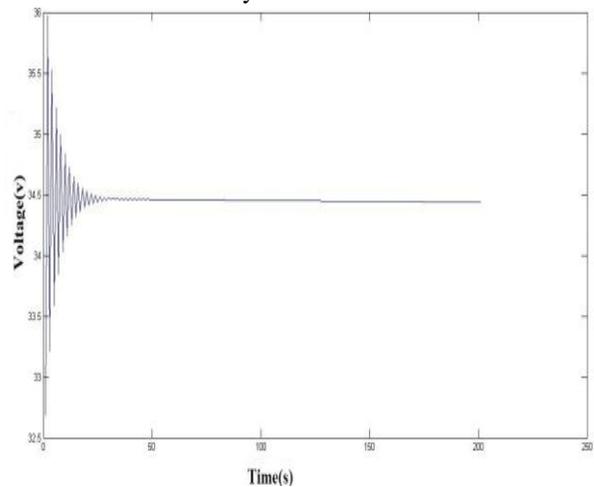Figure 5: MATLAB/SIMULINK model of the hybrid PV cell



Figure 6: MATLAB/SIMULINK model of the hybrid PV cell

b)MULTILEVEL DUAL OUTPUT DC-DC
CONVERTER:

The output of the hybrid PV cell is coupled to the multilevel high step-up dual output converter to increase the voltage gain. The Dual output converter operates in two modes depending upon the Duty cycle of the operating switch. The voltage gain of the cell can be increased by adding suitable no. of switches and diodes to the actual circuit.
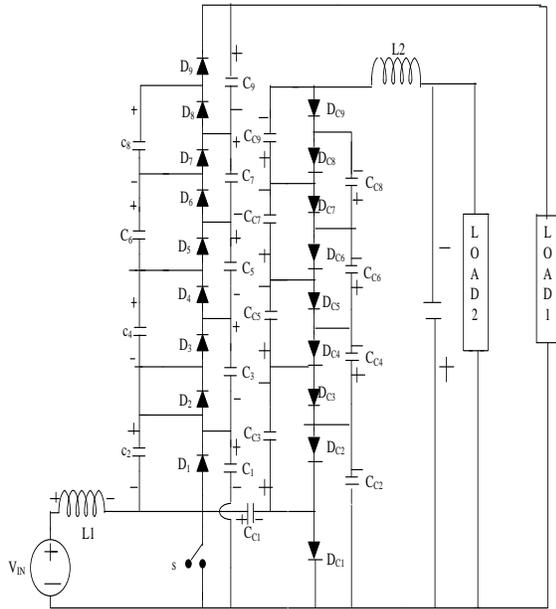


Figure 7: Dual output Multi level Boost –Cuk converter

The input output voltage relation for the given converter can be given as shown below.

$$V_{out} = \frac{N}{(1-D)} V_{in} \qquad (2)$$

The converter specifications are taken as $L_1$=700µH, $L_2$= 700µH and the voltage gain of the converter is given by $v_{out1} = 125v$ and $v_{out2} = -125v$ respectively. The figures above shows the MATLAB simulated work of the dual output Multilevel converter .For an input of 36v,an output voltage of +126v is obtained from Boost converter & a voltage of -126v is obtained from Cuk converter. The entire operation of the circuit depends upon the on and off periods of the conducting switch .The SIMULINK model and MATLAB simulated output of the dual output DC-DC converter is as shown in figure 8 and 9.
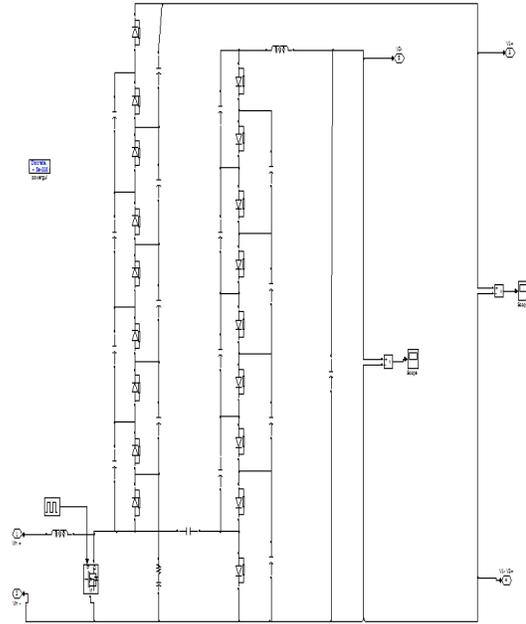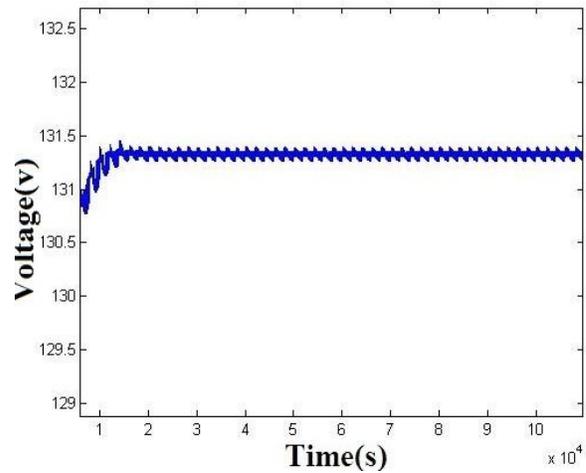


