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Design and Analysis of Modified Single P&O MPPT Control Algorithm for a Standalone Hybrid Solar and Wind Energy Conversion System

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Abstract

In this paper, a modified single P&O MPPT control algorithm for hybrid solar and wind energy system is designed and analyzed for the standalone application. The extraction of maximum power from the intermittent and erratic nature renewable energy sources are the main target in the hybrid renewable energy system. In the literature, many researchers developed an individual MPPT control algorithm for solar and wind energy system, which in turn increases the number of control algorithms in a hybrid system. The proposed single modified P&O control algorithm is implemented to extract maximum power from both the sources simultaneously. The performance of the proposed P&O MPPT control algorithm is analyzed by comparing with the conventional individual P&O MPPT control method under different weather conditions. A 560 W PV system and 500 W wind system is considered with conventional Boost converter topology for the design of the hybrid system and it is simulated in MATLAB/Simulink environment to analyze the performance of proposed control algorithm.

Nomenclature:

V_{pv}: PV panel output voltage (V)
I_{ph}: PV Cell phase current (A)
I_{PVRSC}: Reverse saturation current of PV panel (A)
G: Applied solar irradiations to the PV panel
K: Boltzman constant pf PV panel (1.38 $*10^{-23}$ J/K)
η_{PVP} : PV panel generation efficiency (%)
η : Ideality factor
V_{oc}: Open circuit voltage of PV panel (V)
P_m: Mechanical output power
λ: Tip speed ratio
ρ: Air density (Kg/m^3)
β: Blade pitch angle (degree)
P_w: Output power (W)
V_v: Wind velocity (m/s)
V_n: Rated wind speed (m/s)
V_o : output voltage
D : duty cycle
R_{sh}: Shunt resistance of single diode model (Ω)
I_{PV}: PV panel output current (A)
G_n: Nominal irradiation to the PV panel
T: Ambient temperature (K)
A_{PVP} : PV panel area (m^2)
R_{se}: Series resistance of single diode model (Ω)
q: Electron charge (1.60217$*10^{-19}$ C)
I_{sc}: Short circuit current of PV panel (A)
A: Swept area of wind blade
C_p: Rotor power coefficient
V_v: Velocity of the wind (m/sec)
V_d: Cut-in wind speed (m/s)
P_n: Nominal power (W)
V_s: Cut-off wind speed (m/s)
M : voltage transfer gain
I_o : output current

1. INTRODUCTION

In the recent years, the usage of fossil fuels like coal, gas, etc., increases rapidly due to the increase in the load demand on the power system and its effects on the environment and leads to serious problems [1-3]. Due to its non-renewable nature, fossil fuels may exhaust in the next few decades [4]. In spite of the availability of the energy sources, demand for electricity increasing day by day due to the modernization of the society. In order to meet this load demand, the best solution is the utilization of available renewable energy sources [5-8]. From the literature solar and the wind are the most promising renewable energy

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sources and its grid-tied installed capacity in India is 57% of wind source and 19% of PV source as of Feb. 28th, 2017 [9].

The power generation from the PV and wind systems will depend on the availability of solar irradiation and wind velocity respectively [10]. Due to the high penetration of renewable sources in nature, the power developed from these sources leads to intermittent and uncertain voltage. Hence, to smoothen out these fluctuations different renewable energy sources are to be integrated together with the help of power electronic converters to form a hybrid system and it requires a maximum power point tracking (MPPT) control algorithm to track the maximum available power from the high penetrating renewable sources [11]. In literature enormous number of maximum power tracking algorithms like perturb and observe (P&O), Incremental conductance, Hill climbing, Fuzzy logic controller, Neural network and hybrid based controllers are available for both PV and wind system individually, each of the tracking algorithms is having its own advantages and limitations [12-14].

P&O and Hill climbing methods are most common methods used in PV and wind system [14], due to its simple structure and easy to implement. Both the methods sense voltage and current parameters from the renewable energy sources and its works on the principle of perturbation. In P&O MPPT, voltage is the perturbation element and in hill climbing, the duty cycle is the perturbation element. By varying the perturbation element, it calculates the change in power and compares with the previous values for obtaining the maximum power from the source. But it has the limitation in the effective tracking of maximum power point under variable weather condition.

