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Implementation of Spo - Mppt for Pv Panel using Sepic Converter

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Abstract*: Recent researches in energy has been made mainly with solar energy due to its easy availability and free of cost and easy extraction. Though there are several ways to extract energy, not all methods seems to be efficient. To obtain maximum efficiency and power the smartest algorithm has to be handled and should be effectively used with reduced losses. This paper is implemented using newfangled technique called "self-tuned perturb and observe algorithm (SPO)" that tracks the maximum power as quick as possible and is converted into required level of voltage with reduced ripples using SEPIC converter. This proposal improves the response and efficiency of the tracking with lost implementation cost, eliminating the limitations in the existing methods and also the limitations that cannot be solved using the other modified methods is also encountered and the system is altered.

***Keywords*: Solar MPPT, self-tuned P&O algorithm, DC-DC SEPIC Converter, duty cycle.**

I. INTRODUCTION

Nowadays, the need for energy is extremely getting increased by the modern human lifestyle due to the technical development in the human life. Due to this scenario, people shifted their search of energy to renewable energy sources due to its clean and availability nature. Among many of the resources solar energy has many merits [1]. These energies are more reliable, secure, atmospheric friendly, needs less maintenance and the very most important thing is its noiseless power production and predominant in the world.

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There are many ways of extracting energy from the sun. Photoelectric cell has become a fashion in the places where the sun's radiation is high. But the main energy that can also be stored for further use is the electricity [2]. The energy obtained is used in many applications such as home usage, industrial use, vehicles, street lighting, etc. This electricity is extracted using a photoelectric cell [3].

The cell is designed so that it produces voltage and current by receiving the photons on the solar panel. It has the capability to convert heat and light energy into direct current [4].

The power can never be stable all the time because it is blindly depended on the sun's light and heat energy. It requires some methodology which is termed to be maximum power point tracking technique [4]. This technique clings on the sun's energies of light and heat. In case of any abnormality, it leads to deviation from maximum power. Thus the control algorithm easily tracks the displacement and reacts swiftly to fix up with the MPP.

There are various MPPT techniques such as incremental conductance method, P&O method, constant voltage algorithm, particle swarm method, Beta algorithm, system oscillation method, ripple correlation algorithm which differs from parameters, responding time, cost, complexity, etc. [5],[6] Considering all the techniques, few are most commonly used due to its simplicity [6],[7]. Perturb and observe method is the simplest and easiest among all the methods, but it has some demerits during the rapid variation in weather conditions [8]. It is observed that steady state oscillations are greatly found at the MPP which leads to additional power losses.

Many modified methods has been put forth to overcome some limitations. Some of them are fuzzy logic based MPPT, modified P&O, improved incremental conductance method, artificial intelligence based MPPT approach, so on [8]. Though many algorithms has been proposed, reliable and efficient technique has not come because a technique works well for one limitation and vice versa. There are some techniques that are designed to overcome all the limitations that existing system possess, but their huge design and computation complexity results in high cost.Hence, in the aim to reduce the cost of the total system and to overcome all the limitations, the modifications are made to the simplest MPPT technique called P&O method. This method mainly decides the size of the step change according to the dynamic weather conditions by tuning on its own. Thus the method is named asSelf-tuned Perturb and observe (SPO) algorithm.

The method is also used to alleviate the problems in traditional techniques such as steady state oscillations, fixed step size issues and slow dynamic responses.

This is because of the various change in climatic conditions results
in different output from the solar panel that is power and voltage. If the panel's output power is not constant, the appliances would get damaged or the lifespan gets reduced [9]. The technique is coupled with SEPIC converter that mainly reduces the ripple in output even during the variations in atmospheric conditions.

II. EXISTING SYSTEM

To maintain the maximum power as the output from the system, the existing MPPT techniques are coupled with different DC-DC converters such as boost, buck, buck-boost, CUK, SEPIC, etc. Each and every algorithm is combined with different types of converter to obtain different range of efficiency and gain. To obtain efficient way of output from the sun, the existing systems are designed to generate duty cycles that produces maximum power. The self-tuned perturb and observe method was implemented to a boost converter for a low voltage of weak grid system [1].

The converter used would convert the incoming voltage from the solar panel of low value into higher value depending upon the maximum power point obtained. The pulses for the semiconducting device is generated according to MPP. Since boost converter is used, the level of harmonics in the output is high. To eliminate ripples, LC set up can be implemented in the setup. But it results in the increase in the cost of the system.

