Design and Control of Grid Connected Hybrid Energy sources based BEMS

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Abstract—*In this, a synchronized control of grid connected SPV-DG-BES system is proposed with energy management control. The synchronized control regulates the DC-DC converter according to the availability of energy sources and grid system so that the injection of real power is done in order to charge the battery with reduced cost.*

***Key** words*—**Photovoltaic source, dc-dc converters, Diesel generator system, battery charging.**

I. INTRODUCTION

Traditional energy sources such as fossil fuels are going scarce compared to the growing demands and also it leads to more pollution. The renewable energy sources such as PV is adapted due to low operating cost and as the power generation process is free of any pollution. But it is less efficient and non reliable due to frequent changes in weather conditions. To make it more efficient MPPT techniques such as Perturb and Observe (P&O), Incremental conductance algorithms are developed for single PV panel systems. These algorithms track the maximum PV power and corresponding voltage, so that it makes the converter operates on that particular voltage and extracts the maximum power. SPV (Solar Photovoltaic) energy is the mostly useable renewable energy source in the distributed generation (DG) units. The quick development of the SPV methods and usage of SPVs in the grid-interfaced applications denotes that the SPVs are beneficial to generate eco friendly electrical power generation [1]. In grid intefaced SPV unit, the maximum power is provided to the grid system by the SPV unit at MPP (Maximum Power Point) [2]. The traditional VSC (Voltage Source Converter) associated with smoothening inductor is the highly used synchronizing unit in grid-interfaced SPV system [3]. The single and two stage grid connected PV units are commonly used in three phase systems. The two-stage conversion system consists a DC-DC converter stage with tracking of MPP and boosting up the voltage, and a DC-AC inverter stage for connecting the PV system to the grid system [4], [5]. A synchronized methodology of two stage grid interfaced PV and BESS (Battery Energy Management System) with ANFIS for voltage control [6] is proposed. Two-stage PV and battery energy storage system which operates by usage time for cost [7] is proposed for residential usage. The above mentioned systems suffers with lesser efficiency and higher cost, hence, for efficient grid-interfaced system it is not applicable. But, the single-stage methods provides higher efficiency compared to two stage toplogies. Various single stage methods are proposed, and a comparison between them are made [8], [9]. A grid interfaced single stage PV unit with better performance is analyzed [10], [11]. However, the compensation of neutral current is not provided, which leads to the higher harmonic contents in grid current.

In this, a single stage PV, Diesel generator and battery energy storage system is proposed. The DC-DC converter is operating under voltage control based on availability of sources. Based on the power generated by PV, the proposed control is classified into two modes 1) Power generation > Power Demand and 2) Power generation < Power Demand. During the time when PV is not generating power, the battery gets charged from other sources such as DG or grid.

II. MODELLING OF PHOTOVOLTAIC CELL

The equivalent circuit of a PV cell is shown in Fig. 1

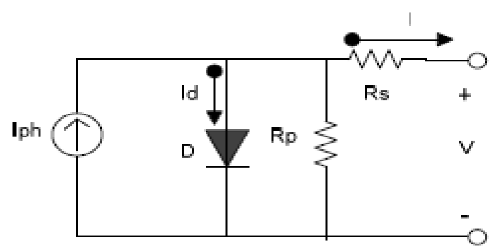

Fig 1 Solar Cell equivalent circuit

In various literatures it is also termed as a five parameter model (I_{ph}, I_o, n, R_s and R_p).

Where

I_{ph} is current of Photovoltaic cell (A), I_o is Saturation current of diode(A), n is Diode factor (1 <=n<=2), R_s is Series resistance (Ω) of solar cell and R_p is Shunt resistance (Ω) of solar cell.

•R_s is used to represent internal current flow losses and voltage drops.

•R_p is used to measure the internal leakage current flow due to reverse biasing of diode.

$$I = I_{ph} - I_o\left(e^{\frac{V*IR_S}{R_S V_T}} - 1\right) - \frac{V * IR_s}{R_p}$$

III. PV & DG FED BATTERY CHARGING UNIT

The proposed PV-DG fueled battery charging unit is shown in Fig. 3 below.