Incremental conductance method is another method used in both PV and wind system [12], due to its ability in handling the non-linearity characteristics to extract maximum power. It senses voltage and current from the renewable energy sources and tracks maximum power by finding the ratio between instantaneous conductance to the incremental conductance. It is less complex and easy to implement compared to the other available MPPTs in literature.

The fuzzy logic controller is an artificial intelligent MPPT technique for renewable energy sources [13], it is applicable to both PV and wind system. In the design of fuzzy rules, for extracting maximum power a prior knowledge of existing weather conditions is required. In order to extract maximum power from renewable energy sources through fuzzy logic controllers, it undergoes three steps i) Fuzzification, to convert real data into fuzzy data by using membership functions, ii) Fuzzy inference system, to identify the output regions and iii) Defuzzification, to convert back to the real crisp values. It is the most suitable for rapid change in environmental conditions and it effectively tracks maximum power under partial shading weather conditions compared to the other soft computing methods.

Artificial neural network is an intelligent control technique to track maximum power from renewable sources and it is developed by inspiring the biological human neuron [14]. The structure of the neural network consists of three layers, i) input layer to take input data from the renewable sources like voltage, current, irradiation, temperature and wind speed data. ii) Hidden layer for adjusting the weights of the network, the better performance is achieved by adjusting the weights of the hidden neuron layer and iii) output layer to provide output variable like duty cycle. As it requires fewer sensors, it is a cost effective method. The limitation in this method is as it requires an accurate training to track the maximum power which increases the computational burden and higher complexity in extracting maximum power.

The individual MPPT control algorithms available for both PV and wind system are listed in the above literature. In a hybrid system, as a number of control algorithms increases which increases the system complexity and implementation of the system. From the discussion, each of the MPPT algorithms has its own tracking speed and characteristics. As a result, if we use different MPPT control algorithms in a hybrid renewable energy system it creates complexity on the system. Hence authors in [15-17] develop a universal MPPT control algorithm to track maximum power from both sources with same convergence time, speed and tracking efficiency.

Even though the above universal controller applicable for both PV and wind sources to extract maximum power, it requires individually dedicated MPPT algorithms for each source, which intern increases the cost, size, complexity in implementation of the hybrid system. In order to overcome the above drawbacks, a modified single P&O control algorithm is proposed to extract maximum power from the high penetrating hybrid PV and wind renewable energy system concurrently. The proposed MPPT control algorithm is implemented in a hybrid PV and wind system of rating 560 W PV source and 500 W of wind source with conventional Boost converter topology. The simulation results are presented to validate the simultaneous power tracking capability of the modified single P&O MPPT control algorithm.

The rest of the paper is organized as follows, in Section-2, the design of hybrid PV and wind system. In Section-3, the proposed modified single P&O MPPT algorithm and in Section-4, simulation and result discussion, followed by conclusion Section-5.

2. DESIGN OF HYBRID PV AND WIND SYSTEM

A hybrid renewable energy system is designed by integrating the both PV and wind energy sources with the individually dedicated Boost converters. The basic block diagram topology of the hybrid system is shown in Fig. 1.