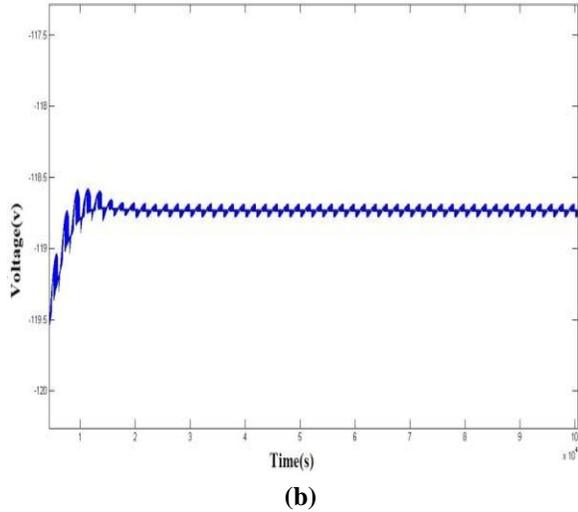Figure 8: MATLAB/SIMULINK model of the Dual output DC-DC converter



(a)

**(b)**

Figure 9: Output of the MATLAB simulated a) multilevel boost converter b) multi level cuk converter

#### c) SINGLE PHASE FULL BRIDGE INVERTER:

A single phase full bridge inverter essentially consists of four semi conductor devices which are connected in cascaded H-bridge combination and four diodes to provide the freewheeling path. It converts the given DC output into AC output .In each stage only two switches will be in conduction period .During the turn off period, the diodes comes into action by providing a freewheeling path if the load is inductive in nature. The circuit diagram of the single phase full bridge inverter is shown in figure 8.
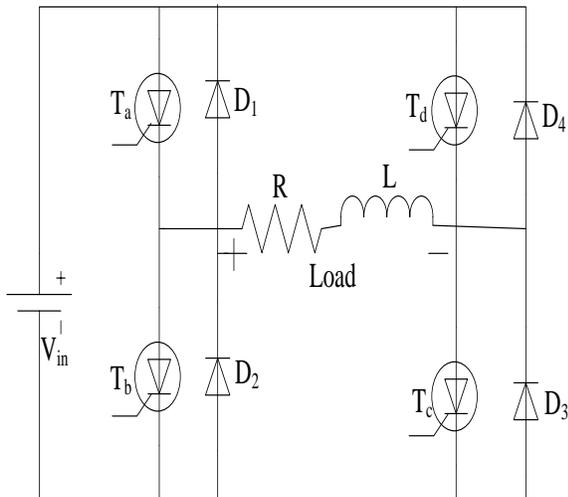


Figure 10: Single phase full bridge inverter

The MATLAB/SIMULINK output of the single phase full bridge inverter is as shown in figure 9 respectively.
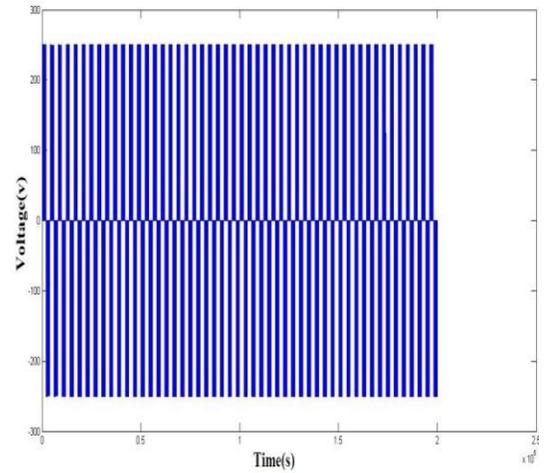


