

# PV Based Grid Connected System For Residential Applications

A.Venkatesh, K.Durgalakshmi, M.Pradeep

**Abstract** : A technique of combining a solar power photovoltaic (PV) using an electric battery storage space into a single-phase power intended for domestic uses can be provided in this article. One of the suggested work is certainly, to feed a consistent power to the main grid, although charging as well as, discharging of your battery accomplish electric power levels and load leveling besides improved consistency with the system. And the voltage-source converter will act as an active power filter and then functions the harmonics declination using reactive power compensation. The entire control system is flexible within numerous practically developing circumstances including disconnection in the PV array, any electric battery as well as the main grid from your system. Finally, the comprehensive model and then control of the suggested system will likely be shown. The quality with the recommended model can be carried out by using a research laboratory model designed to get end result voltage of 230v.

**Index terms** : Battery Energy Storage System(BESS),Maximum Power Point Tracking(MPPT), Electric Vehicle(EV), Solar Photo Voltaic (PV) Array Utility Power Supply(UPS), Pulse Width Modulation(PWM).

## 1 INTRODUCTION

Solar power is the readily available, essential way to obtain renewable power. Entire world obtains 174 PW from solar power diffusion in the top atmosphere approximately. 30% is usually returned back in environment whilst remaining is usually assimilated by atmosphere oceanic masses territory .Over-all solar powered energy assimilated by means of surroundings is around 3,850,000 Exajoules annually. Time period deviation may possibly influence the potential of solar powered energy. Solar cell could be connected in series or in parallel to improve voltage /current. The output of the solar panel can be regulated by using suitable regulator for battery charging. This paper also include an approach to utilize the solar energy to charge the battery for BESS. BESS can be beneficial for applications such as EV uses, power supplies while integrating with inverter.And the unavailability from solar powered energy especially during night time as well as the unreliability in power main grid occurs the requirement of a good tertiary resource inside the model. And the battery energy storage system (BESS) behaves as a load and then stores the power and as well, behaves as an origin to fulfill requirements of additional electric power by load, therefore raising the dependability of this model. The BESS makes up the most fragile link inside the device. Therefore, numerous topologies have already been recommended concentrating on means of increasing that lifetime in the electric battery besides effective success from the designed performance of preserving the power stability inside the model. The following improves

the dependability in the model. This kind of solar powered energy is also utilized for UPS recharging model. MPPT protocol could be applied to make sure you get over that \

challenges including unavailability connected solar power lights as a result of numerous geographical conditions. A comparison connected numerous MPPT methods are given in [11] as well as [20]. MPPT( maximum supply point tracker) can be an electronic DC so that it will DC conversion app which usually improves the match up with solar choice (PV panels), as well as electric battery bank or perhaps power main grid. Putting it simple, they will replace an increased voltage POWER output coming from solar power panels straight down towards the reduced voltage required to recharge battery packs. Numerous studies have been performed for developing PV by way of main grid. Maximum electric power taken out right from solar power panel is usually given so that it will main grid is shown by [18]. The texts assessment exposed several advantages of inculcating a good BESS inside the model that are enrolled below. Electric power progressing: The change in the SUN electric power because of the changing padding as well as the geographical conditions are smoothen away as developed [2]. Load progressing: The rising and falling load attached to the model the whole day is proportioned away simply by reaching the regulated recharging and as well, discharging in the electric battery. The several loads predicting protocol assists with reaching the switching in the ton to minimize the quantity of electric power bought in from power main grid [6]. Some of the solar powered energy forecasting also helps in achieving the peak shifting, which benefits the consumer by maintaining a co-ordination between the power bought from the entire power grid, solar PV, and the battery in a way to benefit the consumer Electric vehicles (EVs): With advancing technology and increasing awareness of EV, the advantages of the battery will be extended recharging and as well discharging of Electric Vehicles. A variety of research has been proposed in the literature dealing with ways of incorporating plug in vehicles, vehicle-to grid and grid-to-vehicle charging, charging converters for the battery, and swapping of the battery. Various approaches of implementing battery charging have been proposed in [1]. The entire failure of one's main grid due to the occurrence of a problem caused either due to natural calamities or overloading of transmission lines affects the stability of the solar PV system and also possesses threats to the personnel working for the mitigation of the fault. Thus, vast research has been in maintaining a continuous power supply to the load, especially critical masses such as therapeutic equipment, telecommunication

