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Voltage regulation and maximum power tracking of single stage grid tied photovoltaic system at different irradiance levels

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K E Y W O R D S

Boost Converter

MPPT

Photovoltaic

P&O

PID Controller

Voltage Regulation

A B S T R A C T

Distributed generation has played a vital role in recent times. The majority of the world's power producers are trying to produce power from distributed generation and mitigate losses. Photovoltaic is one of the most commonly used distributed resources in the world due to the availability of solar irradiance throughout the year. Moreover, it is economical and does not evolve any greenhouse gases. As solar irradiance is not uniformly available throughout the day, so at different times, unlike voltages, current and power appear. Due to this tracking of maximum power and voltage regulation are major investigated issues. So, to extract maximum power and regulate voltages algorithm and controller have been utilized. First, on a small scale, the boost converter is designed on hardware and tested with the P&O technique for tracking maximum power. After that in this paper, Perturb and observation algorithm is applied to track the maximum power and the PID controller is designed for voltage regulation in MATLAB Simulink on a large scale. Moreover, two scenarios are considered in this study, first, voltage, current and power are analyzed for a standalone system with and without MPPT. Second, Maximum power is scrutinized with a grid-tied system and THD is also calculated. MATLAB/Simulink tool is used to carry out this whole simulation work on a large scale for two-kilo watt system.

1. Introduction

The growth in population of the world has also enhanced energy needs which have been indeed growing constantly and are projected to rise at a quicker pace in upcoming time. Previously, conventional energy sources have provided the bulk of electricity demand and still remain to be significant contributor [1], [2]. Due to the decline in conventional sources and the enhancement in pollution, it became a great concern for the whole world to continuously utilize these sources [3]. Utilization of renewable energy sources is the best solution and with this contribution, greenhouse and toxic gases in the environment are reduced. There are many renewable energy sources on the globe like, solar energy, wind energy, tidal energy, biomass, and geothermal energy. However, solar energy is the most abundant energy available on this earth [2], [4]–[6].

The growth of renewables like photovoltaic energy [7] often gained economic and commercial attention in subsequent times mostly as a prevalent and green energy source [8], [9]. According to researchers, solar energy became the dominant source to produce about 31% of energy leaving other sources behind such as wind and hydro power [10]. DC-DC converters are widely utilized in distributed generation. So a Single phase voltage source inverter is one of the best techniques for connecting and incorporating limited photovoltaic system rating into the grid for power outputs beneath 10 kilowatts [11]–[13].

The rapid changes in ecological circumstances have affected the photovoltaic output power at large, because voltage and current continuously vary with the solar irradiance received at the PV panel [14]. So, efficiency, high quality and stability of the system are also one of the major concerns in photovoltaic systems. Further, power generated by the photovoltaic system must be incorporated into the grid with a good quality hence output voltage regulation becomes mandatory for PV system [14]–[16]. According to [17], there are many pros of single-phase grid connected photovoltaic system, however, bulk utilization of photovoltaic has created many problems with distribution and grid end. One of them is grid connected DC/AC converter [18]. This inverter causes voltage regulation and power quality issues in the system and to tackle this problem different control schemes are adopted to mitigate the power quality issues [19][20].

The Pulse Width Modulation (PWM) technique is widely utilized for the systems with lower ratings connected to the grid. Adding more, PWM can also be utilized to control the voltage source inverters which are responsible for the injection of current into grid. Total harmonic distortion is another factor which affects the power quality and according to IEEE standards 999-2000, the value of harmonic distortion must be kept up to 5%. There are numerous switching strategies and some of them are well known as unipolar pulse width modulation and bipolar pulse width modulation technique. Usually, the PWM technique helps to perform the comparison between low frequency signals and high frequency signals. Low frequency signals are of sinusoidal waveforms and high frequency signals are of triangular waveforms [21]. The Digital Unipolar pulse width modulation technique (DPWM) is widely used for grid connected photovoltaic systems [19]. Since, Voltage regulation and maximum power point tracking are major problems. Various techniques are adopted by researcher to track the maximum power of photovoltaic system. To track maximum power of the PV systems various optimization techniques are adopted by different researchers such as, perturbation and observation [22], incremental conductance [23], genetic algorithm, particle swarm optimization, ant colony, and grey wolf optimization [24].

In this paper, first, the prototype of the boost converter is designed and tested on hardware using the P &O technique and PID controller to track the maximum power on a small scale and then that circuit is fabricated with the help of a PCB design machine using eagle software. Second, the system of 2 kw has been analyzed on MATLAB/Simulink, in that system MPPT and THD are analyzed for standalone, and grid tied systems under different cases with and without the MPPT algorithm. Furthermore, in this paper, a mathematical model of the photovoltaic system and DC-DC boost converter is discussed in section 2, PID controller and P&O algorithm are discussed in section 3. Methodology is explained in detail in section 4. Meanwhile, results and discussion of this study are carried out in section 5 and section 6 concludes this research work.

2. Mathematical Modelling

2.1 Modelling of Photovoltaic System

The photovoltaic system is mainly classified into three stages. First, is the photovoltaic module which is generating DC power from the received solar irradiance, second is the DC-DC boost converter. This circuit is actually used to track the maximum power point tracking in the system and also matches the impedances of the load as well as the photovoltaic module. After that, it is connected to inverter to supply stable and maximum power to the grid. The PV grid tied system is shown in Fig. 1