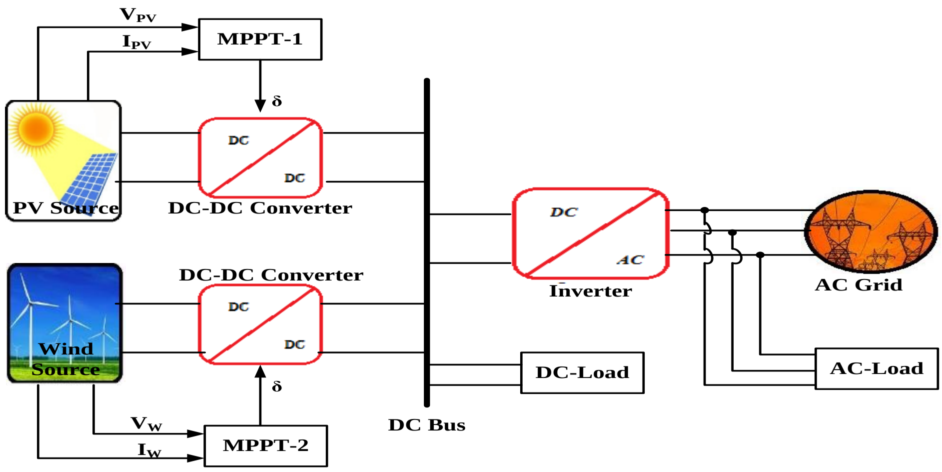


Figure 1. *Basic topology for hybrid PV and wind system*

The PV system is fed to the DC-DC Boost converter and the output of the wind system is rectified by diode bridge rectifier and then fed to the DC-DC converter. Both the sources are integrated together at the common DC link bus capacitor to make a hybrid system. The schematic diagram of the proposed hybrid energy system with modified single P&O MPPT is shown in Fig. 2. In this proposed modified P&O MPPT control algorithm, the maximum power from the both the sources (PV and wind) are extracted by executing the tracing algorithm concurrently. The modeling of PV system, wind system and design of basic Boost converter is presented in following subsections.

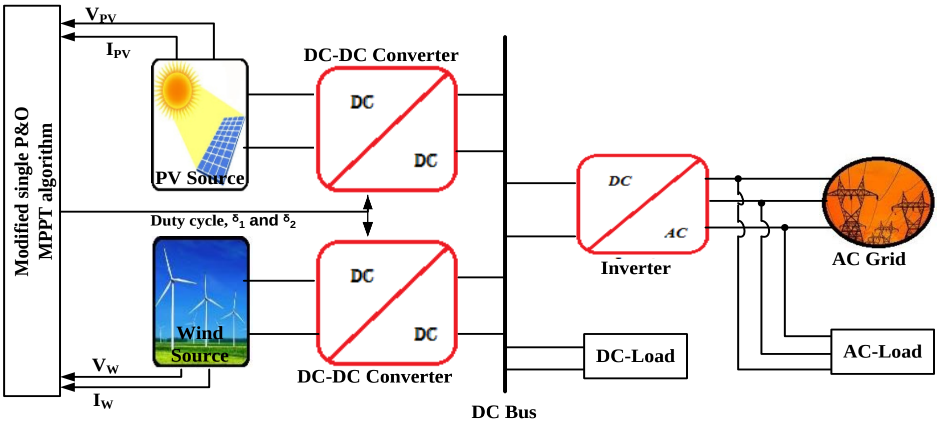
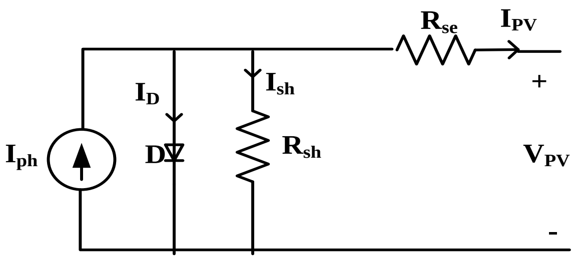


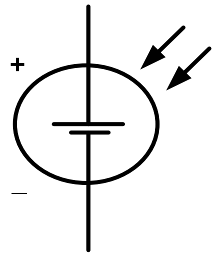
Figure 2. *Proposed topology for hybrid PV and wind system with single MPPT*

2.1. PV System

The design of PV model for making hybrid renewable energy system is presented in this subsection. A single diode model PV cell is considered as shown in Fig. 3(a) and its symbolic representation is shown in Fig. 3(b). The mathematical modeling of the PV system is derived from the basic I_{PV}-V_{PV} characteristics of PV panel.



(a)



(b)

Figure 3. *(a) PV cell single diode model equivalent circuit, (b) PV cell Symbolic representation*

The PV panel output voltage (V_{PV}) and current (I_{PV}) are derived from the basic equations Eq. (1) and (2). [18,19]

$$V_{pv} = \frac{\eta KT}{q}\ln\left(\frac{I_{ph}}{I_{pv}}+1\right) \tag{1}$$

$$I_{pv} = I_{ph} - I_{pvrsc}\left(e^{\frac{q(V_{pv}+I_{pv}R_s)}{\eta KT}} - 1\right) - \frac{V_{pv}+I_{pv}R_{se}}{R_{sh}} \tag{2}$$

