Single-Phase, H-Bridge 3-level Inverter of Wide Range Input Voltage for Grid Connected Solar Photovoltaic Applications

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ABSTRACT

This paper proposes a simple, cost effective and efficient of system for solar photovoltaic.Extensive acknowledgement of solar energy as a feasible substitute, headed for vestige powers has a guide to integrationist of solar production systems to the progressive power network. Included with elevated capacity solar producing unite, distribution height, solar production has picked up the significance and popularity to successfully actualize intellectual systems so as to provide for family unit produced unnecessary power to distribution feeder system, modelling as well as simulation of the grid-tied solar system is elevated importance.

The paper models a residential crown peak solar grid-tie system joined to 230 single-phase network. The job proposes three-level single-phase inverter through an effective production electrical energy control method with the purpose of synchronizing the phase, frequency and voltage of the inverter by means of the network. The MPPT DC-DC converter forced by Perturb and observe (P&O) method in addition called "Hill-Climbing" although the DC to DC converter controls the DC connect voltage agreeing to the network voltage changes towards successfully standardize.

General Term

modeling, solar Photovoltaic voltage controller, grid-tied Inverter, Perturb and observe (P&O) MPPT.

Keywords

Single phase multilevel inverter ,SPWM

1. INTRODUCTION

The prediction of a progressive power method is an accumulation of Predictable along with renewable producing sources. The sun oriented is considered on the road to have the maximum possible of force utilization then just before control this force, possible must be located tapped beginning every job of the ground which is accepting sun-powered insolation. The previously mentioned concept has brought winds of change in the conventional recognition of production then load. The concept of the domestic customer organism a load direct control transgressed in the direction of taking place a source because properly, for example, load, the informant being the rooftop solar photovoltaic (RF-SPV) scheme.

The spreading stage network mind a marine of drifters then annoyance, an operative photovoltaic system ought to take place modelled that nourishes feature power in the direction of the network at the peak of common combination (PCC) by means of the national customer. Production then sends out the purposes.In place of the above-mentioned cause, the job tries in the direction of type an SPV system designed to score the SPV largely comprises of the subsequent units the photovoltaic array, MMPT boost converter, the inverter, filter then the seclusion transformer. The MPPT holds the energy used for maximum power point (MPP) by attractive criticism of voltage and current starting PV array [1]. Fasten indicating the MPP beginning the VI curves contain been tended to by a variety of algorithms ,shown of which the for the most part common are the perturb and observe (P&O)[2], then the incremental conductance (INNCOND) [3] quite a lot of adjustments of these calculations contain been projected in current a long time which brightly calculates pace dimension , tracks MPP inside antenna –less procedure, put in progressive cleverly fuzzy then neural method to exactly recognize the MPP [4,5].

2. SOLAR PHOTOVOLTAIC ARRAY

An ideal Solar PV cell model involves an ideal current source in parallel with an ideal diode as shown in Fig.(1). A Photovoltaic array is designed by linking many solar cells in series and parallel fashion. In PV module, series resistance (Rs) is more predominant and shunt resistance (Rsh) being quite large is assumed to be infinity. As solar insolation increases the open circuit voltage (Voc) also increases, and as temperature increases, the open circuit voltage (Voc) decreases. The reason being for an increase in temperature, the band gap energy (Eg) increases resulting in more energy required to traverse the band gap, resulting decrease in efficiency of the PV cell.

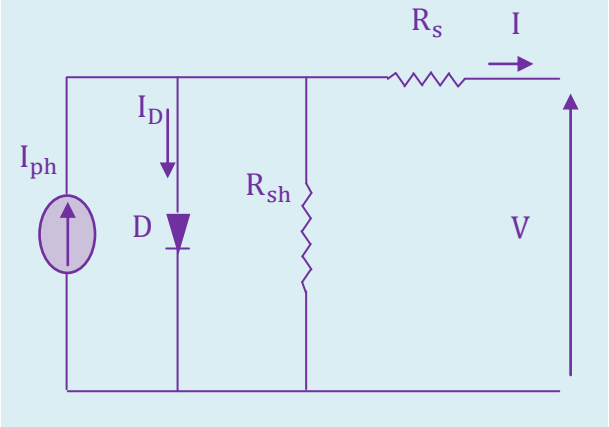
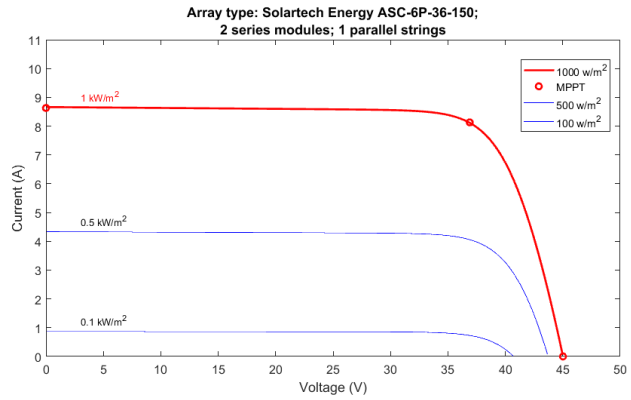