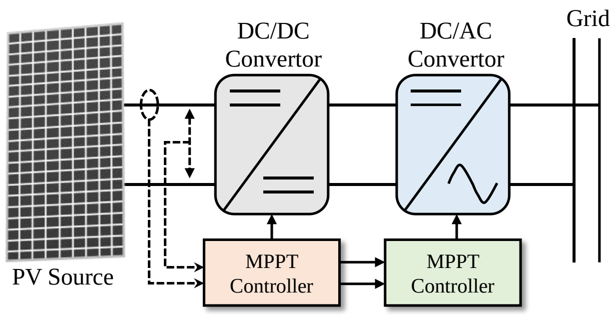


Fig. 1. Photovoltaic Grid Tied System

The photovoltaic module consists of various cells, and these are responsible to produce electrical power by the photovoltaic process. Depending upon the configuration cells are connected in series and parallel to form a module. However, a configuration of a module or cells connected with each other may vary. The equivalent circuit of the PV can be utilized as a current source generator, and it is represented in Fig. 2. It includes one series resistance (RS) and one parallel resistance (Rsh) [25]. Photovoltaic output current (Ipv) can be calculated with Eq. (1)

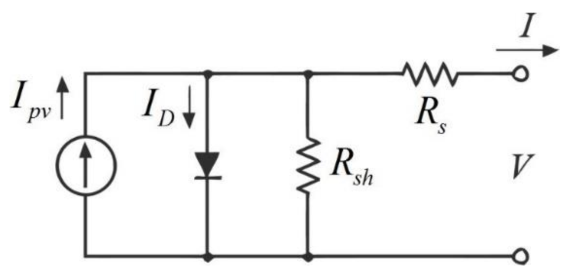


Fig. 2. Equivalent Circuit of PV Module [26]

In Eq. (1) Vpv, Iph, Ir, and p, q, K and Tj represent output voltage, photocurrent, diode reverse current, and characteristic factor, Boltzmann constant and junction temperature are constants that are used to determine diode characteristics. If the influence of RS and Rsh is neglected, then photocurrent (Iph) and short circuit current (Isc) become almost equal to each other. So, in this way Ipv can be calculated by rewriting Eq. (1) as [27] where VOC determines the open circuit voltage.

$$Ipv = Iph - Ir\left(e^{\frac{q(Vph+IpvRs)}{P*k*Tj}} - 1\right) - \frac{Vpv+IpvRs}{Rsh} \quad (1)$$

$$Ipv = Ish(1 - C1(e^{\frac{Vpv}{C2Voc}} - 1)) \quad (2)$$

In Eq. (2) C1 and C2 represents the coefficient which are calculated by taking two assumptions. The first assumption is output voltage of module (VPV) is equal to the maximum current (Im) and output voltage of module (VPV) is also equal to maximum voltage (Vm). The second assumption is when Output Current of module (IPV) is equal to zero and output voltage of a panel is equal to the open circuit voltage. So C1 and C2 are represented in Eq. (3&4) respectively.

$$C_1 = (1 - \frac{Im}{Isc}\exp(-\frac{Vm}{C_2Voc})) \quad (3)$$

$$C_2 = (\frac{Vm}{Voc} - 1)(\ln(-\frac{Vm}{C2Voc}))^{-1} \quad (4)$$

Due to various conditions, some parameters like short circuit current (Isc), maximum current (Im), open circuit voltage (VOC) and maximum voltage (Vm) may vary. So, in order to avoid these situations compensating factors such as a, b, and c are introduced in Eq. (5, 6, 7 & 8) consecutively [26].

$$Isc = Isc - ref * \frac{S}{Sref} * (1 + a\Delta T) \quad (5)$$

$$Im = Im - Iref * \frac{S}{Sref} * (1 + a\Delta T) \quad (6)$$

$$Voc = Voc - ref * \ln(e + b\Delta S) * (1 - c\Delta T) \quad (7)$$

$$Vm = Vm - ref * \ln(e + b\Delta S) * (1 - c\Delta T) \quad (8)$$

It is clear from Eq. (5, 6,7 & 8) that ΔT = T - Tre f is a change in current temperature and reference temperature (Tref) whereas Isc − ref , Voc − ref , Im − ref ,and Vm−ref are short circuit current, open circuit voltage, maximum current and maximum voltage considering reference ecological situations. However, S and ΔS = S – Sref current intensity and reference intensity respectively and e is considered as a natural constant [28].

2.2 Modeling od DC-DC Boost Converter

To accomplish the performance, maximum power point tracking (MPPT) and output voltage control of the photovoltaic system, a DC-DC Boost is often utilized. Circuit diagram of boost converter is shown in Fig. 3 Where Vin is the input voltage, Li is the inductor current, Vdc is output voltage across the load and di represents the duty cycle.

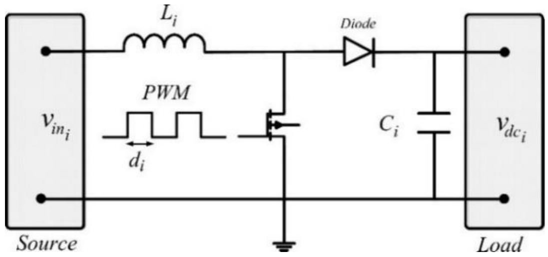


Fig. 3. Boost Converter [29]

Implying that the inductor current (iL) is continuous, the component redundant variables are overlooked. State space vector can be represented as x = [iL vC] T. Here iL and Vc are inductor current and capacitor voltages respectively. Eq. (9) shows when the transistor is on while Eq. (10) is considered when the diode is on.

$$\dot{x}(t) = A_1 x(t) + B_1 w(t) \quad (9)$$

$$\dot{x}(t) = A_2 x(t) + B_2 w(t) \quad (10)$$

Where:

$$A_1 = \begin{pmatrix} -\frac{R0}{L} & 0 \\ 0 & -\frac{1}{RC} \end{pmatrix}, \quad A_2 = \begin{pmatrix} 0 & -\frac{1}{L} \\ \frac{1}{C} & -\frac{1}{Rc} \end{pmatrix}$$

$$B_1 = \begin{pmatrix} \frac{1}{L} & 0 \\ 0 & 0 \end{pmatrix}, \quad B_2 = \begin{pmatrix} \frac{1}{L} & -\frac{1}{L} \\ 0 & 0 \end{pmatrix}$$

$$w = (vin \quad VD)^T$$

Here various parameters like R0, L, C, R, Vin and VD show the resistance of the transistor in on condition, inductance, capacitance, load resistance, input voltage, and voltage across the diode simultaneously. According to [30], the averaged state space representation of a boost converter can be represented by Eq. (11) as:

$$\dot{x}(t) = (d \times A_1 + (1-d)A_2) \times x(t) + (d \times B_1 + (1-d)B_2) \times w(t) \quad (11)$$