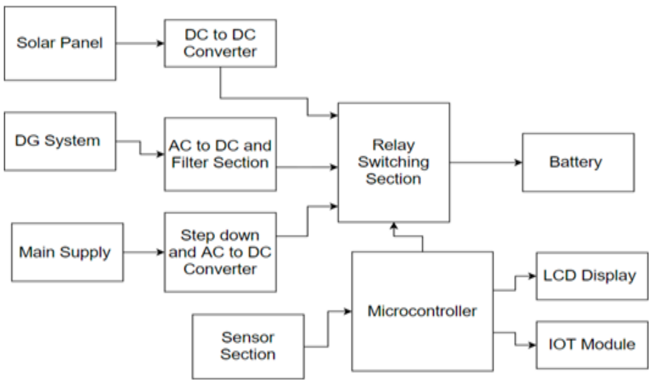

Fig 2 Proposed battery charging unit

The PV power is provided to buck converter which step down the PV voltage according to the duty ratio generated by the controller and the converter output voltage is reduced to battery voltage by the buck converter. The controller will automatically switches the source based on its priority. In this charging station user will be able to see remaining charging percentage and amount in LCD display. It also aims to reduce time and increase functionality. Thus, the system cost is reduced by using renewable power sources, solar panel, DG and main supply which reduces cost of charging. All the control system and sensors are interfaced with controller which is the main heart of the system. The microcontroller does the automatic switching between the sources using relay which receives the signals from the controller. Finally, information is displayed on LCD as well. Based on the battery charging status, user will able to see it in the LCD display.

The circuit of buck converter is shown in Fig. 3 below.

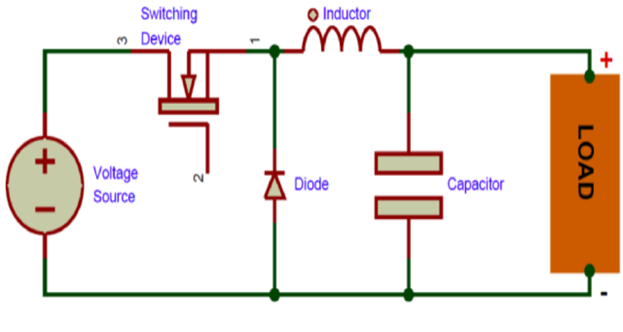

Fig 3 Buck converter circuit

The above provided circuit step downs the voltage as per the pulse width for which the switch is conducting. It comprises of switch, inductor, capacitor and diode. The output voltage is designed to be lesser than that of source voltage. The operation of the buck converter is explained in the modes of operation as follows:

Mode 1:

The equivalent operational circuit for mode1 is shown in Fig. 4. Here, the switch is conducting and the inductor is in charging state. The output voltage is given in the equations shown below:

$$V_o = V_{in} - V_L$$

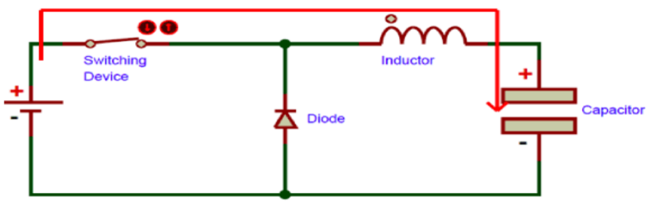

Fig 4 Mode 1 Equivalent circuit of buck converter, Vo=Vin-V_L

Mode 2:

The equivalent operational circuit for mode1 is shown in Fig. 5. Here, the switch is turned off and the inductor is in discharging state. The output voltage is given in the equations shown below:

$$V_o = V_L$$

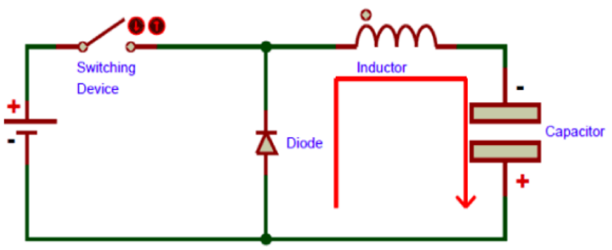

Fig 5 Mode 2 Equivalent circuit of buck converter, Vo=V_L

The design equations of the buck converter are given below:

