International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 11 | Nov 2020 www.irjet.net p-ISSN: 2395-0072

Renewable Energy Source (Solar) based Electricity Generation with Enhanced Feature of Solar Tracking

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Abstract - *In this report has the power electronics based renewable energy (solar) sources utilisation for storage and grid connected load utilisation. The essential part for this system is maximum power extraction from the nature dependent solar energy. The mathematical model of PV array is implemented in MATALB Simulink for testing MPPT algorithms and for further electrical energy utilisation. Furthermore, the Maximum Power Point Tracking (MPPT) technique for photovoltaic (PV) arrays is developed for fast-changing environmental conditions.*

Key Words: renewable energy, photovoltaic (PV) arrays, Maximum Power Point Tracking (MPPT)

Chapter 1. INTRODUCTION

1.1 Current Scenario of Solar Technology

Renewable energy generation has experienced consistent growth in the last two decades, due to the concerns of climate change and high oil prices. Photovoltaic solar electricity, together with solar thermal, has the highest efficiency of all the renewable energies, since solar energy is a practically unlimited resource and it is available everywhere. Today a wide majority, close to 90%, of photovoltaic modules are currently made up using wafer based crystalline silicone, but there are other emerging technologies which are gaining importance in the PV market. In recent years thin-film modules have earned share in the PV market, taking advantage of the photovoltaic-grade silicone shortage and then the higher prices in the PV market. Concentrator PV technology tries to reduce the amount of semiconductor necessary, by using small-area high efficiency cells and inexpensive polymer lenses to focus the light on the cell. This technology generally needs a sun-tracking system and it is more suitable for medium to large PV systems in areas with a high percentage of direct radiation.

1.2 Off-grid Photovoltaic Systems

The applications of photovoltaic systems are usually divided into four main categories: on-grid domestic systems, off-grid non-domestic installations, grid-connected distributed PV systems, and grid-connected centralised systems. When the utility of power is unavailable or too expensive to bring in to your home, off-grid solar system allows you to be your own utility company. An off-grid system is not connected to the electricity grid and therefore it needed battery storage. An off-grid solar system designed as it will generate enough power throughout the year and have enough battery capacity to meet home's requirements, even in the depths of winter and monsoon when less percentage of radiation.

1.3 Project Motivations

Photovoltaic electricity generation offers the advantages of: clean, non-polluting energy generation, production of energy close to the consumer, the less maintenance requirement, and of having a very long lifetime. Due to these benefits today, the photovoltaic is one of the fastest growing system in the world. However, PV power is still considered to be expensive, and the cost reduction of PV systems is subject to comprehensive research. From the power electronics point of view, this goal can be achieved by maximising the energy output of a given PV array. The inverter should ensure the highest possible conversion efficiency, while the MPPT controller is required to operate the PV array at the maximum working point (MPP) in all environmental conditions.

DC-DC converter is linked with a MPPT controller. Constant dc output from the boost converter is fed to the charge controller. Charge controller is connected with battery as well as inverter as per our requirement.

Chapter 2: Interleaved Boost Converter and MPPT

2.1 Need of Interleaved boost converter

Generally, the voltage generated form the resources are at low level. Now to utilize this voltage we need to step up this generated voltage. Therefore, boost converter is used to step up the low-level generated voltage. But in boost converter ripples are present in the output voltage of converter. So, to overcome this problem we use interleaved boost converter. In this the output is ripple free and efficiency is increased.

2.2 Basics of Interleaved Boost Converter

We need more amount of voltage than what we are getting from solar cells. To achieve these, we need to boost up the output voltage for this purpose we need to use IBC to improve power converter performance in terms of efficiency. The

interleaved consist of several identical boost converter connected in parallel.

The key features of IBC compare to conventional boost converter:

- *Increased output voltage and efficiency.*
- *Good current sharing characteristics.*
- *Reduced current peak value.*
- *Improved reliability.*
- *Low input current ripple.*

As the output current is divided by the number of phases, the current stress on each MOSFET is reduced. Each MOSFET is switched at the same frequency but at a phase difference of 180 degrees. The desired output voltage for a given input voltage is depending on duty ratio. For example, if the input voltage is 60V and the output voltage is 120V then we have to keep the duty ratio at 0.5 since we are using two similar inductors in the circuit this will leads to equal sharing of input current. Here, in this proposed method two phase IBC is chosen since the ripple content reduced with increase in number of phases. But, if the number of phases increased further without much decrease in ripple content, the complexity of circuit increases very much, thereby increasing cost of implementation.