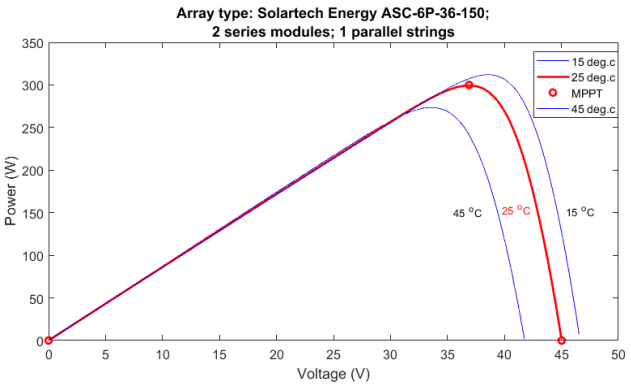
Fig. (1) Equivalent circuit of PV cell

The simulation work employs model of the panel (110 w) specification of the module are as follows:
Short circuit current = Isc = 6.86
Open circuit voltage = Voc = 22
Number of strings in parallel = Np = 1

Number of series-connected modules per string = Ns = 4



(a)



(b)

Fig. (2) current-voltage characteristics (a) and power-voltage characteristics (b) of the implemented PV array

The Photovoltaic voltage-current characteristic is non-linear during natural world the same as shown in fig (2), the power production intended for a certain radiance along with temperatures starting the cell increases to a maximum point through an increase inside output current starting the call the direct taking place the V-I characteristics giving the maximum power are called the maximum power point designed for the particular Irradiance in addition to temperature. This maximum power point tracking Algorithm [1], which gives the voltage by the side of which maximum power is given by the PV cell.

2.1 Maximum Power Point Tracking

The MPPT is a methodology taken after towards gathering the mainly created power on or after certain sources be partial to PV systems then storm turbine [8]. During this investigation, this the calling was defended by a microcontroller-based DC towards the DC converter with the aim of optimizes the equivalent of the solar array (PV panels), as well as the load. Easily, it is an algorithm encouraged by the principles of the voltage and current of the panel by the side of every one moment. [9].

The panel emerges next to daytime. This characteristically gives concerning a 15% increase in power during winter in addition to up to a 35% increase during summer. This is common in locales contain short time, but inside the Middle East region by the side of the majority time inside the year, has a long day then using a sun tracker choice not create a real change inside the production of the panel[10,11] in place of our work we contain utilized the Perturb and observe (P&O) method in addition called "Hill-Climbing" is the majority generally utilized method designed for MPPT because of its plainness in addition to efficiency [12, 13].

The P&O is used in this work for instance MPPT method. The flowchart of the P&O algorithm is shown in Fig. (3).