The Duty ratio (D) is shown below:

$$D = \frac{Vo}{Vin}$$

The inductance is calculated as follows:

$$L = \frac{Vo*(Vo-Vin)}{\Delta Io*Fsw*Vin}$$

The ripple current of the inductor is calculated as follows:

$$\Delta I_L = 0.2 * I_{in}$$

The load capacitance is calculated by the following equation:

$$Co = \frac{\Delta Ioc}{8 * Fsw * \Delta Vo}$$

The ripple voltage of output capacitor is given below:

$$\Delta Voc = 2\% \ of \ Vo$$

IV. SIMULATION RESULTS

The simulation circuit for Hybrid energy sources based battery charging when PV connected is shown in Fig. 6 below:

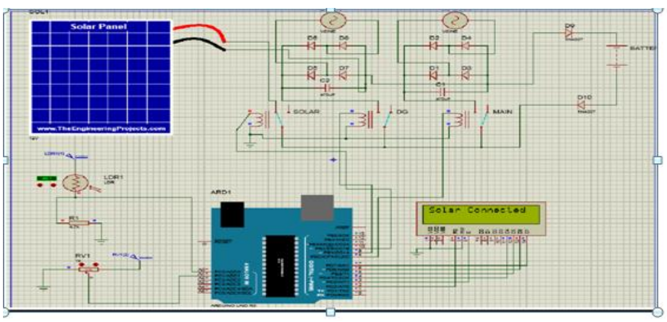

Fig 6. Simulation circuit of proposed Hybrid sources based battery charging System with PV connected status

In this, the PV irradiance is high, and the PV is connected to the system in order to charge the batteries. During this time period DG and grid is not connected to the battery charging unit. The simulation circuit for Hybrid energy sources based battery charging when grid connected is shown in Fig. 7 below:

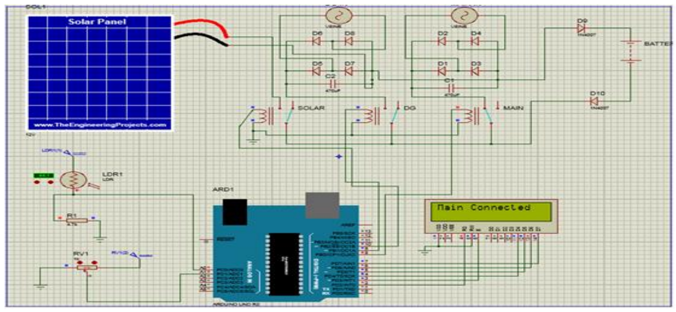

Fig 7. Simulation circuit of proposed Hybrid sources based battery charging System with grid connected status

In this, the PV irradiance is low, and the PV is disconnected from the system so that the grid will be connected to charge the batteries. During this time period DG and PV is not connected to the battery charging unit. The simulation circuit for Hybrid energy sources based battery charging when DG is connected is shown in Fig. 8 below:

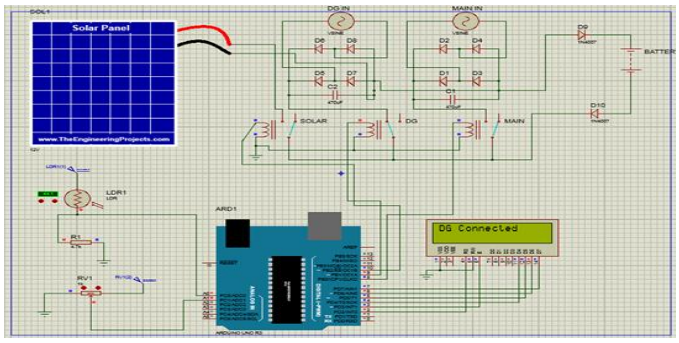

Fig 8. Simulation circuit of proposed Hybrid sources based battery charging System with DG connected status

In this, both the PV and grid is not available, and the DG unit is connected to charge the batteries. During this time period grid supply and PV is not connected to the battery charging unit. The status of the energy sources connected to the battery charging unit is provided in the LCD display. The charging will automatically stop once it is fully charged.

V.CONCLUSION

In the present paper newly automated charging station is creates that would reduce charging station human labor. Solar- powered EVs will minimize grid energy consumption. It provides work possibilities while also strengthening the economy. The non-conventional sources of generation had been employed successfully to charge the vehicle. The simulation work is carried out and the switching of the sources is done by the controller automatically based on the availability of the sources.

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