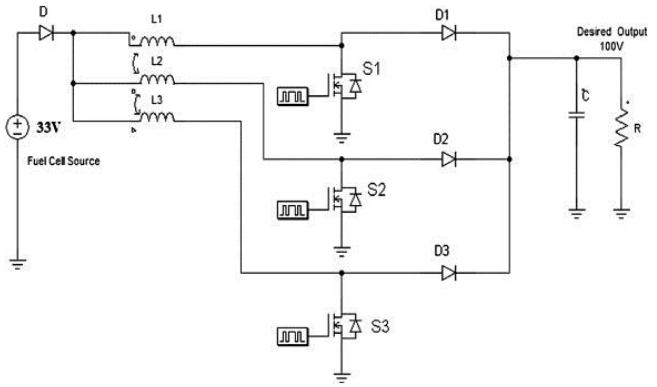

FIG: 2.2.1 Interleaved Boost Converter

2.3 MPPT Method(P&O)

The PV array which is a combination of solar cells and this array develop the power from solar energy directly. To improve the efficiency of energy, it is essential to operate PV systems always at its maximum power point. Typical goal is to obtain the maximum possible power from PV system over the entire time of operation, which always set the system working point to optimum point. "Hill Climbing" or the "Perturb and Observe method" has been used to track the maximum power point of the PV array. So, to overcome the impedance problem, we are using MPPT based P&O method. The P&O algorithm has been appropriately implemented in conjunction with PV system. MPP trackers may implement different algorithm based on the operating condition of PV array.

There are various MPPT techniques are as following:

- *Perturb and Observe*
- *Incremental Conductance*
- *Constant Voltage Method*

P&O method is most common method in which the controller adjusts the voltage by a small amount from the array and measures the power. If the power increases, more adjustments in that direction are tried until power not increases. This is called perturb and observe (also called as hill climbing) method, 10 although it can result in oscillations of power output. It's depending on the rise of the curve i.e. power against voltage below MPP. Also, it's easy to implement & very generic because it's not required whole information about PV array, only the measured voltage and current from the array. The output characteristics of the PV system as functions of irradiance and temperature curves are nonlinear. Also; they are crucially influenced by irradiation and temperature. Under winter or cloudy days, MPPT's are most effective because in those days, the extra power is needed the most.

The Perturb and Observe which is also called as 'hill-climbing' method for MPPT, which is based on the voltage-power characteristic, on the left side of MPP, the variation of the power against voltage i.e. dP/dV> 0, while on the right side,dP/dV< 0.As shown in figure, if the operating voltage of the solar array is perturbed in a given direction when dP/dV> 0, the perturbation moved the array's operating point toward the Maximum Power Point. The P&O algorithm would then continue to perturb the PV array voltage same in that direction. If dP/dV< 0, then the variation in operating point moved the PV array away from the MPP, and the P&O algorithm reverses the direction of that perturbation.

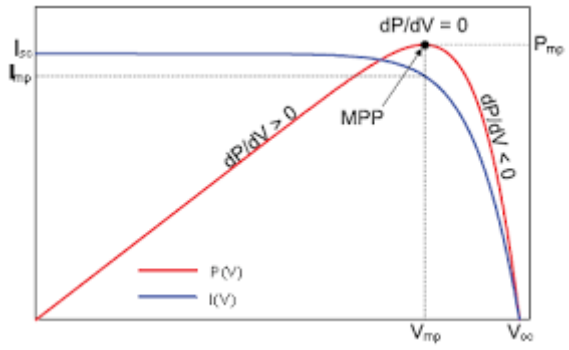

Fig 2.3.1: Sign of dP/dV at different positions on the power characteristic of a PV module

P&O method has low computational demand, and very generic, and because of that it is applicable for most systems, as it does not require any information about the PV array, but only the voltage and current which we have measure. Because of this, today, the P&O is perhaps the most-often used MPPT method.

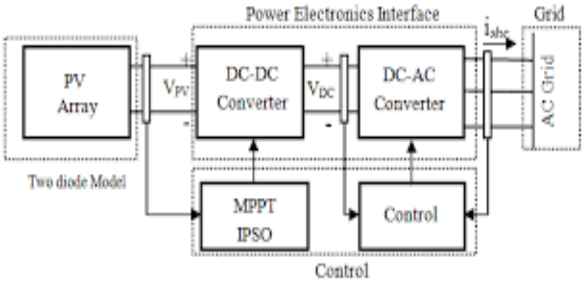

Fig: 2.3.2: Block diagram of PV Implementation

PV ARRAY:

Photovoltaic array consists of many cells connected to provide required terminal voltage and current ratings. The difficulty in power output can be due to such factor as tolerances in PV cell characteristics, environmental stresses. Photovoltaic array makes it necessary for the consumer to extract maximum power from the PV system. Grid connected PV systems have not need battery back up to ensure MPPT but stand-alone PV systems need battery back-up. PV systems have usually two stages: first stage is used to interleaved boost the PV array voltage and track the maximum power and second stage inverts dc power into high quality ac power. The output voltage and current we are getting from the PV array is not constant because it depends on whether condition like humidity, temperature, irradiation etc. So, due to this mismatch, the impedance of PV array and interleaved boost converter does not be matched.

