PSO based Grid Tied PV System with Three Phase Dual Buck Inverter

N. Prasad, S. Hema Silviavinothini, K. Muthuvel and S. Parthiban

Abstract--- *Solar PV method provides a sustainable method for power production. The Solar panel has a nonlinear characteristic so that power extracting from solar panel becomes tedious especially when there is partial shading. Particle swarm optimization based Maximum Power Point Tracking is used, which tracks the maximum power from the Solar panel during partially shaded condition. Interleaved Boost converter which has minimum output voltage ripple is used. This paper proposes a method for grid interactive inverters for solar PV power generation. Three phase dual buck inverter which avoids shoot through problem is investigated. All simulations are done with MATLAB/ SIMULINK.*

Keywords--- *PSO, IBC, SPWM.*

I. INTRODUCTION

A solar panel converts only 30% of the incident solar radiations into electric power. This converted energy can be effectively used. The voltage of the solar panel is less in value and has to be boosted i.e., increased in voltage to be supplied to the grid. This boosting of volatge performed by means of a interleaved boost converter. A particle swarm optimization[1] based Maximum power point tracking algorithm using ordinary boost converter. Since the use of ordinary boost converter the system gives more ripples. A new biological swarm chasing algorithm [2] for tracking maximum power from the solar PV module. This proposed maximum power point tracking algorithm tracks power only at uniformly shaded condition and it fails to analyze the partially shaded condition. Ordinary conventional boost converter is used to track the power from the solar panel. An interleaved boost converter [3], [9] which reduces switching stress and provides minimum output ripple can be used for solar Photovoltaic power tracking since it has variable solar radiations. A Three phase dual buck inverter [4] with unified PWM which has minimum THD value was proposed with reduced switching loss and reducing the possibility of shoot through in the inverter. A Seven level inverter [7] for solar power production has been analyzed which fails to analyze partial shading in solar array. A Grid connected Solar system with a modified Maximum power point tracking [8] algorithm proposes maximum power point tracking algorithm which fails to track partially shaded condition in solar PV.

II. INTERLEAVED BOOST CONVERTER

An interleaved boost converter is dc-dc converter which is the parallel connection of two ordinary conventional boost converters with switches turned ON alternatively. The interleaved boost converter consists of two low voltage

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switches shown in figure 1. The interleaved boost converter has the advantage of minimized ripple in output voltage compared to ordinary conventional boost converter, also as the voltage is divided between the two switches the switching stress between the two switches are reduced.

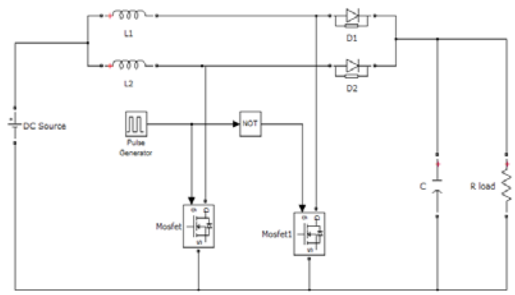

Figure 1: Interleaved Boost converter

First Operating Stage

The first operating stage is that when the switch S1 is turned ON and the switch S2 is turned OFF, the charge gets stored in Inductor2 and the charge stored in inductor1 is added with the input voltage and supplies the load. The capacitor is used as a filter.

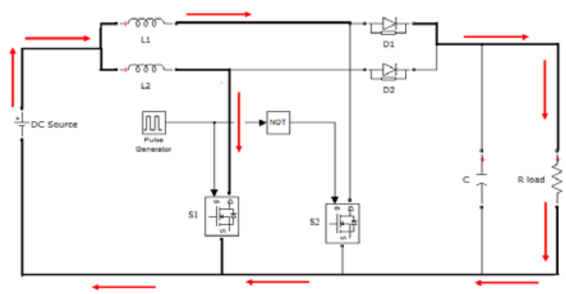

Figure 2: First operating stage of Interleaved Boost Converter

Second Operating Stage

The second operating stage is that the switch S1is turned OFF and the switch S2 is turned ON, the charge stored in the inductor2 adds up with the input voltage and supplies the load. As the switch S2 is turned ON the charge gets stored in the inductor L1.

