AN INTERLEAVED HIGH FREQUENCY FLYBACK MICRO-INVERTER USING SLIDING MODE CONTROL ALGORITHM

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ABSTRACT

The presence of nonlinear voltage current characteristic with a unique Maximum Power Point (MPP) is usually found in PV panels. When their operating conditions are subjected to changes, the MPP will also change. This project aims at the design and implementation of a stand-alone micro inverter for Photovoltaic (PV) applications based on interleaved fly back converter using Sliding Mode Control (SMC) algorithm. Here, a fly back converter is designed at high power rating and its practicality with good performance is demonstrated. A sliding mode controller is used to estimate the MPP which forces the PV system to operate at MPP and to stay on the surface at all times. This method is simple and robust to irradiance and temperature variations. A simulation model is developed and the design is then verified and optimized for best performance based on the simulation results. Finally, a prototype at rated power is built and evaluated under realistic conditions.

Keywords—Flybackconverter, SMC algorithm, Inverter

I. INTRODUCTION

The most abundant natural resource is the solar energy. It is about to play a major role in the future as the greatest energy source. Therefore the research and development of the solar technology is in rise. However, the high cost of the technology still limits its usage globally [1]. The low cost is more important for commercialization especially in small electric power systems. Therefore, the primary objective of the study presented in this paper is to contribute to the research and development in the photovoltaic (PV) inverter technology by using an interleaved flyback transformer at high power using sliding mode control (SMC) algorithm [2]. If it is implemented effectively, the developed inverter would be a low-cost alternative to the commercial isolated grid-connected PV inverters in the market [3]. The previous micro inverter models which use the Perturb & Observe (P&O) algorithm can be replaced by high efficiency SMC based micro inverters.

II. MOTIVATION

Natural disasters always cause immense impact in our daily activities. During the time of flood or any natural calamity all the power stations are affected thereby interrupting our power supply. At these situations home inverters can be used but they won't last longer. This has been the motivation for us to develop this project. Also, the low cost and high efficiency of this device makes it accessible to all the people.

III. PREVIOUS WORKS

The widely used algorithm for finding the maximum power point (MPP) is Perturb and Observe (P&O). This method of finding out the maximum power point had some disadvantages like instability. Given below is the flowchart of the P&O algorithm.

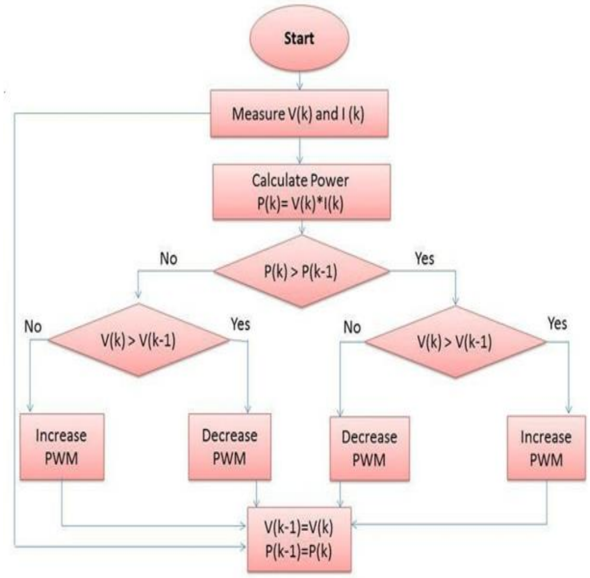

Fig.-1: P & O flowchart

The initial step is to calculate the voltage and current of the system. By multiplying the value of those two, we get the power of the system. Then we have to get the value of the old power. This can be obtained by providing the delay elements. By adding those elements, we can get the old voltage, current and the corresponding old power(P(K-1)). Then the condition is being checked (i.e) the old and new power is being compared. If the new power is greater than the other one, then the old and new voltage is being compared. If the new voltage is greater than the old one, pulse width is being increased else pulse width is being decreased. Variation in pulse width can be obtained by varying the duty cycle [4]. If the old power is greater, then the same condition is being checked like the other case [5]. The only difference is present in the variation of the pulse width according to the result of the condition [v (k) > v (k-1)]. The algorithm continues until the below conditions are satisfied

$$v(k-1) = v(k)$$
$$p(k-1) = p(k)$$

The output graph of the micro-inverter using P&O algorithm is X Axis- Time, Y Axis- Voltage

