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# Design and Simulation of High-Gain DC-DC Converter using P&O Algorithm with Bi-Directional Converter for Minimum Voltage Standalone Solar PV System

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***Abstract:*** ***The inexhaustible source of energy which produced from sun through radiation and it is readily available source at free of cost. Solar Photo Voltaic (PV) systems are used as a primary source to produce power. The solar PV system needs DC-DC converter with enhanced voltage gain as well as efficiency. A typical DC-DC converter provides constrained gain and productivity as increase in requirements. For organization of battery Bidirectional converter is used which allows the energy flow in both the direction. The complete working of below voltage PV system and battery that is used are worked by using various dc converters from which the efficiency and gain level can be improved. Maximum Power Point Tracking (MPPT) is employed to receive peak power from solar PV by sustaining DC line voltage and satisfy power requirements. The perturb and observe (P&O) algorithm is mostly used to obtain the high voltage from solar PV. The entire framework is designed and simulated using MATLAB-Simulink toolbox.***

***Keywords: DC-DC converter, MPPT algorithm (P&O), State of charge (SOC), Simulink.***

## I. INTRODUCTION

The increasing requirement of global energy associated with society's build up awareness of environmental influence from the widespread applications of fossil fuels has leads to the study of PV systems [1]. The solar photo voltaic system are now a day widely used in producing electrical energy from the sunlight this consists of high power and low power values. The solar radiation is directly converted into electricity without any noise through PV cell [4], they are majorly used for several applications such as industries, institutions, villages and rural areas where they can produce their own electricity. For the process of transforming the voltage to the required level with aid of converters [7]. Frequent converters which gives commonly the controlled gain. So that type of converters efficiency is less because of high voltage gain. Hence PV Solar panel is considered as main supply, input voltage produced will not be constant according to the environment changes, the voltage level will be more gain are suggest [10] as a substitute to the common result owing to its higher efficiency, with light weight as well as cost. So many PV systems requires DC-DC converter to recover the essential high voltage. Durability is a critical element in solar PV system. The design of Solar Photo voltaic energy supplying equipment we should produce much determination for strength of the system and so to carry off the needed output requirement, should accumulate about the assessment control performance system. Solar PV system is mainly used as the power supply for the input voltage.

MPPT is used as charge controllers for isolating peak power acquirable from PV system in similar conditions [14]. The maximum output voltage delivered from solar PV system is called maximum power tracking. The supreme power that can be varied according to solar cell temperature, solar radiation and ambient temperature. Maximum power tracking or sometimes used as power point tracking (PPT) technique which are used commonly PV solar systems and also in wind turbines to increase the power output under all circumstance. Although it chiefly spread to solar power, the basis applies commonly to sources with different sources: for example, optical power transmission and thermo photo voltaic. The solar system lies in various compositions with concern to their relationship to inverter applications, additional grids, power banks, or various electrical loads. The quantity of sunlight differs; the typical load that produces better power transfer efficiency also varies, so the system which contains efficiency is optimized when the typical load varies to maintain the power transfer more efficient.

MPPT algorithm tracks the Maximum Power Point for better loading requirement. The boosted duty cycle delivered from MPPT will be given to DC-DC converter switch, the switching device used in DC-DC converter is MOSFET.

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The MPPT here we are using is perturb and observe algorithm. In P&O method, controller regulates the voltage by a low range from the array and chooses the power; certain adjustments are done in the control when the power gets increased. This process is said to be perturb and observe condition, there will some certain difference in output power. P&O algorithm are generally used method due to absence of implementation. P&O method results in high efficiency. The DC converter will gain up the voltage from the panel and it provides the voltage to DC line. The DC line containing voltage should be maintained constant and is used to carry out electrical energy to the load side. It should be maintained always. The DC converter output voltage is then supplied to the three phase converter and bi-directional converter. The total conversion of DC supply to AC supply is done by using the three phase inverter. The three phase AC power is then provided to load that are to be associated [10]. The solar panel cant able to give the continuous power supply so that we are connecting a bidirectional converter interfacing with battery. The bidirectional converter which operates as both bucks and boost converter for battery charging and discharging.