Chapter 3: Modelling of PV Cells and Simulation of Model

Parameters	***Values***
Pmax	*213.15W*
K	*K 1.3805*10-23*
Q	*1.602*10-19*
Voc	*36.3V*
Isc	*7.84A*
Vmp	*29V*
Imp	*7.35A*
n	*60*
Rs	*0.3938 Ω*
Rsh	*313.3991 Ω*

Table2.3.1 parameter of PV cell

3.2 MATLAB Simulation

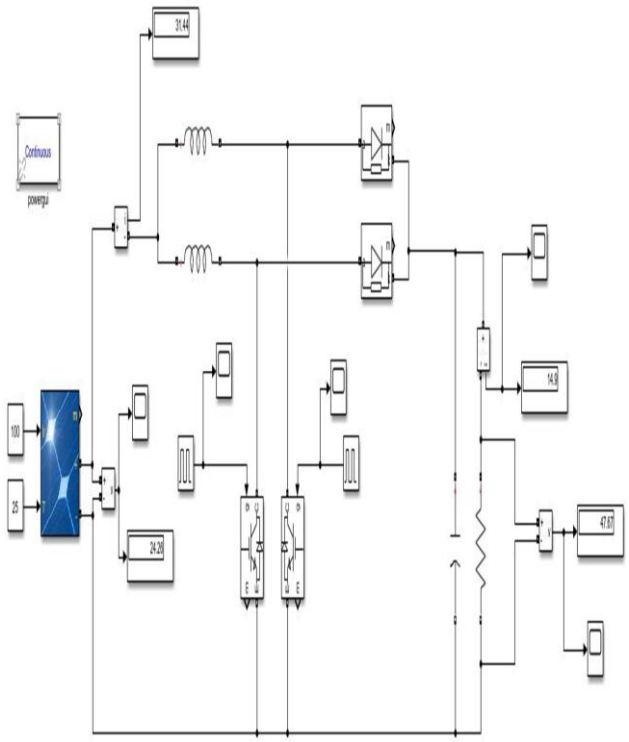

Figure 3.2.1 *Simulation model*

3.3 PV System Modelling

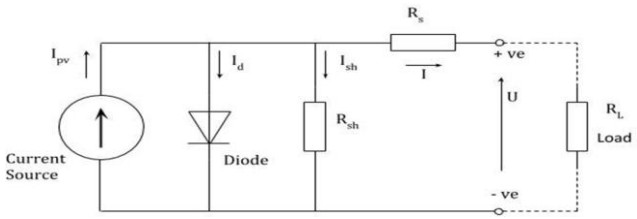

Figure3.3.2Circuit of PV cell

To model the behaviour of a PV system, composed of parallel connected arrays, which in turn are formed of series connected modules. The aim is to predict the behaviour and power output of such systems in various environmental conditions. The purpose of such a model is to gain an insight on the effects of change in irradiation, module mismatch, and cell or module failure on a PV system's output power and I – V characteristics, and to test the performance of MPPT techniques in non-ideal *conditions.*

Chapter 5: Conclusion and Future Expansion

Solar power is a renewable energy source so it is very good for us to move towards the solar power and nowadays there are different types of PV array are available which use more efficient PV cells so we get more output from it with low cost as well as good efficiency To use power generated by solar

effectively we have to convert the available voltage into boosted form so, we can increase efficiency of plant also power point tracking is also useful in such case and after this we can store this power into battery and then by using inverter, we use this voltage Interleaved boost converter has many advantages and is a suitable converter for renewable energy applications. This report shows the design and implementation of IBC. From the obtained result we can conclude that, the IBC has higher boosting capacity, reduced inductor peak current and increase efficiency compare to conventional boost converter. In IBC two inductors works such that we obtain continues output in addition it also reduces the ripple content the authors can acknowledge any person/authorities in this section. This is not mandatory.

5.2 Future Expansion

The attempt made in this report to contribute to the improvement of MPPT techniques, photovoltaic array and interleaved boost converter have far from finished the task. In upcoming generation boost converter will be eliminated by interleaved boost converter because of ripple free output and increased efficiency. Now the current scenario will be fully dependent upon renewable sources because non-renewable sources are in limited quantity.

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