Here d is duty cycle/ duty ratio. Assuming u=d, Eq. (11) can be revised as

$$\dot{x}(t) = \overline{A}x(t) + \left(\overline{F}(t) + \overline{G}(t)\right)u(t) + \overline{B}w(t) \quad (12)$$

From Eq. (12)

$$\bar{A} = A_2, \overline{B} = B_2, \overline{F}(t) = (B_1 - B_2) * w(t),$$

$$\bar{G} = A_1 - A_2$$

By discrete transform technique Eq. (12) can be mo

$$x(k+1) = Ax(k) + (F(k) + (F(k) + Gx(k))u(k) + Bw(k)) \quad (13)$$

$$\mathrm{A} = \mathrm{Ts}\overline{\mathrm{A}} + 1, \quad \mathrm{F(k)} = \mathrm{Ts}\overline{\mathrm{F}}(\mathrm{k}), \quad \mathrm{G} = \mathrm{Ts}\overline{\mathrm{G}}$$

Since, two scenarios occur in the boost converter, and these are turn on and turn off as shown in Fig. 4.

The expressions for inductor current and capacitor voltage can be given by Eq. (14,15,16 & 17) respectively.

$$\frac{di_L(t)}{dt} = \frac{V_L(t)}{L} \approx \frac{V_g - V}{L} \tag{14}$$

$$\frac{dv_C(t)}{dt} = \frac{i_C(t)}{C} = -\frac{V}{RC} \tag{15}$$

$$\frac{di_L(t)}{dt} \approx -\frac{V}{L} \tag{16}$$

$$\frac{dv_C(t)}{dt} = \frac{i_C(t)}{C} = \frac{I}{C} - \frac{V}{RC} \tag{17}$$

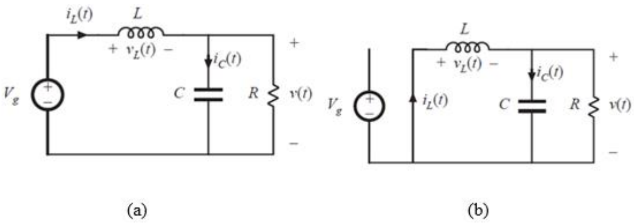


Fig. 4. Turn On (a) and Turn Off (b) Conditions In Boost Converter [30]

Proper selection of inductor and capacitor values while designing a boost converter remains one of the key concerns and Eq. (18 & 19) can be used for the value of inductor and capacitor respectively. These equations are derived from Fig. 5.

$$\Delta i_L = \frac{V_g - V}{2L} DT_S \tag{18}$$

Here,

$$L = \frac{V_g - V}{2\Delta i_L} DT_S \; C = \frac{V}{2R\Delta v} DT_S \tag{19}$$

Where,

$$\Delta v = \frac{V}{2RC} DT_S$$

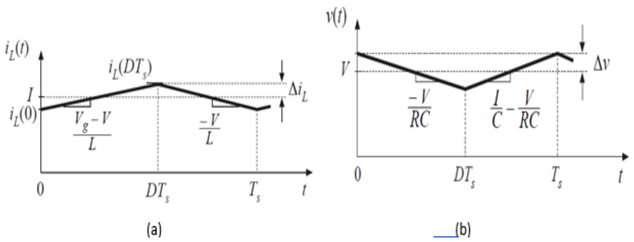


Fig. 5. Charging And Discharging Of Inductor And Capacitor During Turn On And Turn Off Conditions [30]

3. PID Controller and MPPT Algorithm

The PID controller is one of the most commonly used controllers in the area of research. Fig. 6 depicts the block diagram of a PID controller. The PID controller can be denoted by Eq. (20 & 21) [28].

$$C_{(S)} = \frac{K_D s^2 + K_P s + K_I}{s} \tag{20}$$

$$C_{(S)} = K_P + \frac{K_I}{s} + K_D s \tag{21}$$

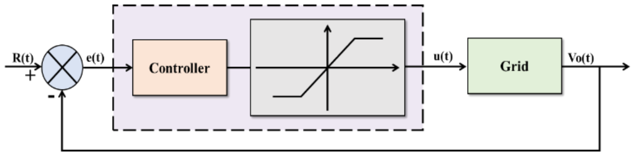


Fig. 6. PID Controller [28]

Three parameters i.e., KP, KI and KD mentioned in Eq. (20 & 21) represent proportional, integral and derivative gain. The signals e(t) as illustrated by Fig. 6 reflect the tracking generated through the difference between the referencing signals that function like input R(t) and the actual output signal represented as Vo(t). The tracked errors have been transmitted through the PID controller that evaluates the D and I of the signal produced. The output of this controller which is u(t) is applied to the grid which is equivalent to the KP times the amount of e(t) plus KI times the integral of e(t) plus KD times the gradient of e(t). In the time domain, the output signal is represented as u(t) which is applied as input to the grid as shown in Fig. 6 can be calculated by Eq. (22).

$$u(t) = K_P e(t) + K_I \int e(t)dt + K_D \frac{de(t)}{dt} \tag{22}$$

The P&O approach is developed on a study of the connection between two parameters, and that parameters are actually power and voltage. The PV aspects have been illustrated within Fig. 7, While in the Solar panels operating point seems to be on the left side of the PV characteristics (in this scenario dp always remains positive), implying that when current in the panel raises once, the photovoltaic unit current perturbation would then remain inside the identical duration in the command of the MPPs. Whenever the operating point of the panel remained on the Photovoltaic curve right side, the controller would push the Photovoltaic panel functioning point backwards, seeking for the real MPP. That may be via reversing the perturbation path [29][31][32].