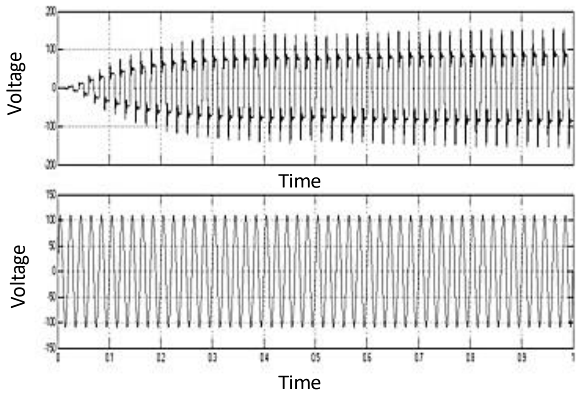

Fig.-2.1: With Filter

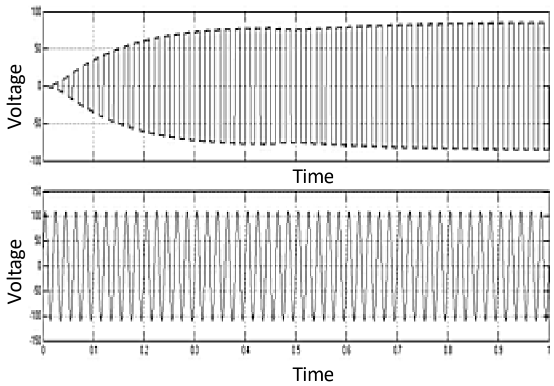

Fig.-2.2: Without Filter

From the above two graphs, it can be inferred that maximum power can be tracked by P&O based algorithm but it can't maintain that MPP [6]. It also creates oscillations around the MPP.

IV. PROPOSED SYSTEM

The proposed system of micro-inverter eliminates the method of Perturb & Observe (P & O) algorithm. Implementation of the Sliding mode control (SMC) helps in removing the unstability nature of the system [7].

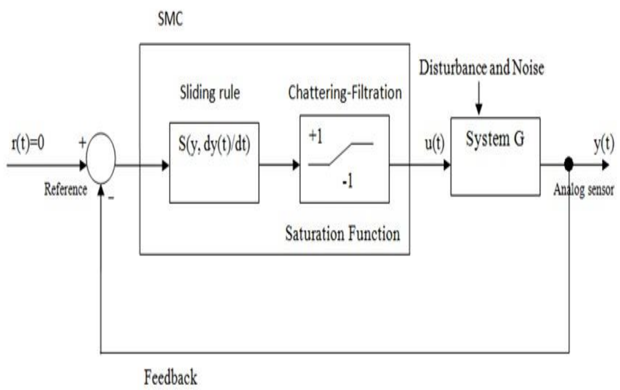

Fig.-3: SMC block

The above diagram depicts the system with SMC block. The basic units present in the block are the sliding rule, chattering filtration and saturation function. The input of the block will be r (t) which is the reference signal [8]. The maximum power point (MPP) which is desired is being given as the reference. The feedback signal is given to the error detector. The feedback signal is taken from the output with the help of an analog sensor. The analog sensor senses the maximum power point from the output of the present system. The error detector inputs will be the reference and feedback signals. The output of the error detector will be the difference of the reference and the feedback signals [9].

The sliding rule helps in guiding the curve to the desired MPP. Within the SMC, there is a need for the removal of the chattering effect. Chattering is the high frequency oscillations present in the output. This has to be removed in order to have a desired maximum power point. The saturation function does the work of maintaining the curve along the point of maximum power point (MPP) [10].

The system will be given with the output from the SMC block. The system will always be subjected to disturbance and noise. These are the undesired signals that affect the original (or) desired output. The noise and disturbances may be due to natural or man-made sources. The system's output will then be noted and also be given as feedback [11].

V. BLOCK DIAGRAM

PHOTOVOLTAIC PANEL:

The panel is made of solar cells, which is an electrical device that enables us to convert the vastly available solar energy into various useful forms. The conversion of energy is based on the photovoltaic effect. The panel is a collection of 6x10 photovoltaic cells. Photovoltaic panel constitutes of photovoltaic modules which converts the solar energy into electrical energy for commercial and residential applications. DC output power under standard test conditions (STC) is used to rate each module, and it usually ranges from 100 to 365 watts. The efficiency of the module determines the area of the module given the same rated output – an 8% efficient 230watt module will have twice the area of a 16% efficient 230watt module.

FLYBACK CONVERTER:

Fly back converter is the device which can convert both AC and DC signals into DC. This is a buck boost converter with an inductor split to form a transformer. This converter is used in order to transfer the power produced in the panel to the load. The power is boosted to the range according to the design, in this case for 100 watts. MOSFET switches are used to activate the transforming action. These switches get the signals from the Pulse Width Modulator (PWM) on execution of the algorithm.

H-BRIDGE INVERTER:

H-bridge is an electronic circuit that can be used to send the voltage across the load in either direction. The H-bridge is built with four switches (solid-state or mechanical). When the switches S1 and S4 are closed (S2 and S3 are open) a positive voltage will be applied across the load. By opening S1 and S4 switches and closing S2 and S3, this voltage is reversed, allowing the negative voltage to be applied across the load.

DSPic30f4011:

This is a powerful, high-performance microcontroller, this microcontroller features a highspeed core, optimized to perform complex calculations quickly. The microcontroller includes a large 48KB internal flash memory and a wide range of timers together with many PWM modules. The SMC algorithm is coded in the microcontroller. The PWM modules will send the signals to the converter that can initiate the function of the fly back converter resulting the boosting up of the power. The voltage and current from the panel is given as the input and these signals are used in the SMC algorithm to track the maximum power. The DSPic30f4011 consists of mainly 3 components namely, voltage reference, SMC block and PWM generator.

