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Single-Stage and Boost-Voltage Grid-Connected Inverter for PV/Fuel-Cell Generation System


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ABSTRACT

Photo voltaic (PV), with (i) the micro-grid side of the bidirectional voltage-source converters (μGVSC) (ii) tight control of the voltage converter is the ability to multi-functional characteristics of the fuel cell, (iii) MPPT / fuel cell hybrid power conversion system for grid integration group and the low power gain waves cascaded integrated boost (HGICB) DC- DC Converter with high gain tracking the performance demonstrated in this paper. PV solar irradiation from the side of the variable HGICB converter to extract the maximum power is controlled by the P & O MPPT algorithm. In this paper, intelligent functionality (a) the levels of irradiation at a ratio of active power into the grid feed (b) reactive power compensation of the following micro-grid applications maikrogramulu VSC theory postulates that a revised instant symmetrical components (C), load balancing (D), if any, non-linear loads generated by the point of common coupling (PCC) at unity power factor sinusoidal current distribution grid, thus enabling the mitigation of the current balance. Fuel Cell Energy System (BESS) and the utility grid of the power balance between PV generation is controlled. A new control algorithm is also tight for the converter DC link voltage to control the efficiency of the fuel cell is proposed in this paper. The fuel cell converter dynamic performance, researched and conventional average current mode control (ACMC) compared with. The development of a prototype of a hybrid PV Energy Conversion system and MATLAB / SIMULINK simulation environment.

Maikrogramulu VSC converters and battery power conversion system HGICB extensive simulation studies for the effectiveness of the proposed control strategies are validated by.

1. INTRODUCTION

Product availability is not sufficient to meet the growing energy demands of the central power. Several private sectors locally using traditional diesel generators to meet peak load demand and load to meet their contingent under the power cut and also invest huge money. The use of traditional means of power sources due to inefficient and limited functionality are getting annoying. Utilities in the private sector are now in their cleanliness, modularity, high efficiency and reliability of the accounts focus on the benefits of green energy technologies. A variety of green energy technologies, such as: the wind power, photovoltaic, micro-turbines, and fuel cells, fuel cell-based distributed generation, high operating efficiency (40-60%), reliability and the ability to have a high probability of one of the most promising technology [1], [2]. In fact, Distributed Generation, voltage

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support, reduced transmission and distribution losses provides improved reliability and power quality [3]. Fuel cell-based distributed generation system integrity, reliability and efficiency upgrade can be placed anywhere in the system.

On the basis of a boost voltage to a single-phase PV / FC system has been proposed [17]. The two-phase system to a single-phase PV / FC power conditioning system [17] is able to minimize the problems. Paper, single-phase PV / FC system is capable of dealing with the amount reported. The total capacity of the power rating of a single-phase system range and [17] improved by almost 10%. Discontinuous conduction mode inductor current support papers (DCM) boost inverter by using the stand-alone PV / FC system is illustrated in the performance. PV And the ability to cause a reduction in the lifetime of the ripple current cancellation / FC [17] - [19]. However, grid applications and the operating characteristics of the performance of a system is an important step forward that has not yet been reported in the literature is the technology

The aim of this paper is to propose an energy conversion step and using only a single-phase grid-connected PV / FC system is a complete report experimental results. In particular, the proposed system, based on the previously mentioned issues are addressed boost inverter (eg, PV / FC, with its slow dynamics, PV / FC and variable output voltage for low-side current harmonics). Single-stage power conversion and inversion functions to have both increasing and high energy conversion efficiency, reduced size converter, and low cost [17] provides. PV / FC generation system and encouragement for the proposed single-phase voltage inverter connected to the grid or operate in stand-alone mode or can be gridconnected.

DC-DC converter is an integral part of the fuel cell power conditioning unit, the paper DC / DC converter as well as a fuel cell model is not currently planned affair. DC / DC converter and controller to control the power control plays an important role for the development of a common DC bus. Boost converter to push fuel cell system, the interface is probably the pull, half-bridge, high efficiency and low component counts other than the bride and DC / DC converters used to full load, etc. placement offers. As discussed, [11], compared to the benefits and risks of confidence Place DC / DC converters of the components, based on the.

