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Simulation of Single Phase Photovoltaic Inverter in PSIM

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Abstract—In this paper presents a simulation of single phase inverter with MPPT Buck-Boost converter and SHE PWM pattern for reduction of lower level of Harmonics. This method will be usefulinreduces the loses in photovoltaicinverter circuitry for the power produced by solar panel is costly and lower in amount specially compared with conventional energy sources, but the MPPT circuit will increase the efficiency of the solar electrification and the selective harmonic elimination inverter methodology (SHE) will also increases the efficiency by reducing the losses at the inverter with lower total harmonic distortion (THD) ,The perturb and observe algorithm is used in MPPT control methodology.The simulation of this total circuit simulated in PSIM.

Keywords:- MPPT in PSIM, Single phase solar photovoltaics, PWM based Harmonic elimination in PSIM,

I. INTRODUCTION

Due to rising costs of conventional energy and their limited resources, photovoltaic energy becomes a promising energy with advantages such as the absence of any pollution and the availability with more or less large quantities anywhere in the world. Currently, there is a big interest in solar energy applications especially in regions with favorable climatic conditions [8]. Among these applications we mention water pumping and lighting especially in isolated sites.The aim of this paper is to simulate a photovoltaic application that provides a stable AC voltage (220 V/50 Hz) f with MPPT along with SHE PWM based voltage source inverter(VSI) in PSIM software.

PSIM is a simulation software specifically designed for power electronics and motor control. With fast simulation and friendly user interface, PSIM provides a powerful simulation environment to address your simulation needs. PSIM provides an intuitive and easy-to-use graphic user interface for schematic editing. A circuit can be easily created and edited. Extensive on-line help is available for each component. To handle large systems, PSIM provides the subcircuit function which allows part of a circuit to be represented by a subcircuit block. TheRenewable Energy Module includes the models and blocks for battery and solar power applications. SIMCOUPLER module is used to couple the simulation with MATLAB software.

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II. BUCK –CONVERTER DESIGING

The solar panel used here has the following characteristics mentioned inside the table,

Table 1

Open circuit voltage (V_{oc})	21.6V
Optimum operating voltage(V_{mp})	17.2V
Short circuit current(I_{sc})	3.85A
Optimum operating current(I_{mp})	3.49A

A **buck converter** is a step-down DC to DC converter. Its design is similar to the step-up boost converter [1], [3], and like the boost converter it is a switched-mode power supply [8] that uses two switches an inductor and a capacitor.

A. Inductor value calculation

The inductor value, (L) required to operate the converter in the continuous conduction mode is calculated [3], [1] such that the peak inductor current at maximum output power does not exceed the power switch current rating. Thus, L is calculated as

$$L \geq \frac{V_{om}(1 - D_{cm})}{f_s|\Delta I_{lm}|} \quad (1)$$

The DC–DC converter is chosen to operate in continuous conduction mode (CCM), the inductance is selected to limit the ripple output current below 10% of its mean value,

D_{cm} = Duty cycle at maximum converter output power;
ΔI_{lm} = peak-to-peak ripple of the inductor current;
V_{om} = maximum of the dc component of the output voltage;
I_{om} = dc component of the output current at maximum output power.
f_s = switching frequency;

B. Output capacitor value calculation

The output capacitor value calculated to give the desired peak-to-peak [3], [1] output voltage ripple isthe output capacitor is selected to limit the output voltage variation at 1%.

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$c \geq \frac{D_{cm} I_{om}}{r f_s V_{om}}$ (2)

$r = \frac{\Delta V_{om}}{V_{om}}$; usually $r < 2\%$

C. *Input capacitor value calculation*

capacitor value is calculated to be Taking into account that the ripple of the [1], [3] PV output current must be less than 2% of its mean value, the input capacitance value is

$$C_{pv} \geq \frac{(1-D_{cm}) I_{om} D_{cm}}{0.02 I_{Pvm} R_{pvm} f_s} \qquad (3)$$

I_{Pvm} = converter input current at maximum input power,
R_{pvm} = PV array internal resistance at the maximum power point

D. *Designed parameters of buck-converter*

L = 1mh

c = 1.5 mF

C_{pv} = 340 uf

III. MAXIMUM POWER POINT TRACKING

Maximum power point tracking (MPPT) is a technique that grid tie inverters, [2]solarbattery chargers and similar devices useto get the maximum possible power from one or more solar panels. Solar cells have a [7] complex relationship between solar irradiation, temperature and total resistance that produces a non-linear output efficiency known as the I-V curve. It is the purpose of the MPPT system to sample the output of the cells and apply the proper resistance (load) to obtain maximum power for any given environmental conditions.