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network, etc. To achieve a rigid synchronization between the grid and load concentration, various phase-locked loop (PLL) have been presented[5]. Specific controllers are devised in support of interconnecting the entire main grid back to the system after clearance of one's problem. The entire seamless switch of power in a single-phase grid between grid-connected and standalone modes are proposed in [7]. The entire controller switches the control at the focus crossing on voltage and so current, thus emphasizing the entire utilization of each zero-crossing metal detector resulting in low reliability of the system. Transition using power drop control of things is proposed in [15]. The entire resynchronization is achieved using a PLL-PI-based controller. The stability analysis of the controllers is carried out through the frequency blog and linearization of the conversion application models. Since the focus of the work is usually to analyze the integration of one's electric battery recollection to the grid, perturb and form is implemented for the entire removal on optimum power. The unique results reveal the satisfactory performance of the system when subjected to varying disturbances. The block diagram of the proposed topology is depicted in Fig. 1. It depicts about how the proposed system is working. PV array converts solar energy to dc supply which is then regulated using suitable regulator and then used for BESS charging also it is boosted by using buck-boost dc-dc converter simultaneously. The boosted dc voltage can be used as inverter input thus we get sinusoidal output with the help of suitable filter. The main feature of this proposed method is implementing the buck-boost converter for boosting the solar panel output , and implementing the power MOSFET switch for its advantages such as with its high commutation speed and high efficiency during its operating voltages ( $< 600V$ ). The gate signal of the MOSFET switches PWM pulses inverter. The inverter used in proposed method is H-bridge type inverter (Bipolar switching). The outcome in dc-dc converter could be managed by simply manipulating the duty cycle with the converter .Fig.2. displays C'uk converter topology which works on duality theory just like buck boost converter in which buck or perhaps boost operation can be managed by way of duty cycle variation of one MOSFET switch .if the switch is usually on, the source stimulates the inductance L, nevertheless it can be from the energy source can be utilized in the outcome. The voltage relationship is given by

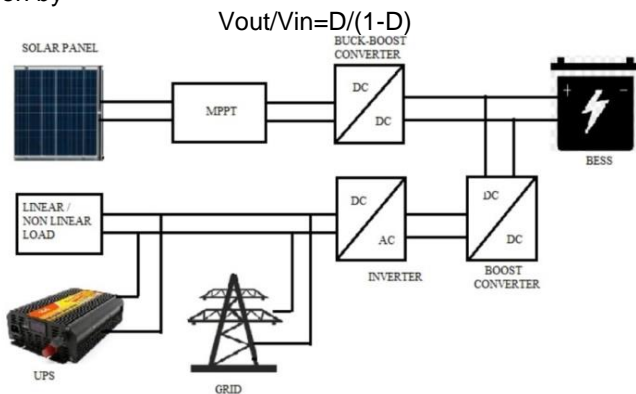


Fig 1. Block diagram of the proposed topology.

where  $D$  = Duty cycle of the switch. If  $D > 0.5$ , it is a boost converter, if  $D < 0.5$ , it acts as buck converter.