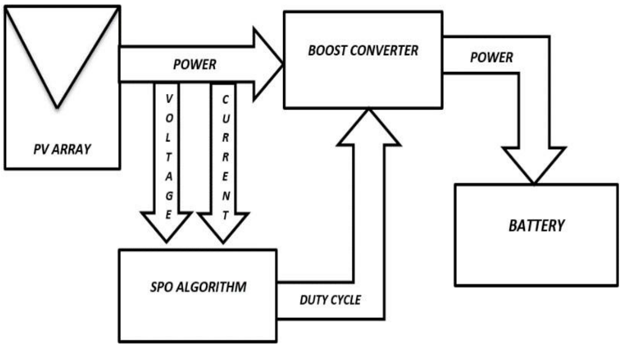

Fig.2 Block diagram of Existing System

The SEPIC converter is also coupled with many other MPPT techniques for constant power output. Each implementation resulted in different efficiency with some limitations such as fixed step size, slow dynamic change and steady state oscillations [1]. An example of the existing model is shown in the fig.2 for power conversion.remains unchanged in all dynamic changes and thus there is a deviation in the MPP.It should be clear that the final output power from the converter should be stable in order to attain maximum efficiency. Thus the variation in duty cycle for different atmospheric conditions is required. And also the ripple and chances of harmonics are greatly reduced with the use of SEPIC converter.Fig.3 demonstrates the model that is put forth. The block diagram denotes the common outlook of the system in which the technique is fed to the SEPIC converter to generate duty cycle strategically, so that the desired output is obtained.

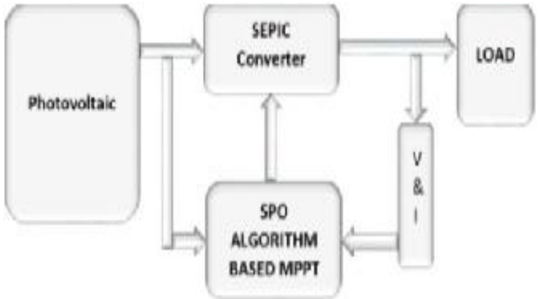

Fig.3 Block diagram SPO algorithm with SEPIC Converter

The SEPIC converter has a set-up of LC combination that acts as a filter and also there is an additional filtering component to improve the output power. The ripple free output is demonstrated as it is implemented as simulation and the results are also produced.

IV. MODELLING OF SOLAR PHOTOVOLTAIC CELL

The photo voltaic cell is simply a PN junction semiconducting diode which is specifically designed to convert solar energy directly into power. Some PV cells can also transform infrared and ultraviolet radiation into direct current. Photo voltaic cells are an important part of converting solar energy into electricity, which is an important growing alternative sources of power production of the utilities. The extraction of power from these type of cells is modelled and the corresponding current equation is shown in the equation 1 below.

III. PROPOSED SYSTEM

$$I_a = I_a - \frac{\left[I_{ph} - I_a - I_r\left(exp\frac{(V_a + I_a)R_s}{V_t}\right) - 1\right.}{\left[-1 - I_r\left(\frac{R_s}{V_t}\right)\right]\left[exp\frac{(V_a + I_a)R_s}{V_t}\right]}$$

In order to overcome the above mentioned demerits, the self-tuned perturb and observe algorithm uses a special type of strategy to change the duty cycle that is given as input to the converter. In other algorithms the size of the duty cycle

V_a - denotes the output voltage of the solar cell, I_a - stands for the output current of the solar cell, I_{ph} - stands for the photocurrent,

R_s - stands for the series resistance and

V_t - denotes the junction temperature voltage.

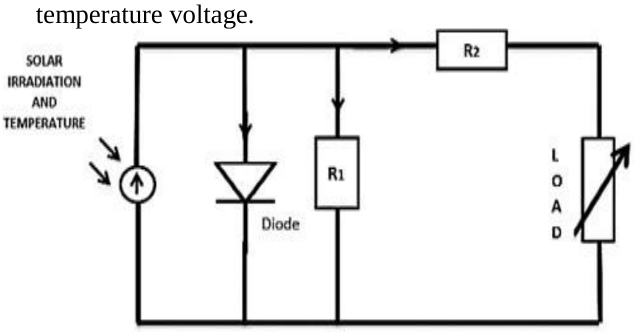

Fig.4 Photovoltaic cell

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The solar PV cell is modelled so that the power is obtained from it by receiving the photons from the solar energy and is supplied as usable power to the load connected as shown in the fig 4.

V. SELF-TUNED PERTURB AND OBSERVE METHOD

Basically, MPPT algorithm for maximum power extraction is mainly used to intensify the outcome from the PV array. Although there are many most well-known techniques that can be easily implemented, they ultimately suffer with some demerits such as slow dynamic responses, steady-state oscillations and fixed step size issues. Concerning the above specified predicament, the technique is put forth and implemented.