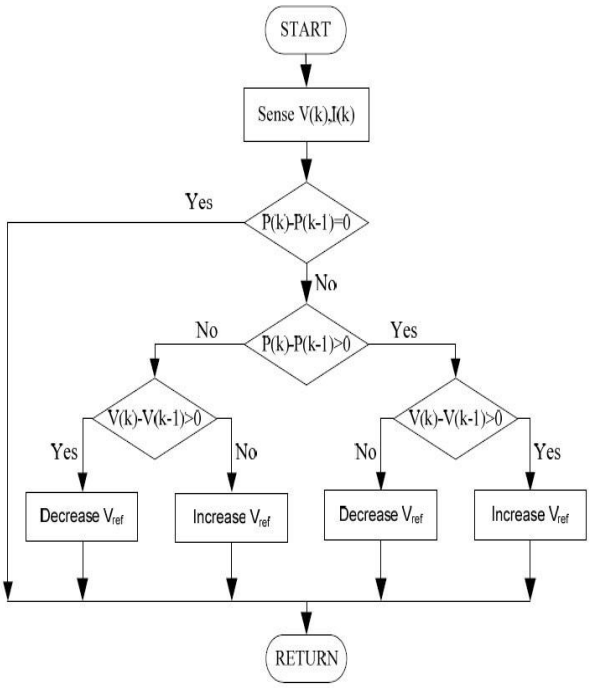


Fig (3) Flowchart of the Perturb & observe algorithm

2.2 MPPT Boost Converter

Around are plentiful converter topologies obtainable in place of MPPT converter actualized the same as seen during the creative writing [7, 8, 11] designed for our work we include determined leading boost converter topology. The PV cell is a current source, consequently, the essentiality defamation inside maintenance a constant voltage summarizes crossways the load intended for maximum taking out of power intended for changing insolation levels in addition to temperature.

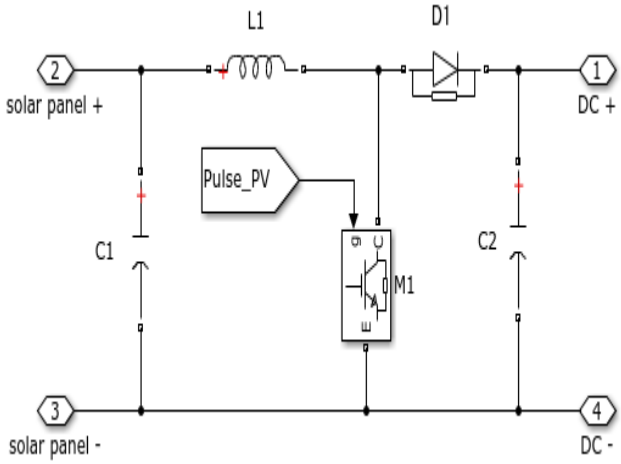


Fig. (4) Circuit diagram of MPPT Boost Converter

The input capacitor is required on the way to stabilize the input voltage appropriate towards the peak current obligation of switching power source. The input capacitor is chosen at this juncture is: C1=300µF. The choice of the inductor is of

superior significance seeing that inductor lying on the enter boundary of the converter stores energy in addition to giving incessant input current waveform. Evaluated beginning the formula:

$$\text{Lmin} = \frac{\text{Vin}*(\text{Vout}-\text{Vin})}{\Delta IL*fs*Vout} \quad (1)$$

L_{MIN} is the minimum value inductor necessary intended for boost process with no saturation of the central part of the inductor. V_{IN}= 60 to 80 V, input voltage beginning solar PV V_{OUT}=330 V, the output voltage of the MPPT boost converter, i.e., the voltage comparing to maximum power point. fs=20 kHz, switching frequency of the MOSFET, M1 Fig. (4)

$$\Delta \text{IL} = (0.2 \text{ to } 0.4) * \text{I out(max)} * \frac{\text{Vout}}{Vin} \quad (2)$$

This current ripple is not accepted previous is like this an approximation of 20% towards 40%.
$I_{OUT(MAX)}$ = 1.27A, is the maximum Output current of this MPPT converter
Δ_{IL}= 2.4A is the current ripple of the inductor [from equation(2)] L_{MIN}=2.7 mH.
Is assessed from eq (1) & (2) The inductor chosen intended for this converter is L1= 3mH, The output capacitor is chosen towards minimizing the output ripple voltage is assessed by the formula: MOSFET, M1 Fig. (4)

$$\text{C Out(min)} = \frac{\text{IOUT(max)}*\text{D}}{\Delta\text{VOUT}*\text{fs}} \quad (3)$$

The D = duty cycle of the converter, which is accepted towards being located, 25% with acknowledging to 80 V organism input and 330 V for the instance output of the MPPT converter.ΔV_{out} = 3.3 V, voltage ripple is accepted $C_{OUT(MIN)}$ = 287µF, is calculated from eq. (3).We contain occupied C2 = 300µF, for our simulation purpose intended for improved voltage waveform.