Perturb and observe is the most [7] commonly used MPPT method due to its ease of implementation. Perturb and observe method may result in top-level efficiency in outputpower, [7] For every cycle the duty cycle will be perturbed, In this algorithm first the starting duty cycle will be initialized to 0,where it lies between 0 to 1, the continuous sample of input voltage and has taken continuously, [5] If the difference in power between the power for two continuous samples lies positive the duty cycle will be increase to small step value if it is negative value the duty cycle will decreased to small step value, and the tracking gets saturated once the maximum power has reached.

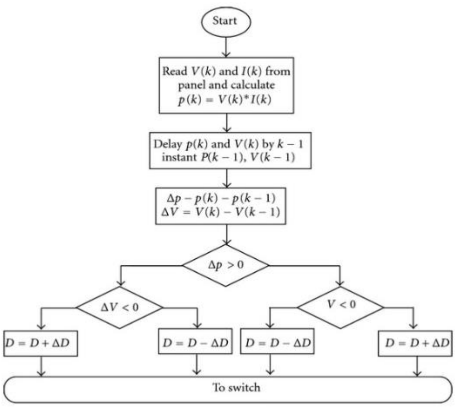

Fig 1:algorithm for duty cycle perturbation

Fig 1 shows the algorithm for MPPT in P&O method.MPPT [4] has been implemented with SIMCOUPLER module shown in Fig 3 along with MATLAB embedded block. The MPPT control methodology implanted along with the buck converter as shown in Fig 2. Fig 4 shows the values of output voltage and current.

MPPt algorithm has been implemented with the help of the embedded MATLAB tool.This has been implemented with the help of the SIMCOUPLER Module in the MATLAB. This provides the facility to couple the PSIM and MATLAB software foe co-simulation operation.

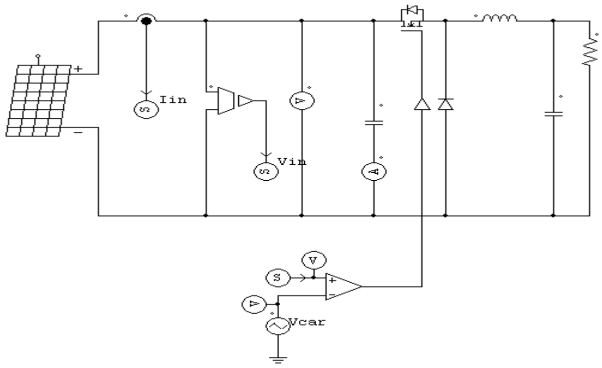

Fig2:Circuit diagram o pv panel with mppt buck converter

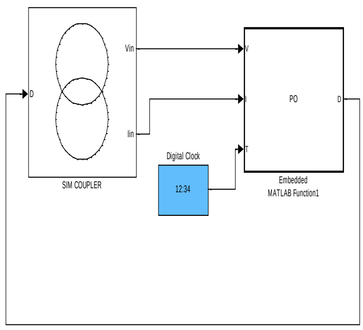

Fig 3 MPPT co-simulation in MATLAB

Mppt Has been Implemented in PSIM with Matlab in the co-simulation option.