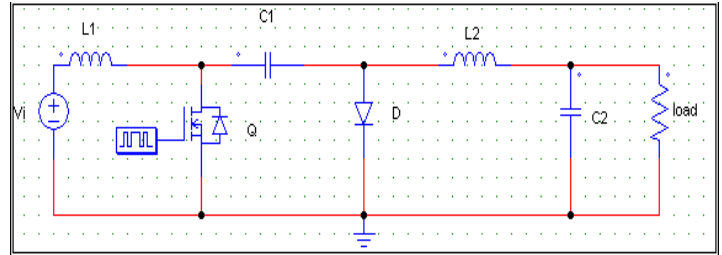


Fig 2. Buck-Boost converter topology (Cuk converter)

### 2 SOLAR PANEL EQUIVALENT CIRCUIT

To comprehend the digital behavior of the solar power cell, it can be beneficial to make a unit which can be electrically comparative, and it is based upon discrete electric components as their actions are well-known. A perfect solar power cell can be designed using a current source in parallel having a diode; in fact no solar power cell is perfect, therefore a shunt resistance including a series resistance element will be included with the unit. The resulting comparative circuit of the solar power cell is demonstrated on the left. Likewise displayed, on the right, certainly is the schematic illustration of the solar power cell use with circuit diagrams.

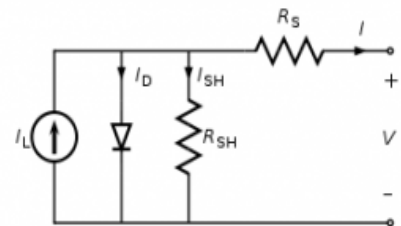


Fig 3. Equivalent circuit of solar cell

### 3 CHARACTERISTIC EQUATION

$$I = I_L - I_D - I_{SH}$$

where

- >  $I_D$  = diode current (amperes)
- >  $I$  = output current (amperes)
- >  $I_{SH}$  = shunt current (amperes).
- >  $I_L$  = photo generated current (amperes)

$$V_d = V + IR_S$$

where

- >  $V_d$  = voltage across both diode and resistor  $R_{SH}$  (volts)
- >  $V$  = voltage across the output terminals (volts)
- >  $I$  = output current (amperes)
- >  $R_S$  = series resistance ( $\Omega$ ).

By the Shockley diode equation, the current diverted through the diode is:

$$I_D = I_0 \left\{ \exp \left[ \frac{qV_j}{nkT} \right] - 1 \right\}$$

where

- $I_0$  = reverse saturation current (amperes)
- $n$  = diode ideality factor (1 for an ideal diode)
- $q$  = elementary charge
- $k$  = Boltzmann's constant
- $T$  = absolute temperature
- At 25°C,  $kT/q \approx 0.0259$  volts.

By Ohm's law, the current diverted through the shunt resistor is:

$$I_{SH} = \frac{V_j}{R_{SH}}$$

where

- $R_{SH}$  = shunt resistance ( $\Omega$ ).

Substituting these into the first equation produces:

$$I = I_L - I_0 \left\{ \exp \left[ \frac{q(V + IR_S)}{nkT} \right] - 1 \right\} - \frac{V + IR_S}{R_{SH}}$$

A different derivation generates an equation identical in features. The 2 alternative options will be individual; that may be, they will generate exactly the matching outcomes. In basic principle, provided a specific functioning voltage  $V$  the formula might be resolved to look for the functioning current  $I$  at that voltage. Nevertheless, since the formula entails  $I$  upon both sides within a transcendental action finally, the formula does not have any standard conditional answer. On the other hand, without even an answer it can be actually instructional. Secondly, it is actually quickly resolved employing statistical strategies.

#### 4 SHORT-CIRCUIT CURRENT & OPEN-CIRCUIT VOLTAGE

The open circuit voltage and short circuit current are given by the expression as follows:

$$V_{OC} \approx \frac{kT}{q} \ln \left( \frac{I_L}{I_0} + 1 \right).$$

$$I_{SC} \approx I_L.$$

#### 5 EFFECT OF PHYSICAL SIZE

$$J = J_L - J_0 \left\{ \exp \left[ \frac{q(V + Jr_S)}{nkT} \right] - 1 \right\} - \frac{V + Jr_S}{r_{SH}}$$

where

- $J$  = current density (amperes/cm<sup>2</sup>)
- $J_L$  = photo generated current density (amperes/cm<sup>2</sup>)
- $J_0$  = reverse saturation current density (amperes/cm<sup>2</sup>)
- $r_S$  = specific series resistance ( $\Omega$ -cm<sup>2</sup>)
- $r_{SH}$  = specific shunt resistance ( $\Omega$ -cm<sup>2</sup>).