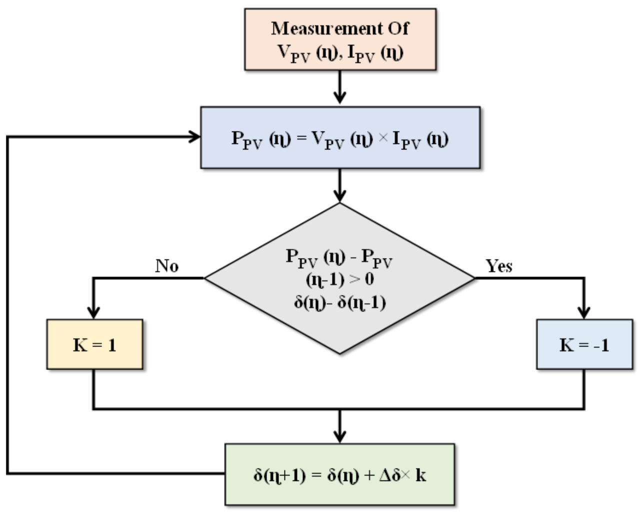


Fig. 7. Perturb And Observe Illustration

4. Methodology

4.1 Hardware Implementation and PCB Design Process for Boost Converter

The experimental setup of the boost converter with the MPPT algorithm is shown in Fig. 8. In this circuit at mega 328p has been utilized. The P&O algorithm is programmed and implemented in the Arduino Uno. Furthermore, in this setup, the Perturb & observe method is implemented to track the MPP by using a boost Converter. This Perturb & observe method calculates output voltage, and current from the PV module and then compares it with the required value and generates the duty cycle and that duty cycle is fed to the DC-DC converter i.e. Boost Converter. The input voltage is applied to the testing circuit of the boost converter which is 10 volts. It is evident from Fig. 8 that the boost converter is working properly and it is boosting the voltage by delivering 13.43V across the capacitor at the output as shown in the digital multimeter.

Table 1

Specifications of components

S.No	Component name	Ratings
1	Electrolytic Capacitor	10µf, 100µf 50V
2	Ceramic Capacitor	0.2 µf, 200V
3	Inductor	45mH
4	MOSFET IRF740	400V, 10A
5	Diode IN4007	1kV, 1A
6	Resistors	10KΩ,100Ω,0.25W
7	ATMEGA 328	8 Bit (Programable Flash)
8	Voltage Regulators 7805 CV, 7812 CV	+5V, +12V, 1A
9	Crystal Oscillator	16 Mhz
10	LED Energy Saver	12 VDC, 1A and 12W
11	Battery	12 V 7Ah, 28W
12	Voltage Sensor	25VDC

The specifications of the boost converter used for hardware setup are mentioned in Table 1. The following steps are used to design the PCB.

Step-1: The schematic of the PCB is designed on Eagle software.

Step-2: The designed schematic is routed and generates 3 files. One file belongs to the boundary of the board in which the whole circuit is printed, the second files is of components holes and the third file is of routes or paths through which current will pass.

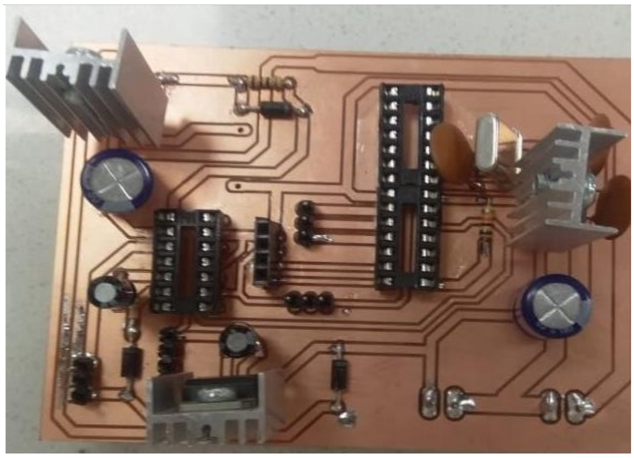
Step-3: These three files are provided to the Ultimaker device to print the designed PCB.

Step:4: The components are placed on the designed PCB and are soldered at their respective location.

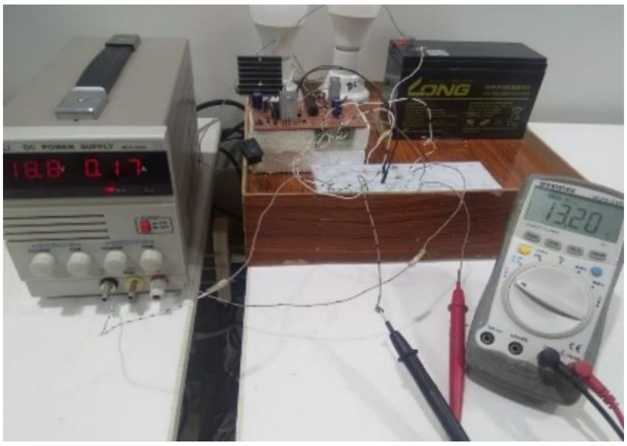
Table 2

PV panel specifications

S.NO.	PARAMETER	VALUE
1	Open Circuit Voltage (VOC)	36.7 V
2	Short Circuit Current (ISC)	8.18 A
3	Voltage at Maximum Power Point (VMP)	29.9 V
4	Current at Maximum Power Point (IMP)	7.53 A
5	No. of series connected Cells (NS)	60
6	Voltage Temperature Co-efficient	-0.132
7	Current Temperature Co-efficient	-0.04



(a)



(b)

Fig. 8. (a) PCB Design, (b) Complete Design and Hardware Setup

4.2. Software Simulation

In this research study, a system of two kilo watt is assumed for tracking the maximum power at three different irradiance levels i.e., 230 W/m2, 500 W/m2 and 1000 W/m2. The Perturb and Observe algorithm is used for MPPT purposes. Moreover, first, the comparison of power is carried out with and without MPPT algorithm, second the comparative analysis of load voltages with MPPT and without the MPPT has been done at different irradiance levels. After that, the output voltages, current, power, and harmonic distortion are analyzed with the integration of the inverter and grid. The whole analysis has been done on MATLAB Simulink and the specifications of PV panel used in the software are mentioned in table 2. The data is taken from the NASA website, and the minimum irradiance throughout the year was 230 W/m2. Fig. 9 represents the block diagram of the two-kilo watt system designed in Matlab. The Flow chart of the algorithm is shown in Fig. 10.