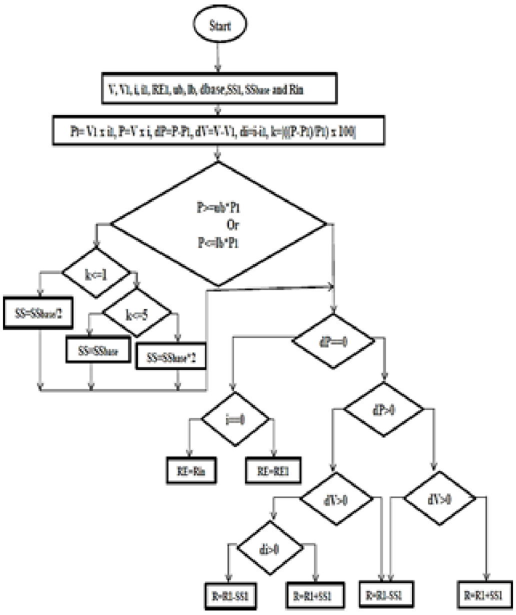

Fig.5 Flow chart for SPO algorithm

The working of this algorithm is detailed in the fig 5 for obtaining the maximum power constantly. It is initially divided into two sections where one part deals with the constant situation that requires reduction of oscillations by tranquilize the size of the duty cycle.

First step is to calculate the upper and lower boundary as shown in equation 2 and 3 and check whether the power is within it. Only after this, the divisions occur. These limits mainly depend upon the base step size (d_{base}) and maximum voltage (V_{max}) obtained.

$$ub = \left\{100 + \left[\left[\frac{V_O}{1-d_{base}}\right] - V_O\right] * \frac{100}{V_{max}}\right\} * \frac{1}{100} \dots (2)$$

$$lb = \left\{100 - \left[\left[\frac{V_O}{1-d_{base}}\right] - V_O\right] * \frac{100}{V_{max}}\right\} * \frac{1}{100} \dots (3)$$

On the other hand, wobbly condition which is made to jump to the reference voltage by enhancing the size of the duty cycle.The next step is to check the percentage variation in power that is being received by the panel. That is calculated in k, as shown in the fig.5.

The proceeding step is to go as such the flow chat and check for the conditions to get satisfied. Then finally after calculating the reference voltage R_1 , the duty cycle is calculated using the equation 4.Thus using the above equation, the required duty cycle is calculated and the signal is sent to the SEPIC converter for producing the maximum power.

VI. SEPIC CONVERTER

The DC-DC converter is mainly used to convert the DC voltage into required value of DC voltage with the usage of capacitors, inductors, diodes, etc. the input voltage can be increased or even decreased in the output side, depending upon the type of converter connection applied. Basically to increase and to decrease the voltage, buck-boost voltage converter is used. Later on, the converters were modified to CUK converters, SEPIC converter etc.The advantage of the SEPIC converter while comparing with other two types is it has a special inductor that specifically smoothens the ripple in the output current. This type of converter also reduces the electrical stress caused to the components and prevents from overheating or device failure.

VII. SIMULATION RESULTS

The simulation results are obtained by modelling the circuit using MATLAB 2017a. The Simulink model was done by connecting the modelled PV cell and then it is sent to the programmed technique. It generates a step signal for the semiconducting device present in the converter as per the desired output.

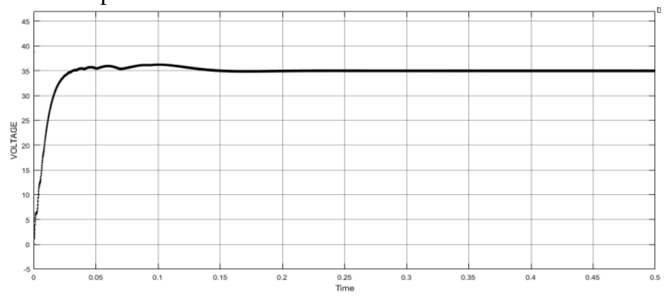

Fig.7.1 Voltage from PV array

Fig 7.1 and 7.2 demonstrates the actual voltage and current received from the PV cell. Their average voltage obtained is 35V and current remains constant as 9.9A. The level is not suitable for running loads. Thus it is further converted using converter.