3. GRID TIED INVERTER

Grid-tied inverter theatres the significant position in the solar photovoltaic grid-tied power technique. The job of a GTI is double .single creature of changing over DC power beginning SPV to AC power which is in the direction of being located given to network ,then the previous organism to realize so as to in a shape that the photovoltaic panel otherwise array is spared as of response of network connected .readily available are frequent topologies planned in creative writing [13] which utilizes a extensive breadth of semiconductor switches .intended for our job we contain conceived a single phase H-Bridge inverter by means of IGBT existence our high-frequency switch, as revealed in Fig. (5).
After the platform boosting, the DC power is connected to the inverter to modernize towards AC power. In that case, this favourably harmonic response is accepted through a filter which causes a damaging effect on the harmonics to obtain a suitable sinusoidal response. An awfully low Total Harmonics Distortion (THD) is achievable by appropriate determination of filter.

Designed for our modelling, we choose the Sinusoidal pulse width modulation (SPWM) for instance, our gating technique to IGBT then an LCL filter configuration,causing the gating pulse to be constrained on a gate of IGBT of H-Bridge. The sacking arrangement is such that S1 and S4 Fig.(5) changes their switching situation consistently then the opposite switching situation is conventional by S2 &S3 simultaneously. Thereby generous an in close proximity sinusoidal ventured output, which is filtered towards reducing THD so as to can be established by the network standard [9].

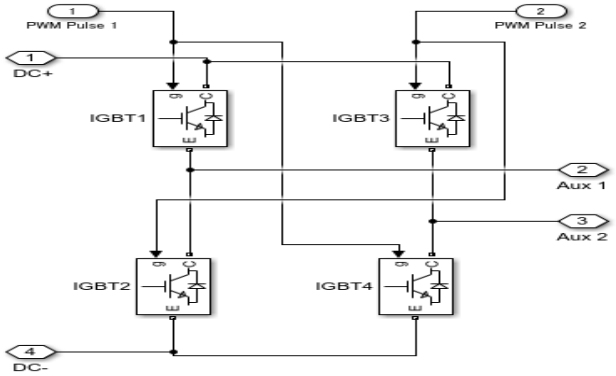


Fig. 5 Circuit diagram of the grid-tied inverter.

4. FILTER MODELING

Filters are utilized just before keeping in check the harmonic satisfied during the current waveform of a scheme like this progresses the source voltage waveform [15],.In our occupation, we contain utilized streak filters as it reduces the harmonic satisfy during currently fashioned by the high-frequency switching process in PWM inverters,The line filters L-Filter &T- filter is principally utilized.
L-Filter: L-Filters are first order filters having a constriction 20 dB/decade in excess of an extensive range of frequency. Intended for very high switching frequency PWM inverter it causes good quality attenuation.
T-Filter or LCL Filter: the T-filter are comparatively improved than L-filter for constriction of switching harmonics for PWM inverter In addition, other profit of using the T-filter creature.

- Current distortion is low down, then the generation of reactive power
- Attenuation of -60 dB/decade designed for frequencies acceptably more than the resonant frequency
- For a provide harmonic decrease, the lower switching frequency can take place utilized T-filter in addition forces the improvement of low THD stable at the low switching frequency than by a smaller amount storage space of energy. Hence we chose T-filters designed for our occupation. In addition to our choice filter, the meaning is: With a THD =4.31 %. At the moment the AC power following taking into consideration the filter drop meets the acceptable network THD standards[14], which is fewer than 5% THD in addition to fulfils the voltage level regular of a creature more than network voltage with the intention of can take place encouraged to the power network.

5 SIMULATION MODUL & SIMULATION RESULTS

The projected system was actualized on MATLAB R2017a Platform in addition to the results are discussed in this subdivision. The aggregate operational Simulink Circuit Diagram is made known in Fig. (9). The Irradiance in addition to temperature were given in the direction of PV array utilizing single builder group of buildings in Simulink, the levels of Irradiance, in addition, to signal builder building block in Simulink, the levels of Irradiance and temperature.