5. Results and Discussion

5.1 Parameters Measurement at STC

Fig. 11 shows the maximum values of voltage, current and power. It is important to note that under STC conditions the solar irradiance assumed is 1000 W/m2 and under this condition, the generated power by the PV cell is 2000W, meanwhile current produced by the panel is 8A and the maximum voltage produced is about 275V. In addition to this, at 230 W/m2, the panel is generating 2A maximum current, about 265V maximum voltage and 500W maximum power.

5.2 Performance Analysis of PV Panel with And Without Algorithm

Fig. 12 depicts the voltage, current, power and efficiency of a PV panel under STC conditions with two different scenarios. First, an input irradiance of 1000 W/m2 is applied to the panel with a load resistance of 70.3 ohms when there is no MPPT algorithm applied. Under this scenario, the maximum voltage, maximum current and power achieved is about 310V, 4.4 A and 1.36Kw consecutively. Besides, the efficiency of the PV panel calculated is 66%. After that, the MPPT algorithm is applied to the PV panel and it is evident from Fig. 12 that maximum current, power and efficiency enhances rapidly up to 7.53A, 2.055Kw and 98.7% effectively. Meanwhile small decline in the value of maximum voltage is observed and that is 273V.

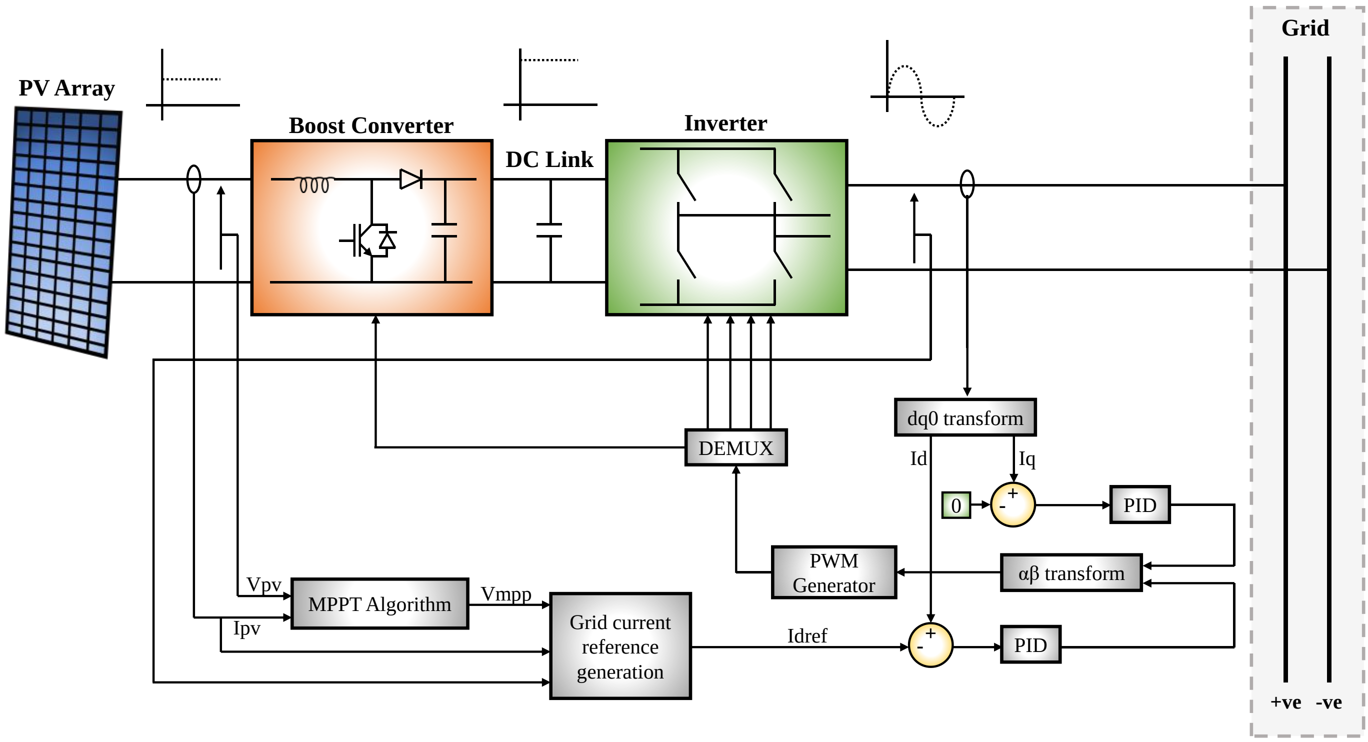


Fig. 9. PID Control Scheme for Grid Tied System

5.3 Load Power Measurement with and without algorithm

In Fig. 13 load power with MPPT and without MPPT is compared. First, MPPT algorithm is not applied at 230W/m2 from 1 to 1.5 seconds the power is about 250W and when MPPT algorithm is applied during the same period, the value of the loaded power is about 185W. So, at the start, there seems declination of power. After that when the input irradiance is increased from 230W/m2 to 500 W/m2 from 1.5 to 2.3 seconds, the loaded power without MPPT is about 1000W. However, when P&O MPPT technique is applied it takes some time of 0.8 seconds to reach the same value of power, i.e., 1000W. Hence, the difference of time is mentioned in Fig. 13. So, with the passage of time as solar irradiance enhances for both the cases up to 1000w/m2, the loaded power without MPPT is about 1330W and with MPPT it is about 2000W from 2.5 to 3.1 seconds and a difference of 770W is analysed for loaded power with MPPT algorithm.