The PV output power depends on the availability of solar irradiations and temperature in the environment and it is calculated by using Eq. (3) [20]

$$P_{PV} = A_{PVP} * G_n * \eta_{PVP} \tag{3}$$

The single diode model series and shunt resistances are calculated by using Eq. (4) and (5), in order to simulate the accurate I_{PV}-V_{PV} characteristics of PV panel [21].

$$R_{se} = 0.09\frac{V_{oc}}{I_{sc}} \tag{4}$$

$$R_{sh} = 11\frac{V_{oc}}{I_{sc}} * \frac{G}{G_n} \tag{5}$$

where, V_{PV}: PV panel output voltage (V)

R_{sh}: Shunt resistance of single diode model (Ω)

I_{Ph}: PV Cell phase current (A)

V_{OC}: Open circuit voltage of PV panel (V)

I_{SC}: Short circuit current of PV panel (A)

R_{Se}: Series resistance of single diode model (Ω)

η : Ideality factor

q: Electron charge (1.60217*10-19 C)

η_{PVP} :PV panel generation efficiency (%)

A_{PVP}: PV panel area (m^2)
K: Boltzman constant pf PV panel (1.38 *10-23 J/K)
T: Ambient temperature (K)
G: Applied solar irradiations to the PV panel
Gn: Nominal irradiation to the PV panel
I_{PV}: PV panel output current (A)
I_{PVRSC}: Reverse saturation current of PV panel (A)

A hybrid renewable energy system is designed by considering 560 W PV systems and its design specification of BP Solar SX3190 PV module is listed in the Table. 1.

Table 1. *Parameter Specifications BP Solar SX3190 PV Module*

Parameter Description	Rating
Maximum power (P_{MP})	560 W
Maximum current (I_{MP})	7.82945 A
Maximum voltage (V_{MP})	24.3003 V
Short circuit current (I_{SC})	8.51029 A
Temperature (T)	25^0 C
Open circuit voltage (V_{oc})	30.6021 V
Parallel strings	3
Series-connected modules per string	1
Solar irradiation (G)	1000 W/m^2

Based on the availability of solar irradiation, the corresponding I-V and P-V characteristics for BP SX3190 PV module are shown in Fig. 4. It is observed that the generated PV maximum output power will depend on the availability of solar irradiations.

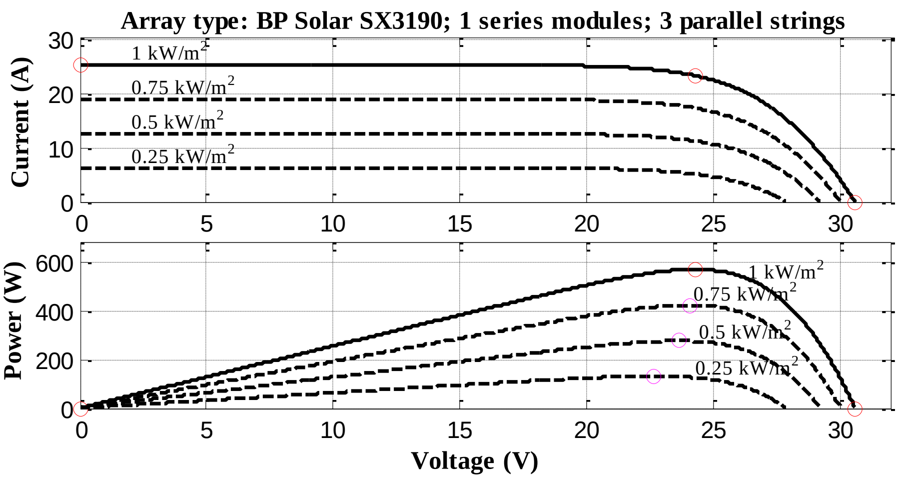


Figure 4. *BP Solar SX3190 model P-V and I-V Characteristics*

2.2. Wind Energy System

The modeling of wind energy system depends on modeling of the wind turbine and electric generator. Wind velocity is given as input to the wind turbine and it produces mechanical power as an output. The total mechanical output power produced by the wind turbine is derived from the Eq. (6) and it is a cube of the wind velocity [18,22,23].

$$P_m = \frac{1}{2}\rho A C_p(\lambda,\beta)V_v^3 \tag{6}$$

where P_m: Mechanical output power
A: Swept area of wind blade
λ: Tip speed ratio
β: Blade pitch angle (degree)
V_V: Velocity of the wind (m/sec)
ρ: Air density (Kg/m3)
C_P: Rotor power coefficient

The Aeolos-H 500W wind turbine is considered for hybrid system design and the design specifications are listed in Table 2.