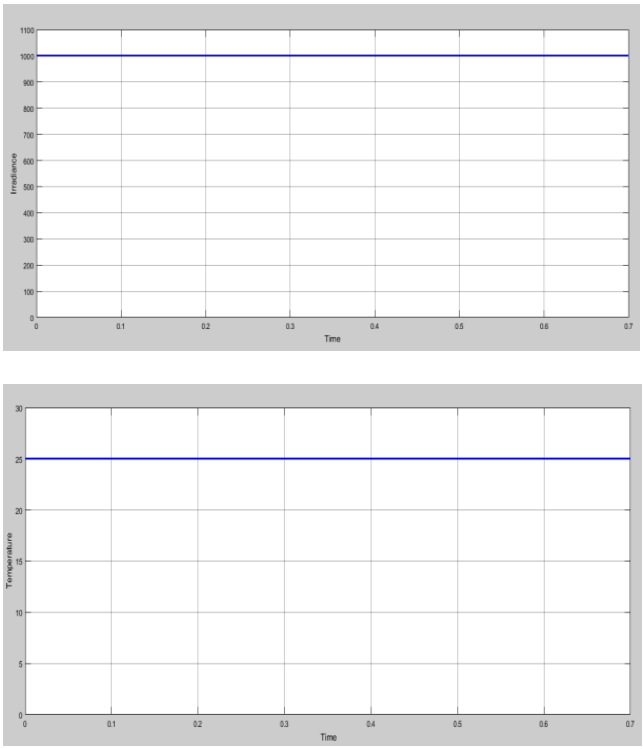


Fig. (6) Irradiance & temperature with time applied to the PV array

In this simulation go to work, the power network is arranged such so as to the voltage of the network changes from 230 V (RMS) to 220 V (RMS), respectively the location from the network such as tapped by the PLL block changes towards generating closed-loop control signals designed for the inverter, am active exhibitions estimation has been surveyed on the designed controllers. The voltage profiles of the , MPPT stage featuring in Fig. (7). Keeping up the imperative of the inverter output voltage is more than the network voltage the output of the inverter after the filters creature 330 V (peak) since shown in the field of Fig. (11). The THD is 4.31% as the Network voltage changes Following filtering the sinusoidal summarize AC power are connected headed for the power network by means of an Isolation Transformer. The output voltage waveform starting inverter before the filter is given away Fig. (10).

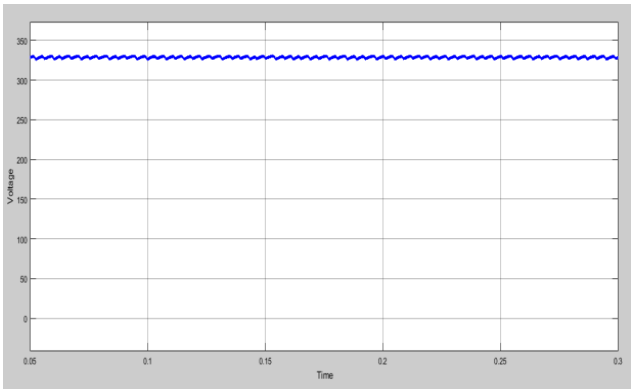


Fig. (7) Voltage of Boost converter By using MPPT

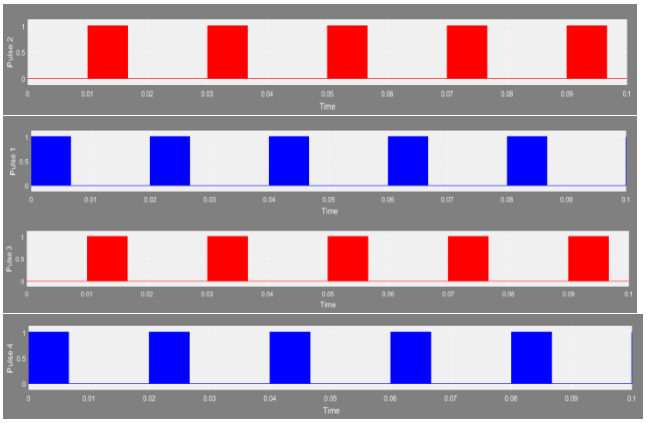


Fig. (8) Three-level Sinusoidal pulse width modulation (SPWM) gate of the inverter