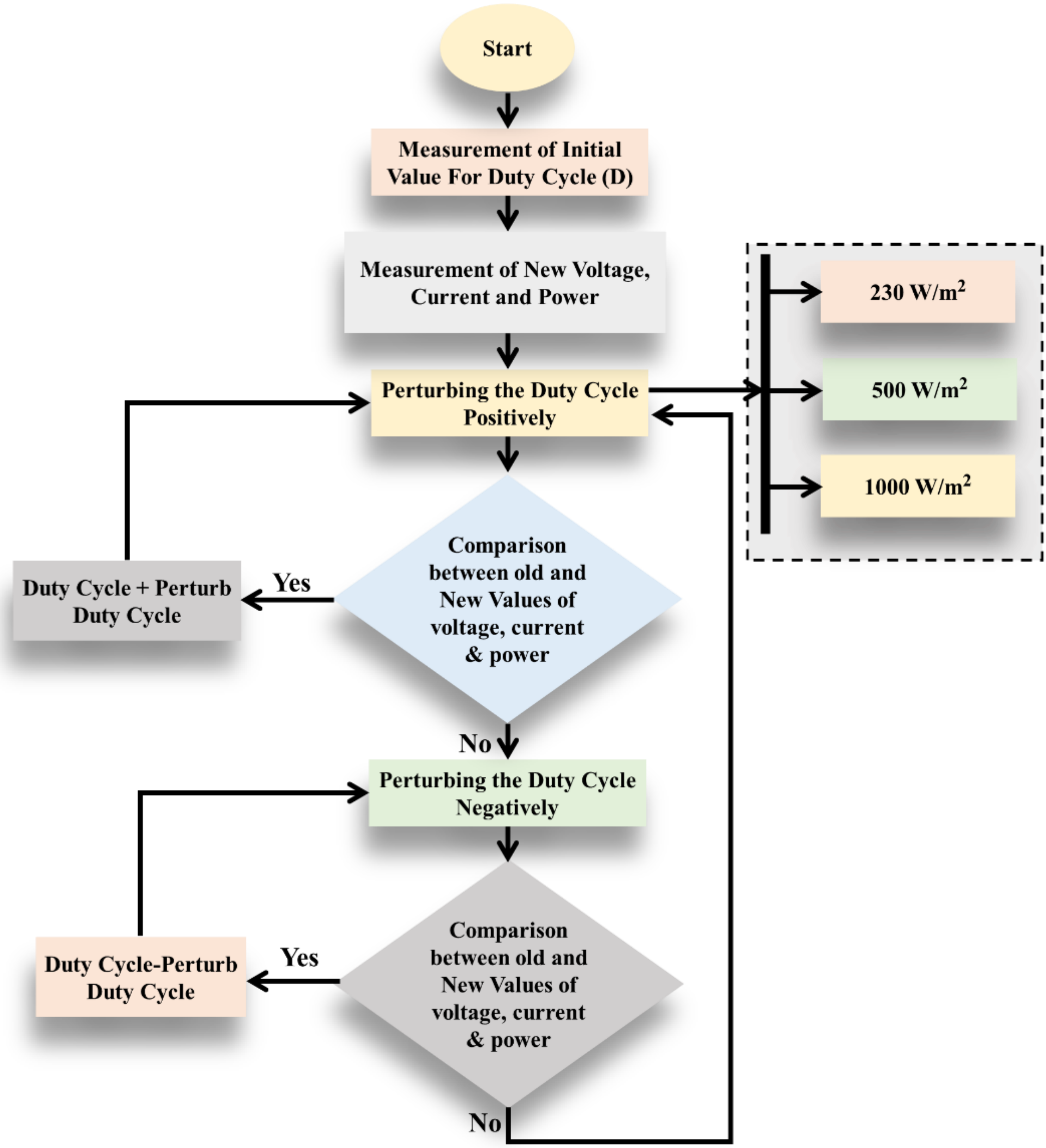


Fig. 10. Perturb And Observe Working Illustration

5.4 Comparative Analysis of Load Voltage and Load Current with And Without Algorithm

It is clear from Fig. 14 that at 230 W/m2 the load voltage without MPPT is about 140V from 1 to 1.5 seconds and the duty cycle is 50%, however when MPPT is applied the load voltage is initially low i.e. 60V. While from 1.5 seconds to 2.5 seconds the value of the load voltages with and without algorithm is about 250V at 500 W/m2 and the duty cycle is reduced to 10%.

Therefore from 2.5 to 3.1 seconds at 1000 W/m2, the load voltage without MPPT is about 300V at 30% duty cycle and with MPPT its value is enhanced and that is about 390V, as a result, a difference of 140V is analyzed. It is important to note that initially irradiance received by the PV panel is quite low i.e., 230W/m2, and with the passage of time irradiance level increases up to 1000W/m2, hence current also starts increasing with MPPT like voltage. Similarly, the initial current with MPPT is low which is 1A and it enhances up to 5.4 A and a difference of 1A is taken into account. Because without MPPT at 1000W/m2, the load current is about 4.4A.