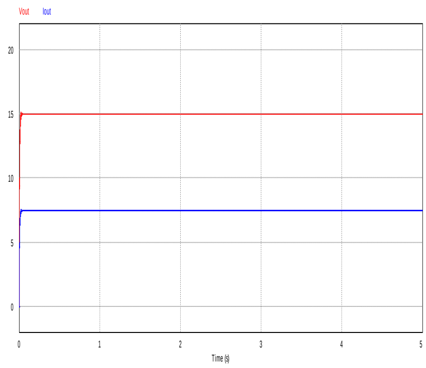

Fig 4:pv system's output voltage and current

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IV. VOLTAGE SOURCE INVERTER

A. *Selective harmonic eliminated pulse width modulation (she pwm)*

The SHE PWM methodology is used here to eliminate the 5_{th},7_{th},9_{th}harmonic components in output waveform. The basic Harmonic component equation is,

$$h_n = \frac{4E}{n\pi} \sum_{k=1}^{s} \cos(n\alpha_K) \quad \text{, for } n = 3, 5, 7, \ldots \qquad (4)$$

The amplitude of odd harmonic component in quarter-wave symmetric multilevel [9] waveform is written again here.

The nonlinear equation of the fundamental component:

$$\frac{4E}{\pi}[\cos(\alpha_1) + \cos(\alpha_2) + \cdots \ldots + \cos(\alpha_s)] = h_1 \qquad (5)$$

The nonlinear equations of the odd harmonic component:

$$\frac{4E}{3\pi}[\cos(3\alpha_1) + \cos(3\alpha_2) + \cdots \ldots + \cos(3\alpha_s)] = h_3 \qquad (6)$$

$$\frac{4E}{5\pi}[\cos(5\alpha_1) + \cos(5\alpha_2) + \cdots \ldots + \cos(5\alpha_s)] = h_5 \qquad (7)$$

$$\frac{4E}{7\pi}[\cos(7\alpha_1) + \cos(7\alpha_2) + \cdots \ldots + \cos(7\alpha_s)] = h_7 \qquad (8)$$

$$\frac{4E}{9\pi}[\cos(9\alpha_1) + \cos(9\alpha_2) + \cdots \ldots + \cos(9\alpha_s)] = h_9 \qquad (9)$$

$$M = \frac{h_1}{sE} (10)$$

Whereh1 is the amplitude [9] of the fundamental component.sis the number of dc sources or H-bridge cells.andE is the voltages of the dc sources.To solve the switching angles, the Newton–Raphsonmethod is applied.

B. *The implementation of SHE –PWM in PSIM*

Fig 5 shows the implantation of the SHE PWM inverter circuit with single phase transformer and filtering circuit. The firing angles has been included inside the PWM pattern controller.

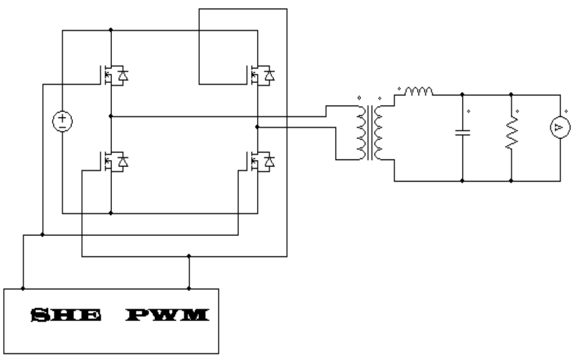

Fig 5: SHE PWM implementation in PSIM

V. RESULTS AND OUTPUT GRAPHS

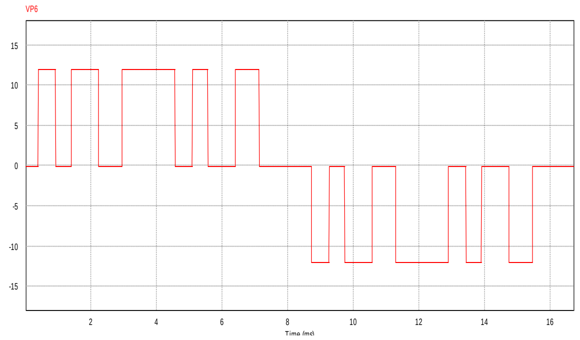

Fig 6VSI output

The resultant simulated graphs are shown in Fig 6, Fig 7, Fig 8,Fig 9,Fig 10.