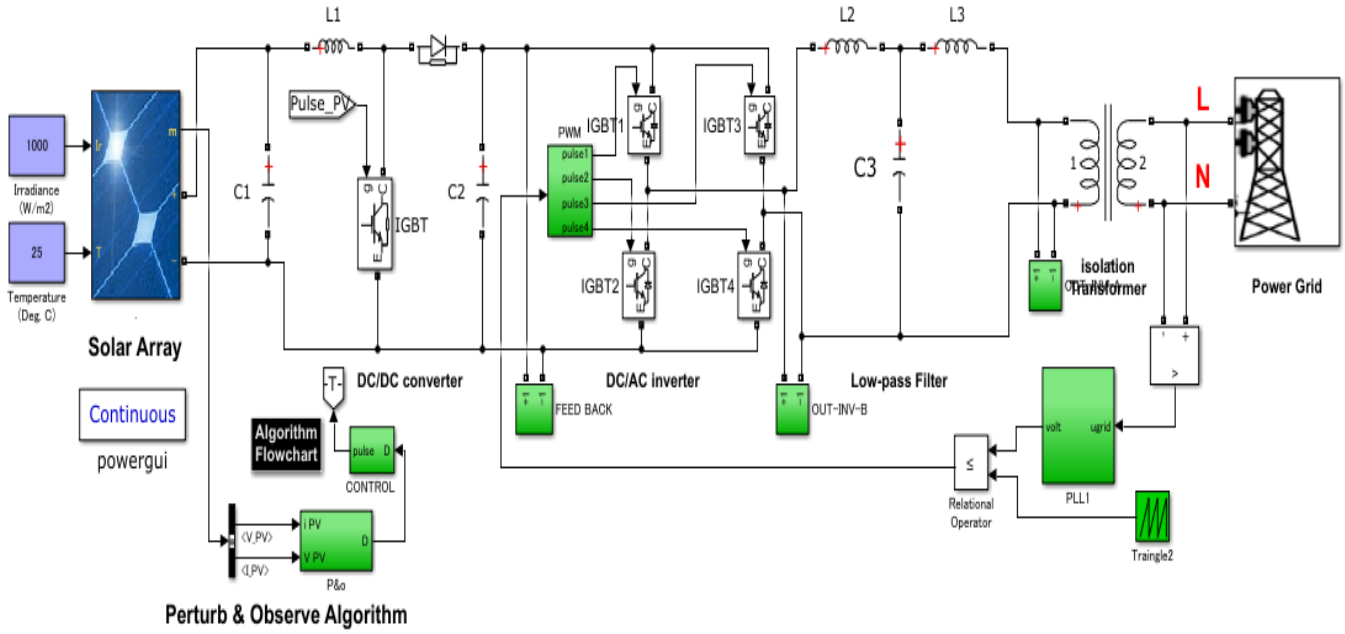


Fig. (9) competes for a simulation diagram of the proposed scheme in MATLAB Simulink