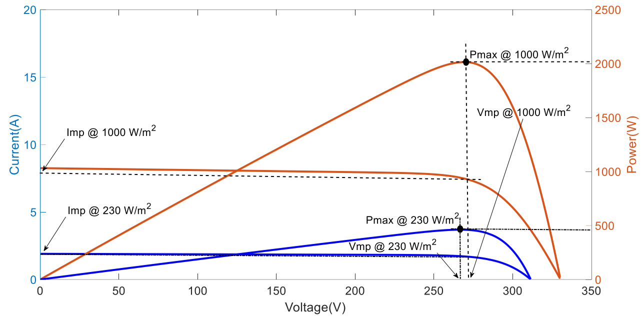


Fig. 11. Measurement Of Parameters at STC and NASA Condition

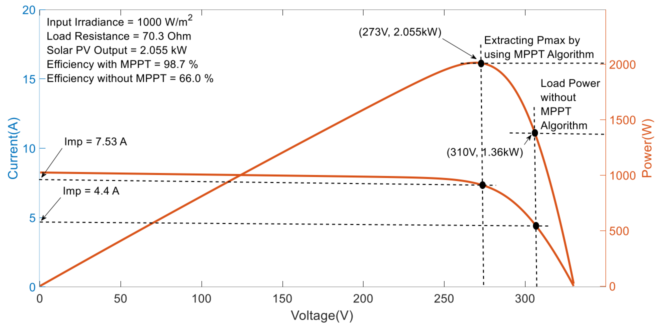


Fig. 12. Performance of PV Panel with and Without MPPT Algorithm

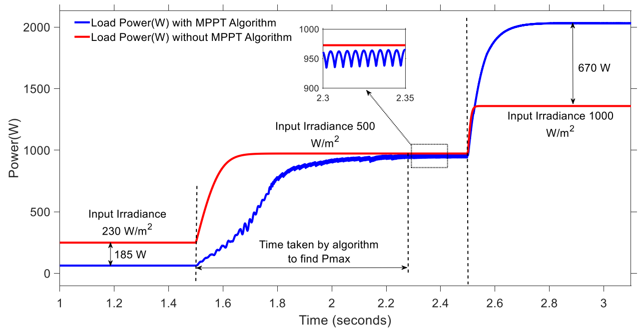


Fig. 13. Comparison Between Loaded Power with And Without MPPT

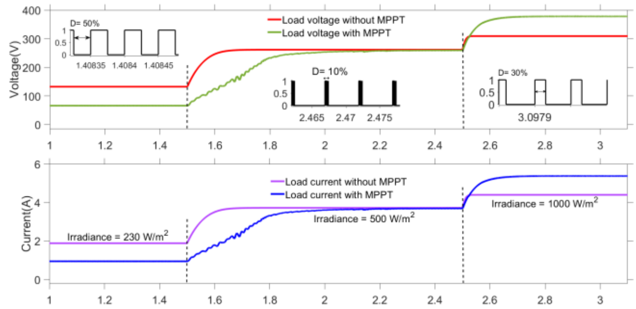


Fig. 14. Comparison of Load Voltage and Load Current With And Without MPPT

5.5 Grid Parameters at Different Irradiance Levels

It is evident from Fig. 15 that the inverter output current is also increasing with solar irradiance and time period. It is about 9A at 230 W/m^2, 16A at 500 W/m^2 and almost 30A at 1000 W/m^2. However, grid voltages are stable. But it is also important to note that continuous variation of input solar irradiance received by photovoltaic panel causes continuous variation in the voltage current and power. Due to this inverter produces harmonics at the output and it is also worthwhile to note that soar irradiance is directly proportional to the THD. This is shown in Fig. 16, at 230 W/m^2 the calculated value of THD is 22.17%, at 500 W/m^2 it declines up to 9.98% and at 1000 W/m^2, 5.04% THD is analyzed. Moreover, the current also enhances from 6A to about 26A.