This kind of formula offers many positive aspects. The first is that seeing that cell features will be referenced into a prevalent cross-sectional region they might be contrasted intended for cells of various corporal sizes. Whilst this really is of small

advantage within a developing environment, exactly where almost all cells continue to be a similar shape, it really is within analysis in addition to evaluating cells among producers. An additional would be that the thickness formula normally scales the variable values to comparable orders in magnitude and degree, that will make mathematical removal of these easier and even more appropriate remedy strategies.

### 6 PROPOSED METHOD SIMULATION

The IGBT continues to have those drawbacks of the relatively huge current tail as well as the insufficient body-drain diode. Early on IGBT types had been vulnerable to latch up, as well, yet it had been mainly removed. An additional probable risk which includes IGBT designs may be the unfavorable temperature coefficient, which could result in thermal runaway, which makes the paralleling in tools difficult to successfully accomplish. Presently, this issue has been resolved inside the most recent versions of IGBTs which can be based upon non-punch-through (NPT) concept. The IGBT may be the method intended for breakdown voltages over 1000 V, even though the MOSFET is perfect for gadget breakdown voltages under 250 V. Standard full bridge inverter with the 4 MOSFET switches is displayed on the fig 4. Right here we tend to use two gate pulses seeing that MOSFET is usually voltage controlled system. Finally, the load chosen at this point is resistive.

#### A.MATLAB/SIMULINK SIMULATION

The simulation of proposed method is done using simulink in MATLAB which has solar panel model followed by an embedded program to limit power output which is then followed by a capacitor to match the impedance so that the dc-dc converter performance is improved that is shown in fig 4.

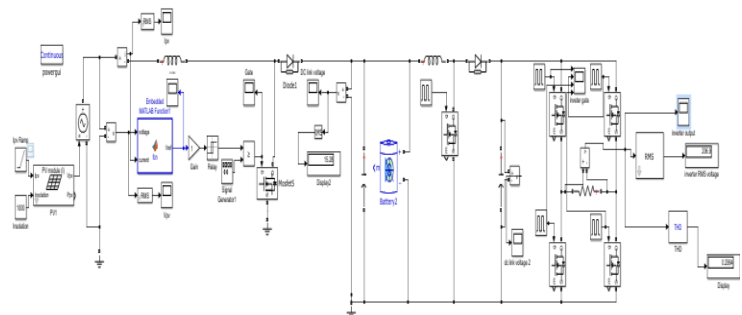


Fig.4. MATLAB/Simulink simulation for proposed method

#### B.EMBEDDED PROGRAMMING FOR PWM GENERATION

An embedded system program is done in MATLAB which get input from solar panel to create PWM signal .It is then compared with signalgenerator's signal along with relay control. The duty cycle of PWM signals is controlled by manipulating variables in embedded program. The topology used is H bridge with 4 MOSFET whose gate signal is programmed such that modified square wave is obtained as output. The proposed method of inverter topology is shown in the fig 5.