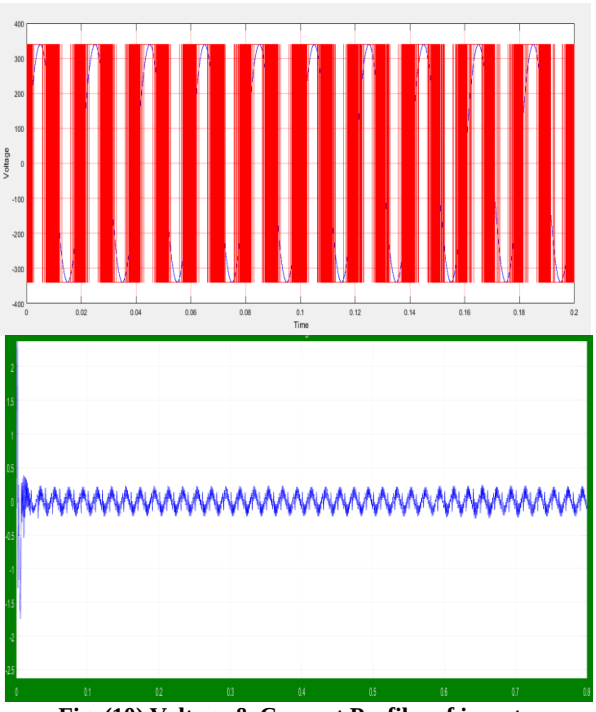


Fig. (10) Voltage & Current Profiles of inverter

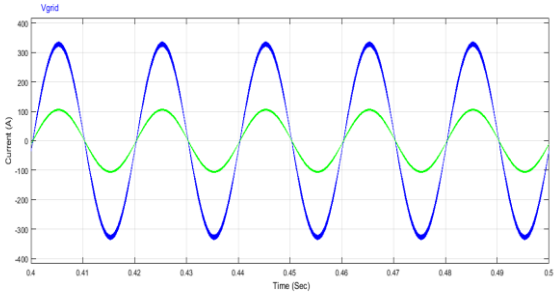


Fig. (11) Voltage & Current*(100) Profiles of inverter after the filter

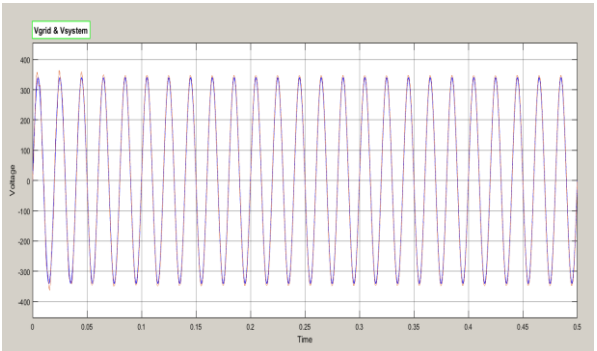
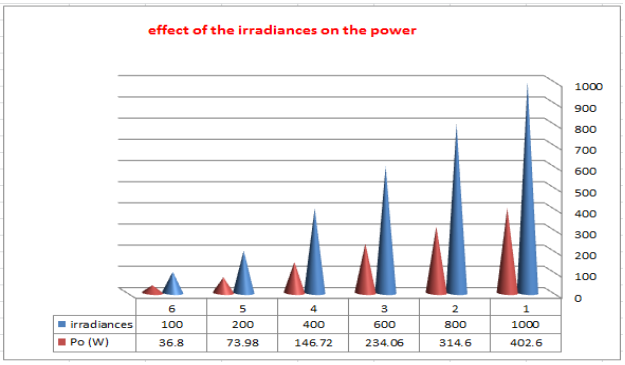


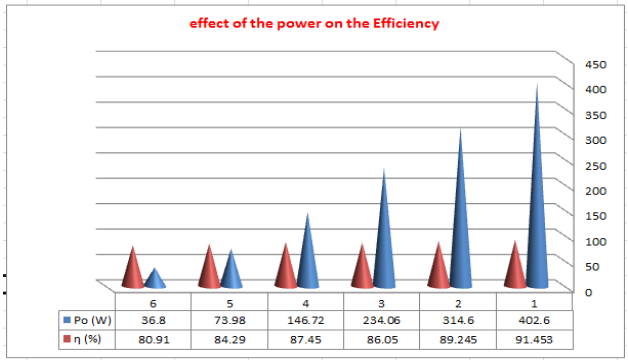
Fig. (12) Voltage grid& voltage of system before the filte

Table 3 Effect of the irradiances on the output

irradiances	Po (W)	η (%)	THD
1000	402.6	91.453	4.31
800	314.6	89.245	4.52
600	234.06	86.05	5.01
400	146.72	87.45	5.86
200	73.98	84.29	6.9
100	36.8	80.91	7.27



(a)



(b)

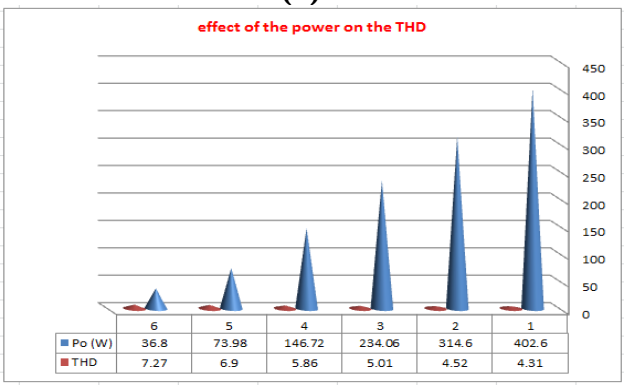
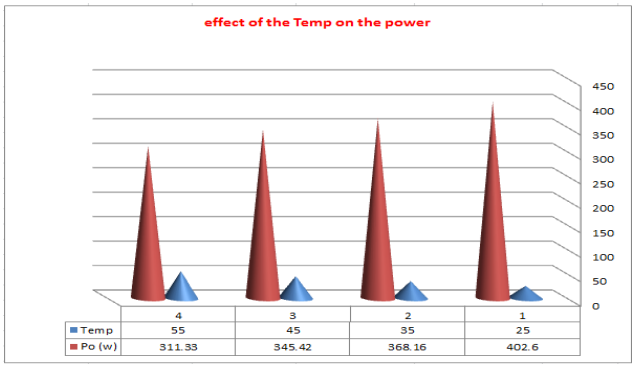