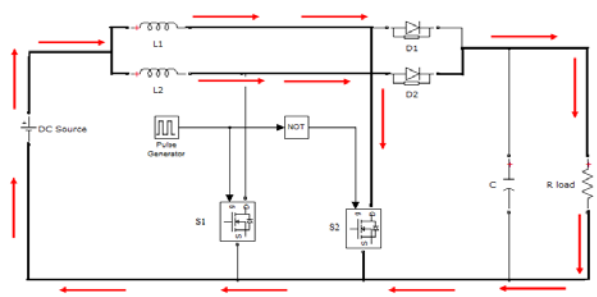

Figure 3: Second operating stage of Interleaved Boost Converter

Table 1: Experimental Parameters for Interleaved Boost Converter

Parameters	Symbol	Value
Inductance of IBC	L_1,L_2	20mH
Output Capacitor	C_{out}	220uF
Resistance of Load	R	20 Ω

III. Solar PV Cell

A Solar cell is the building block of a solar panel. A solar array is formed by interconnecting solar cells in series and parallel. By connecting solar cells in series voltage of the panel gets increased. By connecting solar cells in parallel the current of the solar panel gets increased. This single diode model of solar cell is given below and the model has been developed by the charctistic equations of the solar panel. By increaing temperature of the solar panel, the output power of the solar panel gets reduced.

$$I = I_{lg} - I_{os} \times \left[\exp\left(q \times \frac{V+I\times R_S}{A\times K\times T}\right) - 1\right] - \frac{V+I\times R_S}{R_{Sh}}$$

$$I = \{I_{SCR} + K_i \times (T - 25)\} \times S$$

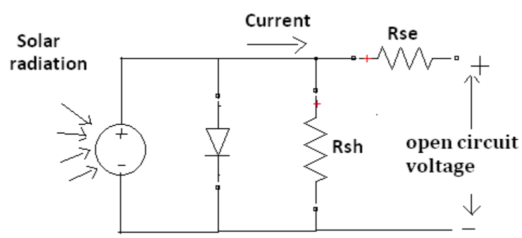

Figure 4: Single Diode model of Solar PV cell

The series resistance of solar panel is more than the shunt resistance, so that even when the ends of solar panel gets short circuited only short circuit current flows through the circuit so that there wont be any effect in the solar panel. The short circuit current and open circuit voltage are the important parameters of the solar panel. The power to voltage curve is uniform and it will have only one maximum power point. When the solar panel is partially shaded there will be many maxima available in the PV curve of the solar panel, As there is byepass diode and blocking diode for disconnecting the partially shaded solar cell, the local maximas will be more. When the solar panel is partially shaded it is difficult for ordinary conevntional MPPT algorithms to track the global maxima.

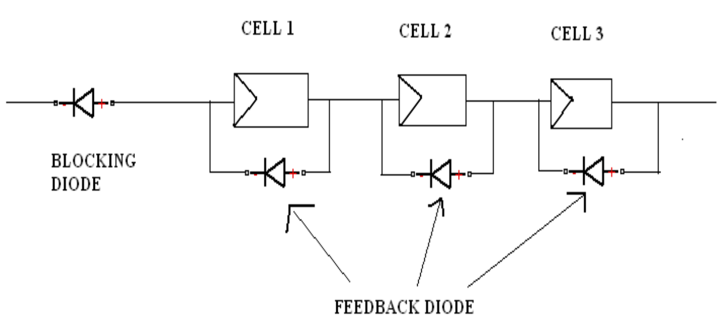

Figure 5: Solar cell with feedback and blocking diode

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As a result the P-V curve will not be uniform producing multiple peaks as shown in figure 3.When there is a single maximum power point, tracking the maximum power point is easy but when the solar panel is partially shaded there is many local maxima and one global maxima. Ordinary perturb and observe and incremental conductance Maximum power point tracking algorithm gets trapped in local maxima so that we need an algorithm to track the global maxima. For this Particle Swarm optimisation is used.