In this article section III, describes the proposed system of the project and defines how the operation is to be performed. Section IV, defines the working of high gain DC converter how input voltage get improved. Section V, shows which type of algorithm is preferred for maximum power tracking and section VI, describes working of bi-directional converter. Section VII, highlights output voltage waveforms of DC-DC converter and battery charging and discharging conditions, Lastly section VII , gives the conclusion and future scope of proposed work.

## II. PROPOSED SYSTEM

The PV system output voltage is less and it is used as an input for high gain boost DC converter that boosts the voltage by adding additional capacitors in the converter circuit. The proposed block diagram is shown in fig.1. The output of high gain boost converter is given to the input for three phase inverter. The Maximum power tracking algorithm contains three main divisions. From that P&O algorithm is selected to track supreme power and it is developed as duty cycle which is inclined to DC-DC converter switch. In proposed work, three phase inverter with 120° operation is suggested. The output of three phase inverter is then given to standalone load [6]. The bi-directional converter is used for performing both boost and buck converter operation.

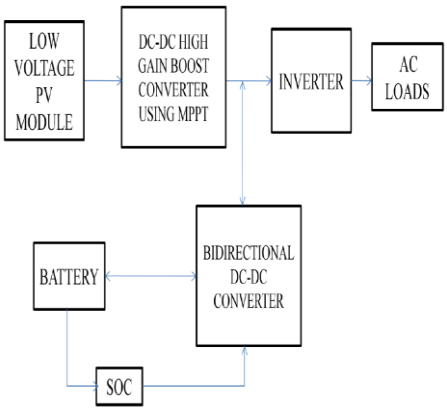



**Fig. 1. Proposed block diagram**

The battery will get charged and discharged while performing as buck converter and boost converter respectively. The State of charge (SOC) is used to determine the charging condition and discharging condition of battery. The SOC will frequently analyze the load handling quantity of circuit. There is trouble appear in the power production of the solar photo voltaic panel such as overloading and reduction, the SOC block will indicate the signal and supply the voltage from the battery through Bi-directional converter which makes them to perform as boost converter and when supply voltage from photo voltaic panel is maximum they perform as buck converter and the battery will get charged.

### A. High Gain Boost converter

An efficient high gain boost converter is used for boosting up the voltage by adding additional capacitors in the circuit and supply voltage is feed from the solar PV module as shown in Fig. 1 [9]. The switching device used is MOSFET. The representation of high gain DC-DC converter is shown in Fig. 2.

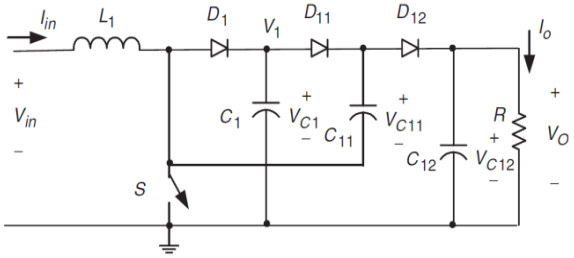



**Fig. 2. Circuit diagram of DC-DC converter**

The voltage across capacitors C1 and C2 is charged to V1 and voltage beyond capacitor C3 is charged to Vo = 2V1. The current iL1 flow through the inductor L1 increments with voltage Vin during Kt and decremented with voltage (V1 – Vin) during (1-k) t condition. DC-DC converters is an electrical circuit which are said to be power electronic components. These devices perform the operation of converting the voltage from one form of voltage to other form of voltage. From the solar panel the maximum power can be tracked by employing MPPT method. Solar resistance of PV system is divided to contest the load resistance by differing the value of pulse.

The DC-DC converter operation is performed for this process. The input voltage for DC-DC converter is supplied from PV module. The output voltage produced from PV module (510 V) is amplified to high voltage (1100V) using high gain boost converter. Here the MOSFET is considered as switch. Generation of pulse is made to determine when the MOSFET should switched ON and switched OFF by duty cycle, on switching MOSFET at perfect working cycle, the desired output can be performed. The duty cycle is generated from the MPPT algorithm.