2. Configuration of Hybrid System and Modeling

Fig. 1 represents the schematic diagram of PV/Fuel cell/SC hybrid system. MPPT, DC-DC converter controller of the system, controller and inverter single phase loads fuel cell system includes a solar energy source. Both PV and fuel cell system can be connected to a common DC link. Supply or load transients adapt to the supercapacitor bank is connected to the DC bus. PV and ratings of 5.7 kW and 5 kW fuel cell system, respectively. DC link voltage (2.7 V capacitors, each of 150) and 92.5% of its charge capacity supercapacitor bank voltage rating of 370 V to 400 V 3 F option is the ability of the supercapacitor bank selection. Into a single phase H-bridge inverter is used to convert AC to DC power output. AC output LCL filter using a filter. The main control system controls the operation of the hybrid power system. It is the system and the voltage and frequency of the AC side to the DC side of the balance of power on the controller is the current control method.

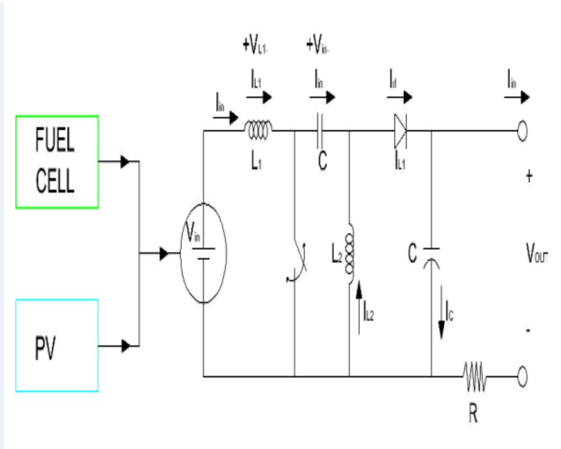

Fig.1The PV/FC/ hybrid system representation.

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2.1. Modeling of PV Array

A solar PV cell is a semiconductor P-N junction device which generates electric current when photons of energy higher than the band gap energy of semiconductor material fall on it. These cells are arranged in series and parallel combination to form a PV module. Several mathematical models were proposed in the literature for PV generation system and single diode model is used in this paper. Fig. 2 represents the equivalent circuit of single diode model of a solar cell.

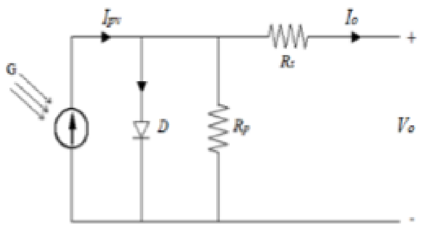

Fig. 2. Equivalent circuit of PV cell

From Fig. 2, output current of the PV cell is given by

$$I_o = I_{pv} - I_r \times \exp\left[\frac{q \times (V_o + I_o R_s)}{kT_c n} - 1\right] \quad (1)$$

Where q = Charge of an electron (1.6 x 10^{-19} C), Tc = Absolute temperature of solar cell (K) . Vo= output voltage and Io= output current of PV cell. The light generated current (photocurrent) Ipv is dependent on solar irradiation G (W/m^2) and cell temperature according to equation (2)

$$I_{pv} = [K \times (T_c - T_r) + I_{sc}] \times G \quad (2)$$

Reverse saturation current of the solar cell (Ir) is also dependent on cell temperature according to equation 3(a)

$$I_r = I_{rs} \times \left[\frac{T_c}{T_r}\right]^3 \times \exp\left[\frac{q.v_g \times (\frac{1}{T_c} - \frac{1}{T_r})}{nk}\right] \quad 3(a)$$

At standard temperature, the reverse saturation current is given by

$$I_{rs} = \frac{I_{sc}}{e^{\frac{qV_{oc}}{KF.T_r}}} \quad 3(b)$$

The cell idealizing factor (n) is dependent on the cell material. The output current of the solar array is given by equation (4). The PV system is modeled using MATLAB/Simulink environment.

$$I_o = N_p \times I_{pv} - N_p \times I_r \times \exp\left[\frac{q \times (N_p V_o + N_s I_o R_s)}{N_s N_p k T_c n} - 1\right] \quad (4)$$

2.2. Modeling of PEMFC

A fuel cell is a static energy conversion device that converts chemical reaction of fuels directly into electrical energy with some heat and produces water as its byproduct [13]. The chemical reaction sustains as long as fuel and oxidant supply is maintained. Fig.3 shows a simple arrangement of fuel cell system. The chemical reaction involved in the anode, cathode and electrolyte membrane for the production of electricity is given below

$$\text{Anode reaction} \quad H_2 \Rightarrow 2H^+ + 2e^- \quad (5)$$

$$\text{Cathode reaction} \quad \tfrac{1}{2}O_2 + 2H^+ + 2e^- \Rightarrow H_2O \quad (6)$$

$$\text{Overall reaction} \quad H_2 + \tfrac{1}{2}O_2 \Rightarrow H_2O \quad (7)$$