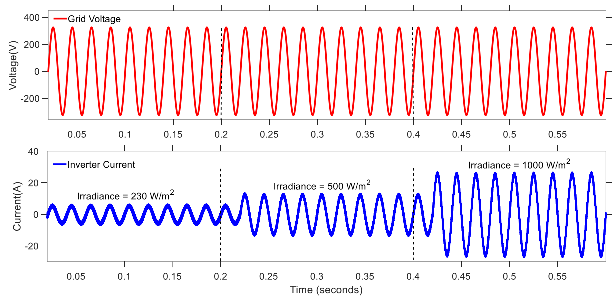


Fig. 15. Grid Voltages and Inverter Current Under Different Irradiance

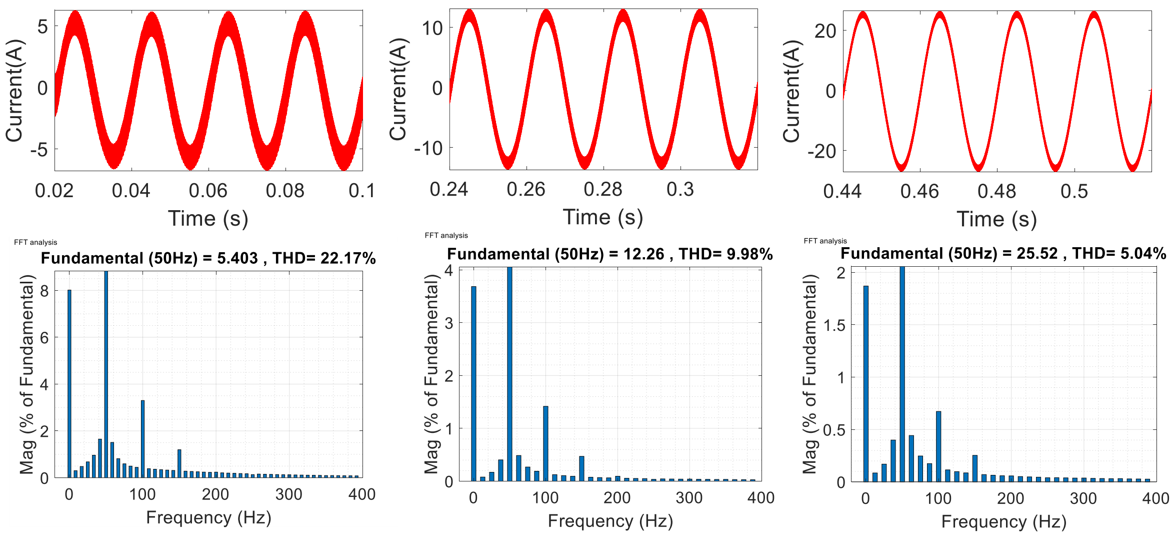


Fig. 16. Harmonic Distortion Under Different Irradiance

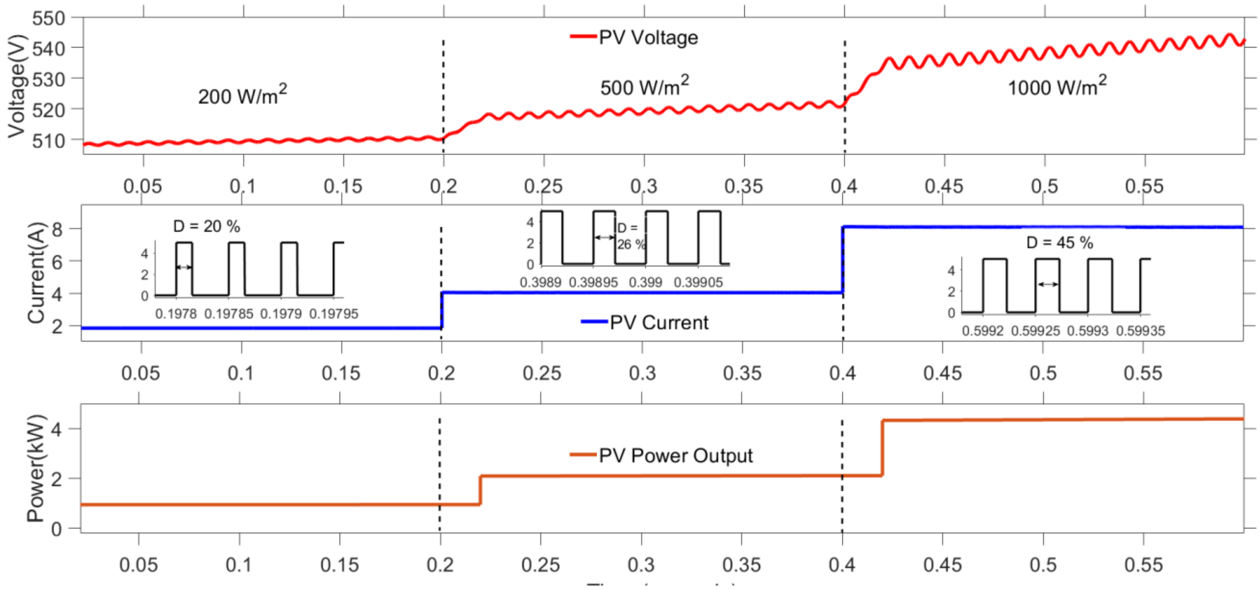


Fig. 17. Inverter Output Voltage, Current and Power Under Different Condition

5.6 Grid Parameters at Different Irradiance Levels

Fig. 17 represents inverter output voltage, current and power at three distinct solar irradiance conditions i.e., 200 W/m^2, 500 W/m^2 and 1000 W/m^2. It is analyzed that continuous variation in solar irradiance is producing oscillation and to control these oscillations and provide stable maximum power PID controller is designed. With this, the duty cycle is defined for different conditions, and it is also obvious in Fig.17 that as duty cycle is increasing from 20% to 45% then voltage, current and power starts increasing however oscillations are also mitigated and Stable output power appears.

5.7 Grid Parameters at Different Irradiance Levels

The detailed comparative analysis of various parameters at 230 W/m^2, 500 W/m^2 and 1000 W/m^2 a with various parameters is analyzed in detail in table 03. The efficiency of PV system at lower irradiance levels is suboptimal; however, as the irradiance increases, the efficiency improves and the MPPT algorithm functions effectively. According to [7], the P&O technique fails to extract maximum power at lower irradiance levels, resulting in reduced efficiency at the initial stages. The P&O technique exhibits improved performance and improved efficiency at higher irradiance levels. This limitation of the P&O technique suggests that alternative algorithms may be more effective in addressing this issue.

Table 3

Detailed comparative analysis

S.No	Parameters	Case 1 230 W/m^2		Case 2 500 W/m^2		Case 3 1000 W/m^2	
		Without MPPT	With MPPT	Without MPPT	With MPPT	Without MPPT	With MPPT
1	Load voltage	140V	60V	250V	250V	300V	390V
2	Current	2A	1A	4A	4A	4.4A	5.4A
3	Load Power	250W	185W	1000 W	1000W	1330W	2030W
4	Efficiency	12.077%	8.937%	22.222%	22.222%	14.777%	22.555%
5	Duty Cycle	50%		10%		30%	
6	Grid Voltages	330V		330V		330V	
7	Inverter Current	9A		16A		30A	
8	THD	5.403		12.26		25.52	
9	THD (Percentage)	22.17%		9.98%		5.04%	

6. Conclusion

In this study, Initially, the boost converter is tested and fabricated on PCB with a P&O algorithm to track maximum power on a small scale. After that stand-alone Photovoltaic system of 2kilo watt on a large scale is analyzed with MPPT and without MPPT algorithm under various irradiance levels on MATLAB Simulink. However, a minimum irradiance of 230 W/m2 as a reference input is taken from the NASA website. This is the minimum irradiance level that is observed in Sukkur, Sindh Pakistan in the year 2021. It was observed that without MPPT less power was transferred to the load. However, with the MPPT algorithm maximum power was extracted by the boost converter and a difference of about 670W at the output was observed. Second, Grid tied system with MPPT and PID controller was also examined. With this, it was analyzed that continuous variation in the magnitude of solar irradiance produces harmonics at the output and generates some oscillations for different conditions assumed in this research. In the end, the PID controller is designed in an outer loop to incline the performance of the boost converter and reduce the oscillations for output voltage regulation in the Photovoltaic system.

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8. Conflict of Interest

Authors do not have any conflict of interest.

9. References

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