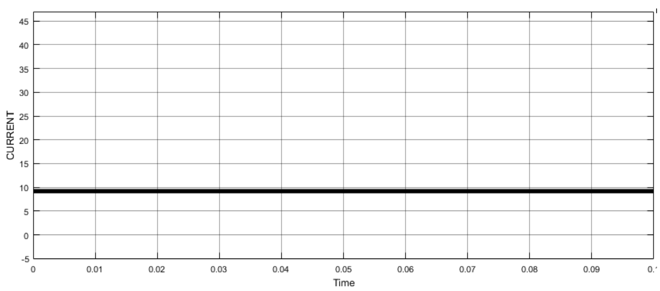

Fig.7.2 Current from PV array

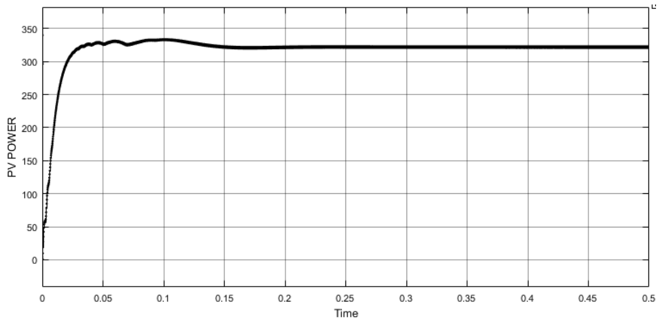

Fig.7.3 Power from PV array

The corresponding power output is approximately equal to 340Watts as per the solar irradiation of 1000W/ m^2 and temperature of 25℃ . As we know that the solar energy will notbe constant at any instant and thus corresponding output power also changes. SEPIC converter is used to fetch expected output. Fig 7.4 and 7.5 shows voltage and current obtained from the SEPIC converter according to the technique used.

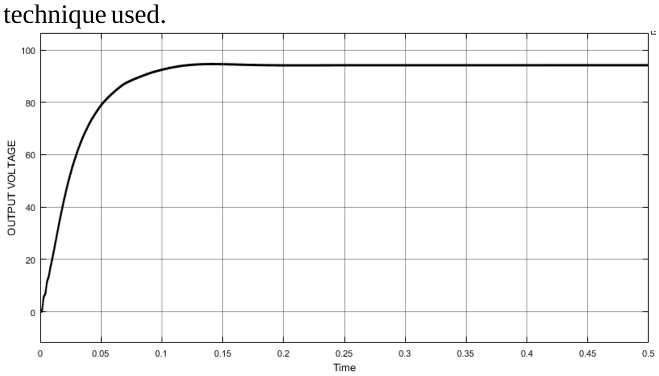

Fig.7.4 voltage output from SEPIC converter

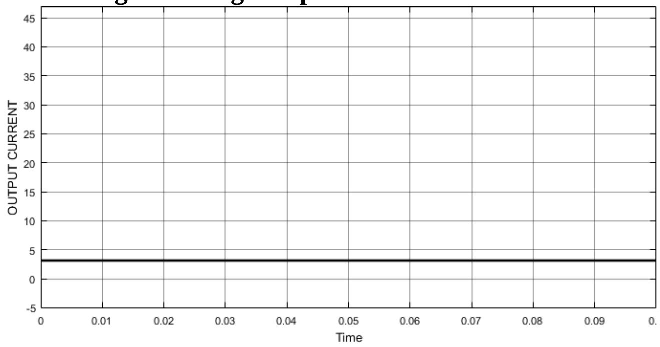

Fig.7.5 Output current from SEPIC converter

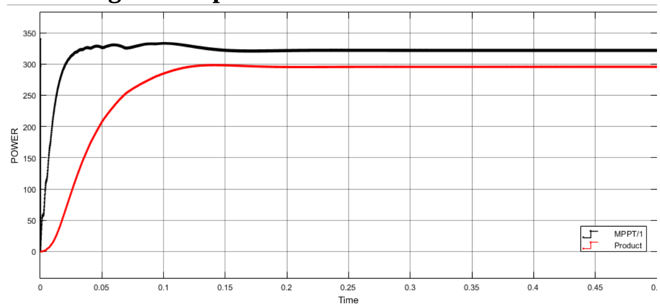

Fig.7.6 actual power vs. Obtained power

By comparing the above results, it is clear that the power obtained from the converter reaches the steady state before actual power that is calculated in the algorithm settles down. The algorithm has proved that the time taken to reach the stability is very less compared to the other methods and it is also proved using simulation results.

VIII. HARDWARE SETUP

The hardware setup is constructed of a PV array of 12v, a 16x2 LCD display, a bulb holder, driver circuit with opto coupler, ATmega328p controller UNO, voltage regulators of 7805IC and 7812IC (for supplying microcontroller and the driver circuit), SEPIC converter that consists of toroid core inductor, 4700μF capacitor, resistors, 1N4007 diode, connecting wires, irfz44 and irf460 MOSFET with heat sink, current sensor and a voltage sensor with required capacitors and resistors.

IX.CONCLUSION

In this paper, tracking of the maximum power point is done using the recently modified algorithm known as self-tuned perturb and observe method for harvesting constant voltage from the PV array. This method is a modified form of perturb and observe method that mitigates the limitations by self-tuning method. This method greatly reduces the steady state oscillations by reducing step change and the dynamic state oscillation is fixed by increasing or decreasing the step size. These changes can be made when the irradiance changes and thus the corresponding power is obtained. The method produces different duty cycle at various atmospheric conditions for the SEPIC converter and thus simulation results shows that the tracking time is very less with lesser computational burden.

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