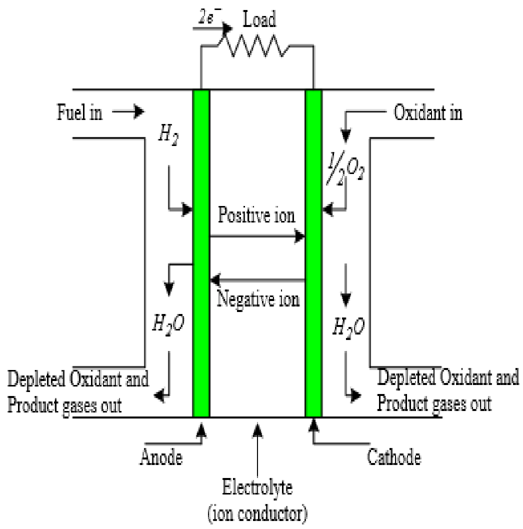

Fig. 3. Fuel cell operation diagram.

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The fuel cell performance is earmarked by its thermal and electrical efficiency. The thermodynamic efficiency depends on fuel processing, water management and temperature control of the system.

The electrical efficiency of the fuel cell depends on the activation & concentration loss apart from natural Ohmic loss. The fuel cell stack voltage under loaded condition (_dc stack V) is a function of activation loss (act V), concentration loss (con V), and ohmic loss (ohmic V) and is given by Nernst equation [14]

$$V_{dc\_stack} = V_{open} - V_{ohmic} - V_{act} - V_{con} \quad (8)$$

$$V_{open} = N_0 \cdot \left[V_o + \frac{RT}{2F} ln\left(\frac{PH_2\sqrt{PO_2}}{PH_2O\sqrt{PO}} \right) \right] \quad (9)$$

$$V_{ohmic} = I_{dc} \cdot R_{FC} \quad (10)$$

$$V_{act} = N_0 \cdot \frac{RT}{2\alpha F} \cdot ln\left(\frac{I_{dc}}{I_0} \right) \quad (11)$$

$$V_{con} = -c.ln\left(1 - \frac{I_{dc}}{I_{Lim}} \right) \quad (12)$$

Fig.4 shows the Simulink model as developed for the fuel cell stack based on the above five equations (8)-(11). Input for the fixed value of the pressures of the fuel cell PEM fuel cell stack voltage for the I-V characteristics of the simulation shown in Fig. 3. It's a low current level, ohmic loss becomes less important and the output voltage can be seen that the increase in the activity of the chemical reactions slowness. So polarization is also active in this area. Because the voltage at a very high power density of the gas exchange capacity reduction will come down significantly. This is due to the catalyst, such as water flooding, and this area is also known as concentration polarization. Active in the region and the concentrations of various departments in the area in the center of the internal resistance of the fuel cell is basically a linear slope. This area is commonly known as ohmic region [10], [15]

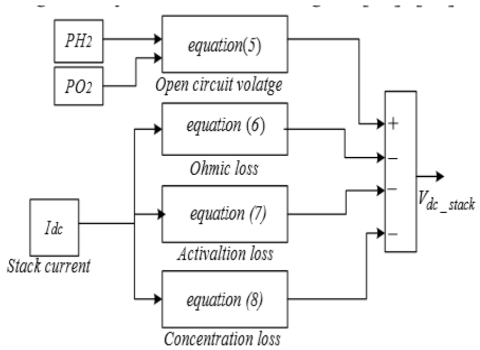

Fig4: Dynamic model of PEMFC using MATLAB/Simulink.

3. POWER ELECTRONIC INTERFACE

Buck / boost converters, it is possible to efficiently convert the DC voltage is either low or high voltage. Buck / boost converters, PV maximum power tracking purposes, regardless of the maximum power load, there is drawn from the solar panels at all times, especially useful for children.

DC / DC boost converter features drooping looking into the curved design of the A., unregulated direct voltage on the DC bus terminal, or residential / grid applications, DC / AC inverters is not possible using the interface. Therefore the design of the converter, a linear region of operation of the fuel cell stack (providing resistance to internal components) is taken into account. Beyond the linear region, the cell electrolyte membrane fuel cells may be damaged, can not be maintained. Fig.5 PWM DC / DC boost converter shows a closed loop continuous conduction mode of operation. The main advantages of the boost converter with high-performance and reduced component count and size of the components and reducing the cost of energy storage at a high switching frequency, duty cycle control voltage into the voltage is regulated by a variety of desired changes. The value of the boost inductor and capacitor value selection of components, such as to reduce the switching frequency is very important for the generation of the waves. However, small inductance inductance switch that turns off the front [17] does not allow for the flow of the coil to ramp up to higher levels will increase

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slightly during the start-up time. Fig.7 and Fig.8 time to time and the time of the switch [18] of the DC / DC boost converter shows the equivalent circuit. (14) (10) from the equations for steady state conditions, the voltage across the inductor converter and drop-off during the show.