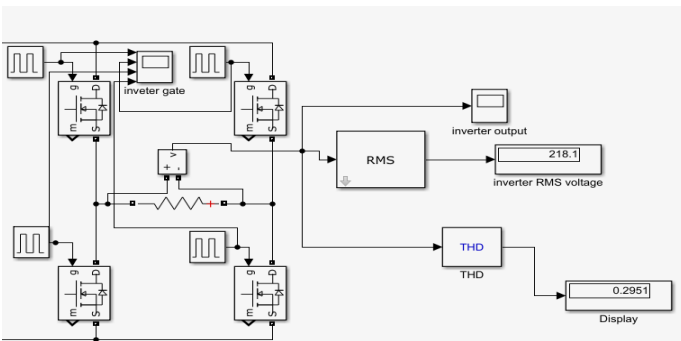


Fig 5. Inverter with output RMS value

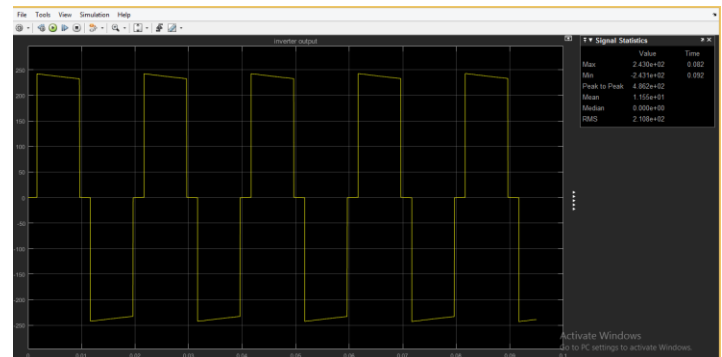


Fig 8. Inverter output of proposed method

The output measured values of open loop method is given in Fig.7. The output value is RMS value ranges to 210-232V AC. The total harmonic distortion (THD) is seen to be 29.5% in open loop method. The BESS shall be installed before the dc-dc converter. The PWM technique is implemented for gate pulse in both dc-dc converter as well as Buck-Boost converter. The generated pulse wave form is shown in figures 6 and 7.

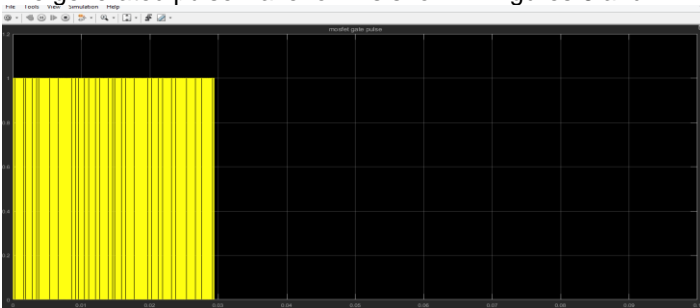


Fig 6. Gate pulse for MOSFET switch in Buck-Boost converter

Fig.6 shows the output waveform of inverter. The waveform is seen to be modified square waveform with 432-480V peak-peak voltage. The BESS can be also used as back up battery during night time. Harmonics can be reduced by using suitable harmonics reduction method. Low pass active filter can be used to convert the modified square wave to sinusoidal output.

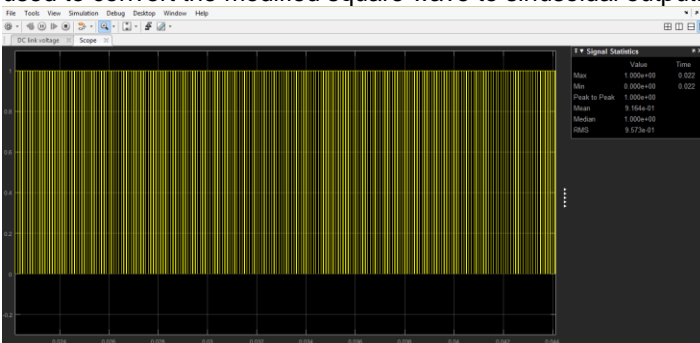


Fig 7. Pulse for MOSFET in dc-dc converter

## 7 CONCLUSION

The suggested plan utilized for a photovoltaic array including a BESS into a single-phase main grid by way of multipurpose properties. The device displays exclusive top features of flexible control within several practically happening circumstances including unavailability of this photovoltaic array, electric power failing following geographical unfortunate occurrences just like cyclone and so on. The device is most effective intended for domestic functions. The electric battery assist smoothens the fluctuations from the photovoltaic array as well as the load, therefore raising the life-span. The execution of total metering creates numerous gains meant for the customer by minimizing the quantity of energy levels from that power main grid. Finally, the VSC has the capacity to minimize the switching harmonics found in main grid current and load voltages from the device. The attained testing outcomes possess verified the effectiveness and then feasibility with the suggested model within several disruptions.

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