Figure 11: MATLAB/SIMULINK output of the full bridge inverter

### V. SIMULATION RESULTS

In this section, the complete system simulation results are included. The complete systems MATLAB /SIMULINK model is as shown in figure 10. The simulated results of the split phase induction motor which is operated with a load torque of 0.1 are presented in this section 5. The split phase induction motor characteristics like main winding current, electromagnetic torque and the rotor speed are obtained as shown in figures 13, 14 and 15 respectively.
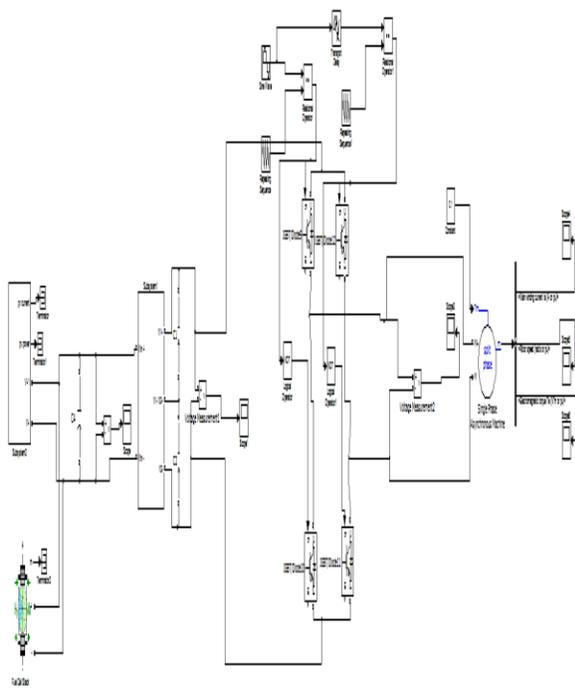
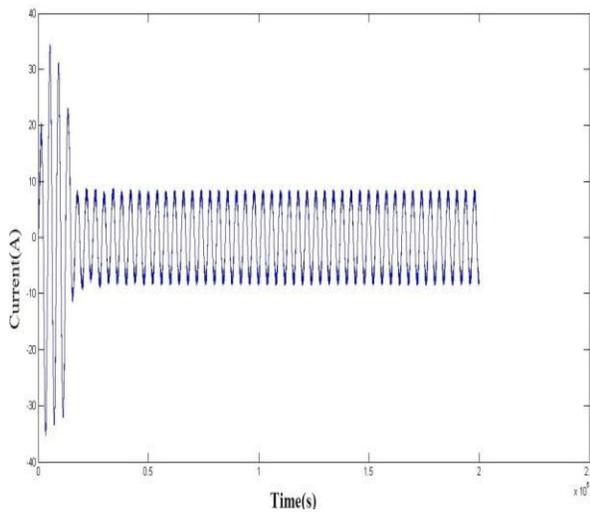Figure 12: MATLAB/SIMULINK model for the complete system
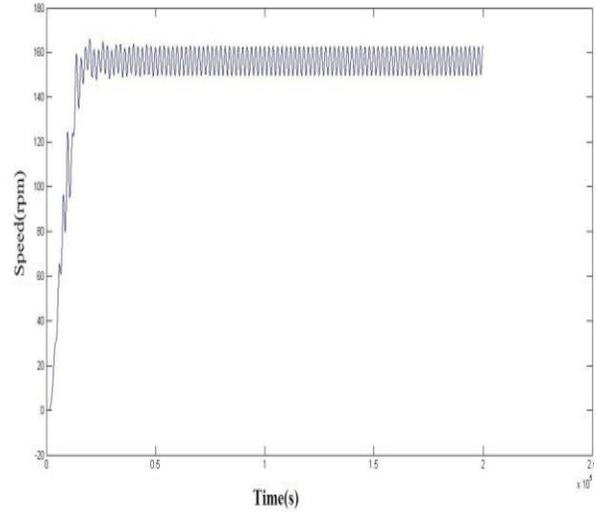

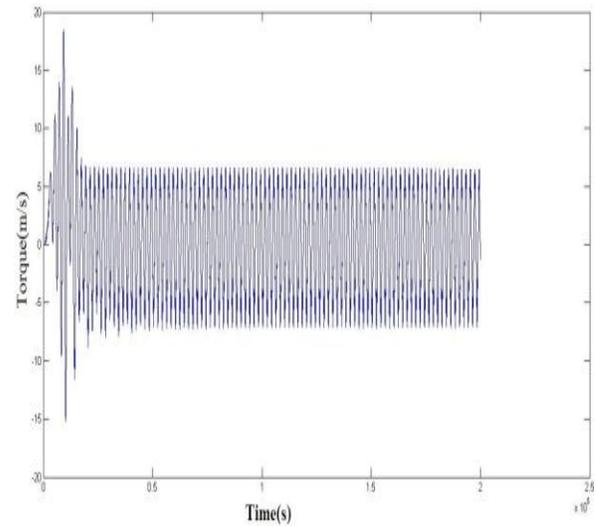
Figure13: Main Winding current



Figure14: Rotor Speed



Figure 15: Electro Magnetic torque

VI. CONCLUSION

In this paper the analysis and the simulation results of the proposed drive system is presented and the results obtained are included in the section 5. It can be seen that the dual output DC-DC converter is a better solution to yield dual output without any reverse recovery problem. Further the modeling of the split phase induction motor in MATLAB/SIMULINK is presented and the corresponding outputs obtained are analyzed.

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