The voltage gain,

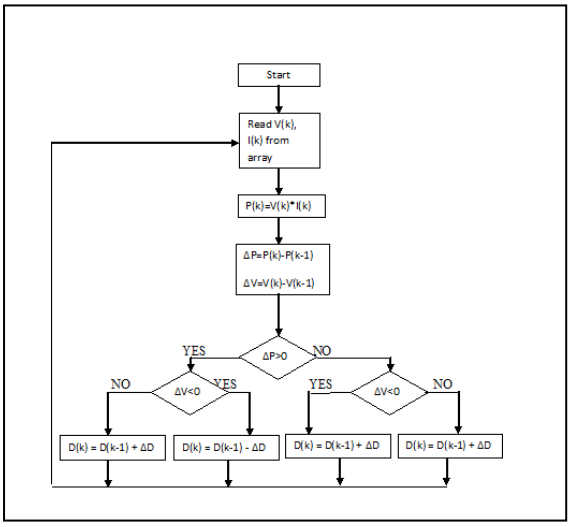
$$G = \frac{Vo}{Vin} = \frac{2}{(1-k)} \quad (1)$$

For this matlab simulink the number of Parallel strings used in the solar panel is 20 and series-connected modules per string 10 for assumption, so that the input voltage produced will be of 510V. When the strings and modules used are when increased, the space required will be more.

### B. Maximum Power Tracking Algorithm

MPPT employed to obtain the peak power from solar PV and to path the changes due to environment therefore [14]; a maximum power tracking should be achieved. The various methods of MPPT algorithm is listed below

1. Constant Voltage and Current
2. Incremental Conductance
3. Perturb and Observe




Mostly for solar PV systems perturb and observe method is used. Fig. 3 represents P&0 algorithms defines that this process operates by perturbing system by improving or else reducing array operative voltage and observing its affect on the array power output. The controlling voltage then concerned along each MPPT cycle. When the Maximum Power Point was achieved, voltage will fluctuate around optimal operating voltage Vamp. The rate of reference voltage Vref, will get diverged according to current controlling region.

### C. Bi-directional converter

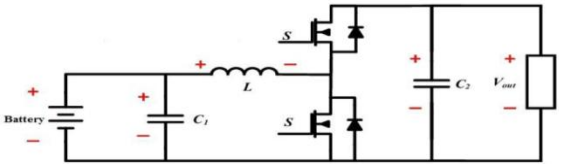



**Fig. 4. Representation of bi-directional converter**

Fig 4 represents the bi-directional converter used in this work. The bidirectional converter performs as both bucks and boost converting operation. The DC line voltage is connected to the one end and a battery is connected to the other end. Battery will be on charged condition when the DC line voltage is constant, the converter will work as buck converter. Once DC line voltage is decreased to the set constant voltage the battery energy will discharge and the bidirectional converter will perform as the boost converter and it will supply voltage to the DC line. State of charge is used to find the consumption of charge in a battery relative to capacity. The unit of State of Charge is mentioned in percent level (100% = full; 0% = empty). Another method of same part is depth of discharge condition (DOD), inverse of SOC (0% = full; 100% = empty). For discussion of current state of battery SOC is generally used, so as DOD is often seen when confer about the lifetime of battery after continuous usage. Battery used for the project is Lithium ion for charging up and discharging down. The battery nominal voltage is 50V and rated capacity of 10Ah. The initial state of charge will be set in percentage.

## III. LITERATURE REVIEW

Guilherme de Carvalho Farias et al (2014) has implemented efficient converter with low cost for PV system without battery. The designed converter is used to control the three phase induction motor without any deviation from PV system.

Rohini et al (2017) have developed a PV fed Bidirectional DC-DC converter which has an essential role of independent solar PV systems to interface the battery.

Seyezhai et al (2018) have implemented a high gain DC-DC converter with low ripple content employing coupled inductor for PV applications. It is highly preferable in amplifying the lower PV voltage to higher voltage.

Sawsan Sayed et al (2018) have designed a mean voltage DC grids to aggregate and integrate PV systems to defeat the issues introduced with AC grid.

Alireza Mirzaee et al (2018) have made MPPT for PV System to produce maximum power PV systems.

## IV. RESULTS

The irradiance value of solar photo voltaic system will be at a range of 1000W/m$^2$ and the temperature is 25°C. Fig. 5 represents the input voltage waveform from the solar PV at voltage of 510 V which will be given as input to DC-DC converter.