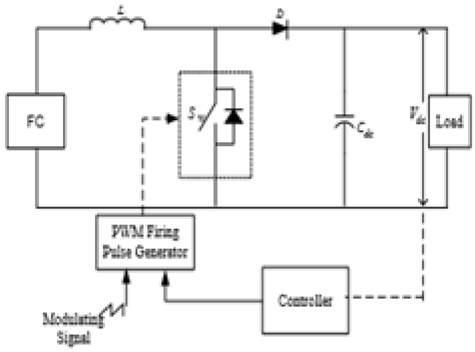

Fig. 5. Typical structure of DC-DC boost converter with feedback control

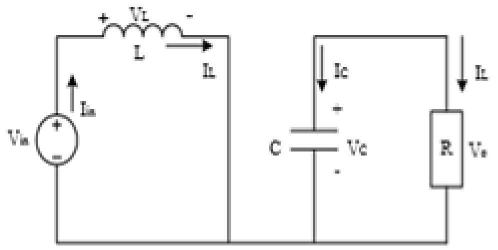

Fig.6.Equivalent circuit of the DC/DC boost converter during switch on time

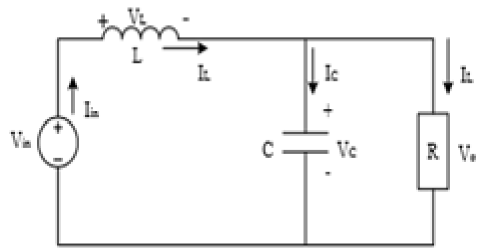

Fig.7.Equivalent circuit of the DC/DC boost converter during switch off time.

$$i_L(t)=\frac{1}{L}V_{in}t+I_L(0) \qquad 0\le t\ge dT \tag{13}$$

$$i_L(t)=\frac{1}{L}(V_{in}-V_o)(t-dT)+I_L dT \qquad dT\le t\ge T \tag{14}$$

Assuming I L(t)=IL(0), at t=dT and t=T, from the above equations

$$\frac{V_o}{V_{in}}=\frac{T_s}{t_{off}}=\frac{1}{1-d} \tag{15}$$

For lossless circuit,

$$V_{in}I_{in}=V_oI_o \tag{16}$$

$$\frac{I_o}{I_{in}}=1-d \tag{17}$$

The gain of the boost converter considering internal source resistance is given by:

$$\frac{V_o}{V_{in}}=\frac{1}{(1-d)+\frac{R_{fc}}{(1-d)R_L}} \tag{18}$$

The size of the reactive elements of Boost converter can be determined from the rated voltage, current ripple, voltage ripple and switching frequency of the converter based on the equations from (18) to (21). Table I enlists the main components of inductor and capacitor values for

Nexa™ 1.2kW PEM fuel cell.

$$d=\frac{V_{in}}{V_{out}} \tag{19}$$

$$Current\ Ripple=\frac{d(1-d)^2RT_s}{L} \tag{20}$$

$$Voltage\ Ripple=\frac{dT_s}{RC} \tag{21}$$

4. MATLAB BASED SIMULATION & RESULTS

The performance of the proposed control strategy was evaluated by computer simulation using Matlab/Simulink Platform. Here simulation is carried out in different cases; 1). Proposed Single-Stage and Boost-Voltage Grid-Connected Inverter for Fuel-Cell Generation System. 2. Proposed single-stage and Boost-voltage grid connected inverter for PV/Fuel cell generation system.