Fig. (13) Effect of the irradiances on the power output (a) & Efficiency (b) & THD (c)

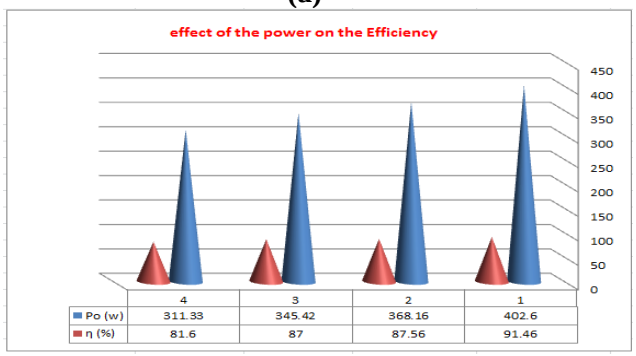
(c)

Table 4 Effect of the Temperature on the output

Temp	Pi (w)	Po (w)	η (%)	THD
25	440.2	402.6	91.46	4.31
35	420.44	368.16	87.56	4.37
45	394.8	345.42	87	4.46
55	381.5	311.33	81.6	5.01



(a)



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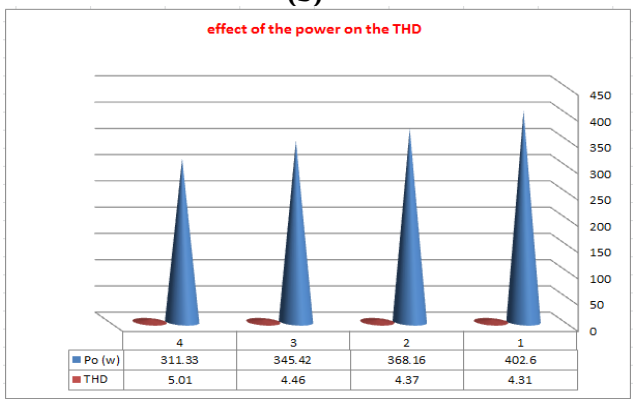

(c)

Fig. (14) Effect of the Temperature on the power output (a) & Efficiency (b) &THD (c)

The Simulation circuit parameters are enlisted in Table 5

Table 5: Circuit Parameters for the Simulation

LIST OF PARAMETERS WITH SPECIFICATIONS USED FOR THE DESIGN	
	Model: stion STN-110 Short circuit current = Isc = 6.86

PV Array	Open circuit voltage = Voc = 22 Number of cells per module = 36 Number of strings in parallel = Np = 1 Number of series-connected modules per string = Ns = 4
MPPT Converter	C1 = 100µF L1 = 3 mH C2 = 300µF
Inverter	Sinusoidal PWM switching frequency 20 KHz Inverter Output Voltage = 330 V(peak) 230 V (RMS),THD = 4.31%
T-or LCL Filter	L2 = 14mH C3 = 2µF L3 = 14Mh
Power Grid	VGRID(RMS) = 230 V Grid Frequency = 50 Hz

6. CONCLUSION

The single-phase inverter with DC-DC boost converter for solar systems with a wide input voltage range is designed and modelled in the MATLAB / Simulink environment. The result of the simulation shows that the DC-DC converter can adjust the input voltage of the PV variable power supply and maintain it at DC voltage regardless of the changes in the supply voltage. The inverter stage successfully converts the DC voltage into the highest AC voltage. The output voltage of the inverter is 230 V RMS AC with 5% low THD, which is suitable for the AC grid in the system and the network application

7. ACKNOWLEDGMENTS

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