According to irradiance and temperature maximum power is determined. The high gain duty cycle is formed and given to switch of DC-DC converter. The x-axis belongs to time in sec and y-axis belongs to voltage.

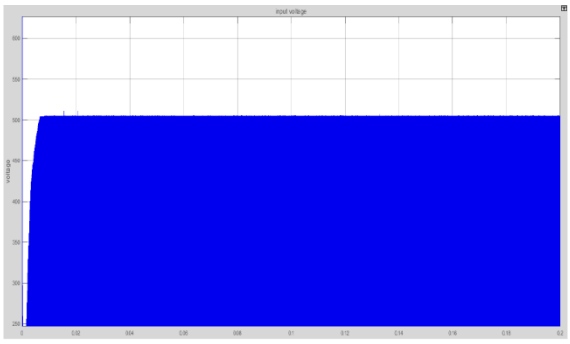


**Fig. 5. Input voltage waveform of solar PV**
**Fig. 6.**

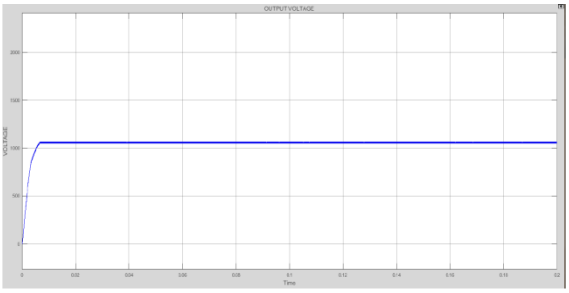


**Fig. 7. Output voltage waveform of high gain converter**

High gain boost converter takes input voltage 510V from solar panel and due to conversion of adding additional capacitors the voltage gets increased; finally the output voltage of 1100V is achieved. Fig. 6 represents the output voltage waveform.

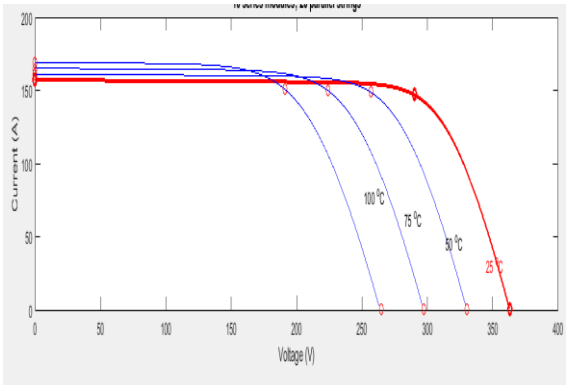



**Fig. 8. V-I characteristics of MPPT**

Fig. 7 represents the current and voltage characteristics waveform of maximum power point algorithm under different temperature, the voltage level gets increased or decreased.

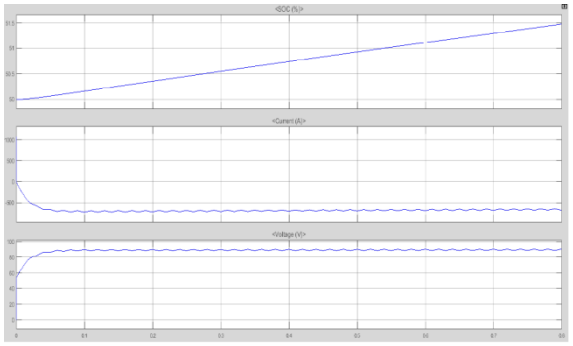


**Fig. 9. Battery status at charging condition**

Fig. 8 represents that SOC of battery determines the charging as well as discharging of battery. The SOC is set to 50V, when the battery condition is below 50V the battery will get charged and when it is above 50V the battery will be in ready condition to get discharged. By this process the DC line voltage is maintained constant by continuous supply of voltage and they are given to the three phase inverter, which will invert DC voltage to AC voltage and they are used for several AC voltage consuming appliances. From this method power can be generated as per the requirement.

## V. CONCLUSION AND FUTURE SCOPE

The proposed strategy is done by taking Solar Photo voltaic system which is a renewable energy. The three phase inverter output can be given for household applications and also it can be given to the grid without using the three phase inverter. Also it can be developed with several types of inexhaustible sources like as wind turbine [5], fuel cell etc. Later this type of operation can be achieved for large power application system.

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