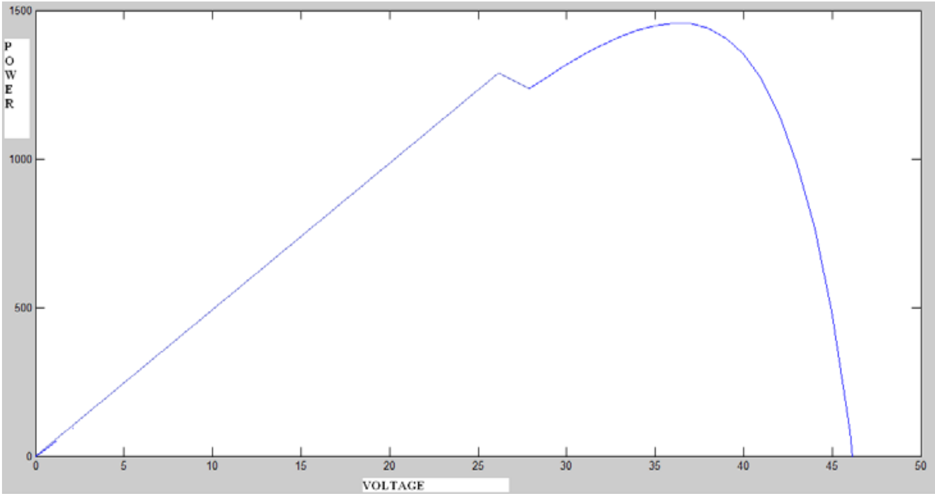

Figure 6: P-V Curve of a partially shaded solar panel

IV. PARTICLE SWARM OPTIMIZATION

In particle swarm optimisation, initially the particles are placed randomly at initial position and these particles will search for a better fitness value in search space. The main objective in particle swarm optimisation is that it always searches randomly for better fitness value. The particle Swarm optimisation is based on two main equations named as velocity update equation and position update equation as shown in equation

Velocity update equation,

$V(k+1)=W\times V(k)+C1\times R1\times(P_{best}-x(k))+C2\times R2\times(G_{best}-x(k))$

Position update equation,

$x(k+1)=x(k)+V(k+1)$

where

W is inertia weight

R1 and R2 are random numbers in search space

C1 and C2 are correction factors

This Particle Swarm optimization based Maximum Power Point Tracking Algorithm Randomly placed Duty cycle which is the search space. The Duty cycle tracks the power, each power tracked by the duty cycle is the Personal Best, on comparing all the personal Best value the maximum value is the Global Best. The iteration goes on as the iteration goes on the Global maxima can be Tracked easily

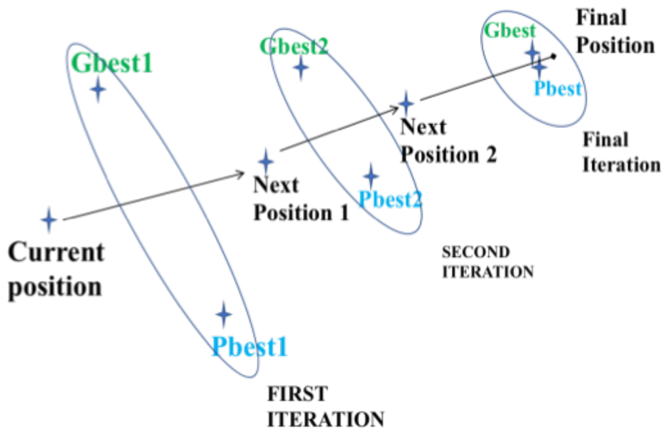

Figure 7: Particle swarm optimisation

V. Three Phase Dual Buck Inverter

The three-phase dual-buck inverter can use MOSFET switches instead of IGBT because of the flexibility in its operation. Ordinary conventional Voltage Source inverter uses three legs, in each leg three active switches, but there is a possibility of short circuiting which is called as shoot through problem. Practically 180° phase shift between the two switches of a leg in conventional inverter is difficult, even when there is no shoot through problem there is more volatge ripple and it produces more THD value. This three phase dual buck inverter as shown in figure.8 has a diode in each leg, so that shoot through problem in each leg has been greatly avoided. Since it has MOSFET the switching stress is reduced, it has minimum switching loss, it produces minimum output voltage ripple. Since MOSFET has minimum switching loss it does not need any resonant switching techniques to avoid switching loss. In this proposed work the input voltage to the three phase dual buck inverter is always varying as there is variation in the solar radiation. The three phase dual buck inverter produces the required three phases output with minimum harmonic content.