DRIVER:

A driver is an electrical circuit or other electronic component used to control another circuit or component. They are usually used to regulate current flowing through a circuit or to control other factors such as other components, some devices in the circuit. Here the driver consists of an isolation and amplification module which amplifies the pulse signal from the PWM generator and sends it to the switches.

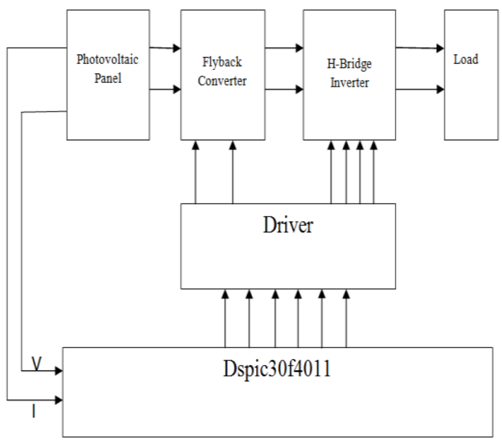

Fig.-4: Block Diagram

VI.COMPARISON OF SMC AND P&O ALGORITHM

There is different control methodology to track MPP such as perturb and observe (P&O), incremental conductance method etc. But the P&O method has two drawbacks:

• By forcing the operating point to operate near the MPP, oscillations around the MPP appear in steady state. Such a drawback gives rise to the waste of some amount of available energy.

• It can be confusing; it moves the operating point far from the MPP instead of close to its under rapidly changing atmospheric conditions. These drawbacks are overcome by Sliding Mode Control Algorithm.

The control algorithm using Sliding Mode Controller is used for Maximum Power extraction from PV Array at various operating conditions. This control strategy provides accurate estimation of point corresponding to maximum power on PV curve and helps to increase its efficiency

The output graph for the micro-inverter using SMC algorithm is X Axis- Time, Y Axis- Voltage

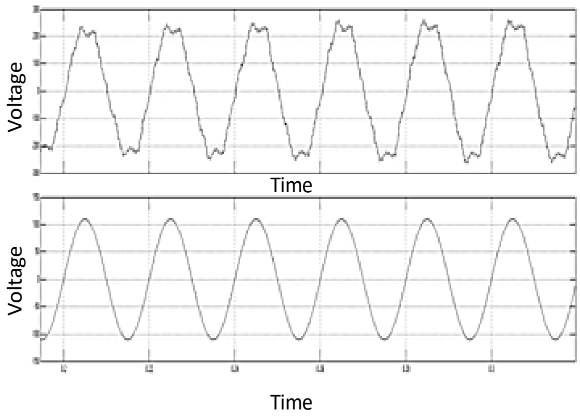

Fig.-5.1:With Filter

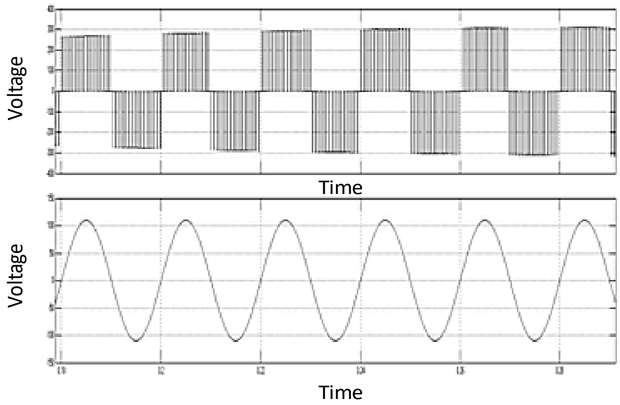

Fig.-5.2: ithout Filter

From the above graph, it can see that SMC based micro-inverters have more stability and it can track the maximum power more effectively than P & O based micro-inverters and also maintain that MPP.

VII. ADVANTAGES

- The main advantage of this SMC based micro-inverter is that it has fewer harmonic than P&O based micro-inverter.
- It is more stable than P&O based micro-inverter.
- It is highly efficient and is of low cost when compared to the other micro-inverters.

VIII. CONCLUSION

The SMC based MPPT is proposed on this brief. The MPPT estimates maximum power point of PV system using SMC-MPPT algorithm. The performance of the proposed solution was tested using realistic simulations accounting for perturbations in both the irradiance and the load voltage, obtaining satisfactory results. Moreover, the sliding-mode controller was contrasted with classical MPPT solutions based on the P&O algorithm, where the SMC provides a much faster tracking of the MPP, thereby increasing the produced energy. Therefore, the proposed SMC enables to increment the profitability of PV installations; hence the return-of-investment time is reduced.

The model proposed to simulate the characteristics of solar PV cell, as the PV system is dependent on the temperature and irradiation conditions and the proposed grid-connected photo-voltaic inverter system has good operating performance.

IX. FUTURE SCOPE

A further improvement to the SMC could be performed in a future work—a different, but more complex, switching circuit could be designed to avoid the sign change of the transversality (i.e) to remove the divergence stages in the SMC operation. This new development will enable to constraint the hysteresis band of the SMC, which will eventually enable to reduce, even more, the settling time of the PV power to achieve a faster MPPT procedure

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