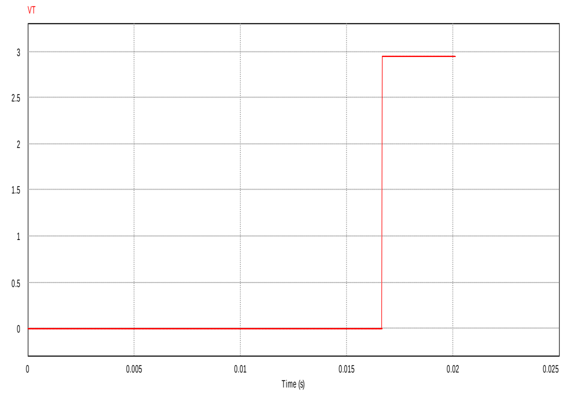

Fig 7THD of VSI

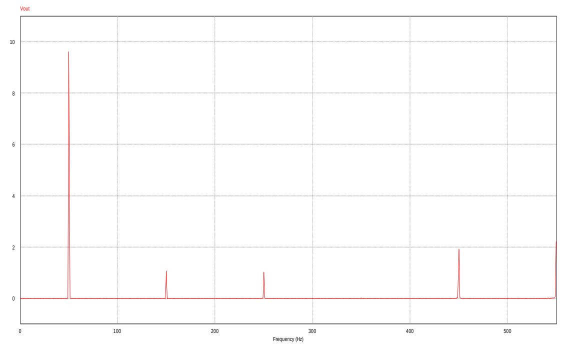

Fig 8 Eliminated Lower Harmonics in VSI

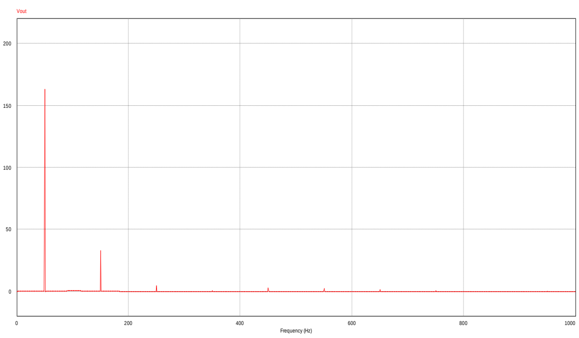

Fig9 Eliminated Higher Harmonics

The number of switchingsin MOSFETS for one full cycle of the inverter operation has shown in Fig 6, The SHE PWM has been implemented with the help of PWM pattern controller in PSIM. Fig 7 shows the THD value of the VSI that is 1.44,and Fig 8 Shows the eliminated lower Harmonics and Fig 9 shows eliminated higher Harmonics. Fig 10 shows inverter's output voltage waveform.

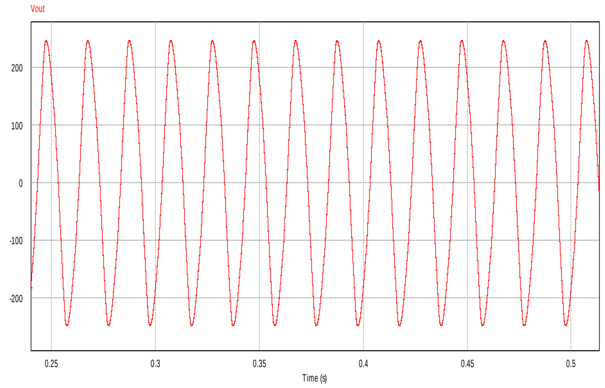

Fig 10 The Inverter out put

VI. CONCLUSION

In this Paper, a single phase photovoltaic system is simulated. The buck converter is used to charge a battery with maximum power algorithm ensuring a low cost implementation, good efficiency. The VSI is controlled by a Selective Harmonic Eliminated PWM method which decrease inverter losses and improve the efficiency of the overall system. The output voltage is easily filtered and a stable 220 V/50 Hz voltage is obtained to feed AC loads.This application can be used to cover home appliances in isolated sites and can be extended to grid connection.

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