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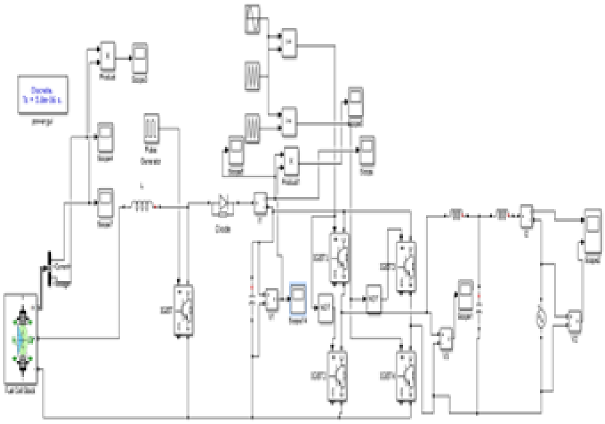
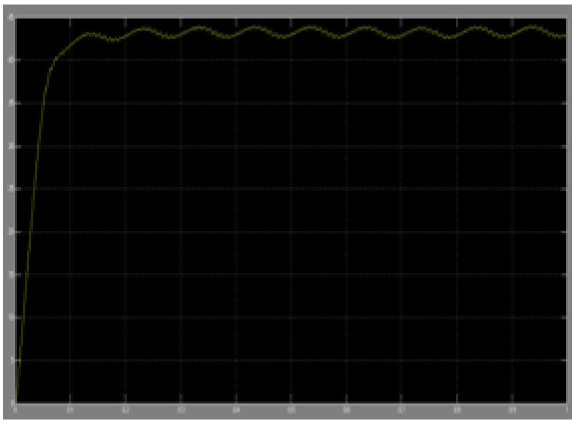


Fig.8 Single-Stage and Boost-Voltage Grid-Connected Inverter for Fuel-Cell Generation System



Output DC Voltage

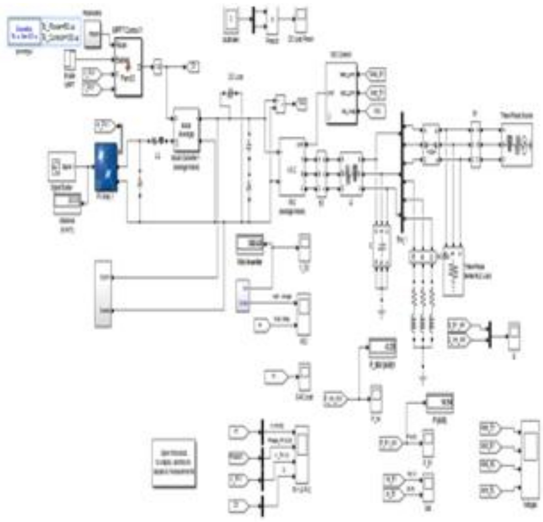
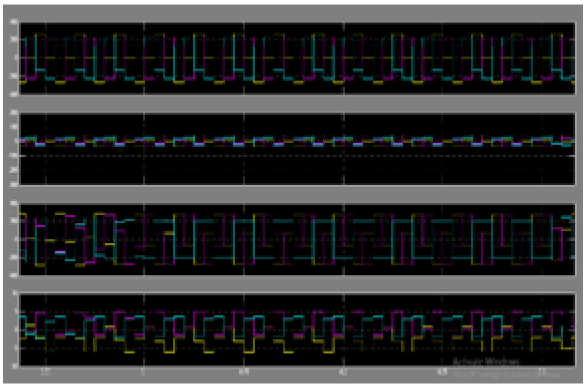
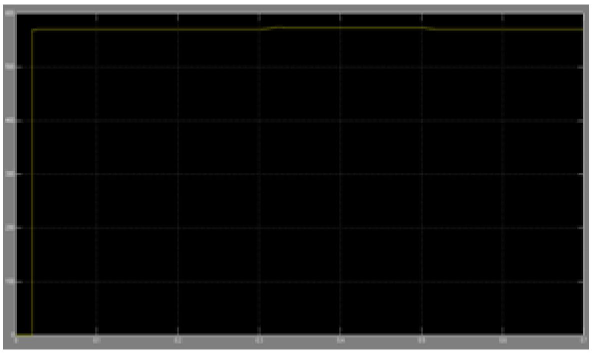


Fig.9 single-stage and Boost-voltage grid connected inverter for PV/Fuel cell generation system



Result: output voltages



Output DC Voltage

CONCLUSION

PV / fuel cell hybrid energy conversion system performance is proposed in this paper can be modified maikrogramulu instant VSC has been demonstrated with the application of the principle of symmetrical components, effective control strategy is also tightly DC To regulate the voltage converter has been proposed for bus fuel cell, solar radiation, and dc under a variety of load conditions. HGICB converter topology with high gain and low current ripple MPPT track. Piji VSC simultaneously PCC harmonic and reactive power compensation for unbalanced non-linear load, along with the ability to inject energy is generated into the grid. The system works satisfactorily under dynamic conditions. 2.06%

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