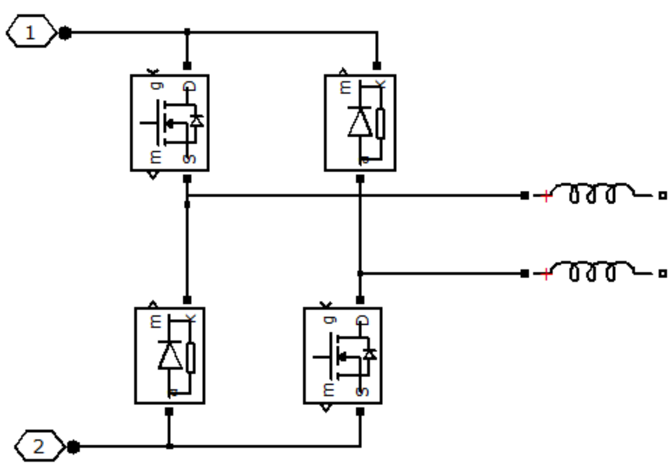

Figure 8: Single leg of Three phase Dual Buck inverter

Sinusoidal PWM is used for genrating pulses which compares the output voltage with the input voltage to generate the pulses.

VI. RESULTS

The Solar panel, Interleaved boost converter and three phase dual buck inverter has been simulated and has been analysed seperately. The Particle swarm optimisation based Maximum power point tracking algorithm has been tested under various atmospheric conditions. The conventional MPPT algorithms are tested in standard testing conditions of a solar panel and the results shows that they get trapped in local maxima Particle Swarm Optimization based MPPT tracks more power since it tracks the global maxima. The output of interleaved Boost converter is given to Three phased Dual Buck Inverter which given THD value of 2.46%.

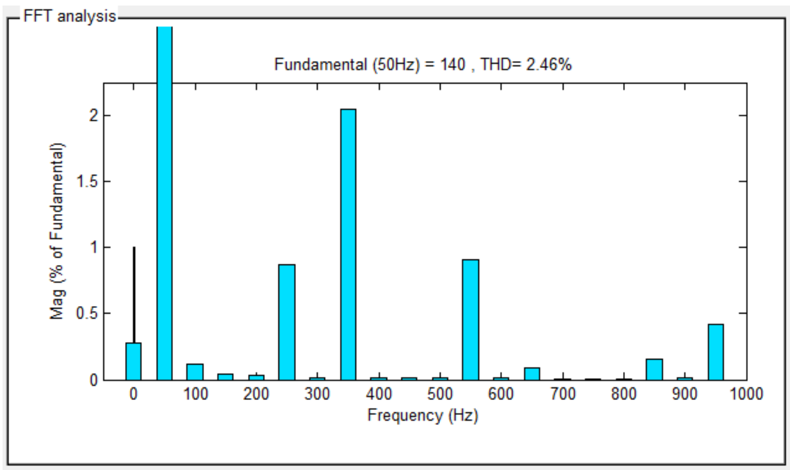

Figure 9: THD Analysis

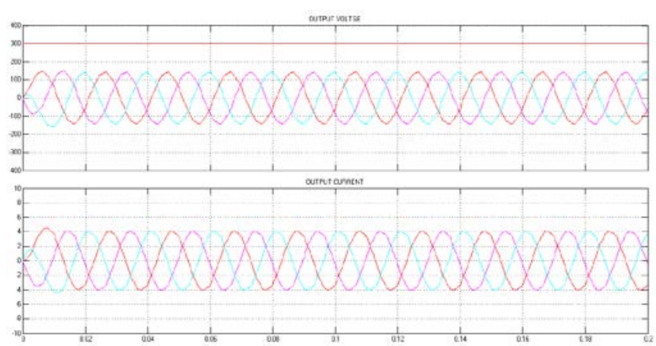

Figure 10: Output Voltage and Output current

VII. CONCLUSION

A new Voltage Source Inverter has been proposed and used for solar PV application. It has the advantage of utilizing power MOSFETs as active switches, and improves inverter reliability by eliminating the possibility of shoot-through and the need for dead-time. PSO algorithm tracks the maximum power even when there is partial shading, The presence of interleaved Boost converters reduces the voltage ripple in the output side. The THD value shows that it is well below the approved standard. In future some more optimisation algorithms can be used to avoid oscillations in tracking peak power.

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