Table 2. *Wind system parameters*

Description	Rating
Power (P)	500W
Impedance (R_a)	0.775 Ω
Inductance (L_q and L_d)	7.31 mH
Magnetizing flux ($Ø_m$)	0.37387 wb
Coefficient of friction (B)	0
Pair of Poles (P_P)	2
Torque/Current (T/A)	1.1216 Nm/A
Cut-in wind speed (V_d)	4 m/s
Moment of inertia (J)	0.00126811 kg/m^2
Rated wind speed (V_n)	12 m/s (26.8 mph)

The total power produced by the wind energy system is derived from Eq. (7) [19,24,25] and the characteristics of the wind turbine power generation system at different wind velocity are shown in Fig.5. It is observed that, the output wind power depends on the availability of the wind velocity.

$$P_w(V_v) = \begin{cases} P_n \dfrac{V_v^2 - V_d^2}{V_n^2 - V_d^2} & ;V_d < V_v < V_n \\ P_n & ;V_n < V_v < V_c \\ 0 & ;V_v \le V_d \, and \; V_v \ge V_c \end{cases} \tag{7}$$

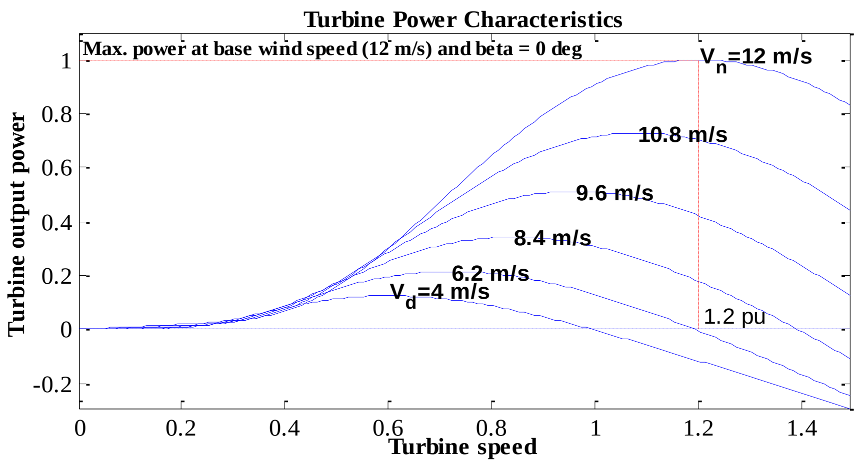


Figure 5. *Aeolos-H 500W Wind turbine power characteristics*

where, P_w: Output power (W)
V_d: Cut-in wind speed (m/s)
P_n: Nominal power (W)
V_n: Rated wind speed (m/s)
V_v: Wind velocity (m/s)
V_s: Cut-off wind speed (m/s)

2.3. DC-DC Boost Converter

The conventional DC-DC Boost converter is considered to connect the PV source and wind system to the common DC link capacitor, due to its simple structure with fewer converter components, higher conversion efficiency and capable of converting low renewable source voltage to desired value by changing the duty cycle at a higher switching frequency rate [26,27].

It consists of the single semiconductor switch (S_1), a single diode (D_1), two energy storage elements inductor (L_1) and capacitor (C_1) as shown in Fig. 6 for each source. The key principle for the operation of Boost converter depends on the inductor, L. Its output voltage is always much higher than the input source voltage [28,29]. The output voltage, current, and voltage transfer gain are given in Eq. (8), (9) and (10) respectively.

The output voltage, current and transfer gain of the Boost converter [30] are

$$V_o = \left(\frac{1}{1-D}\right)V_{in} \tag{8}$$

$$I_o = \left(\frac{1}{1-D}\right)I_{in} \tag{9}$$

$$M = \frac{V_o}{V_{in}} = \frac{1}{1-D} \tag{10}$$

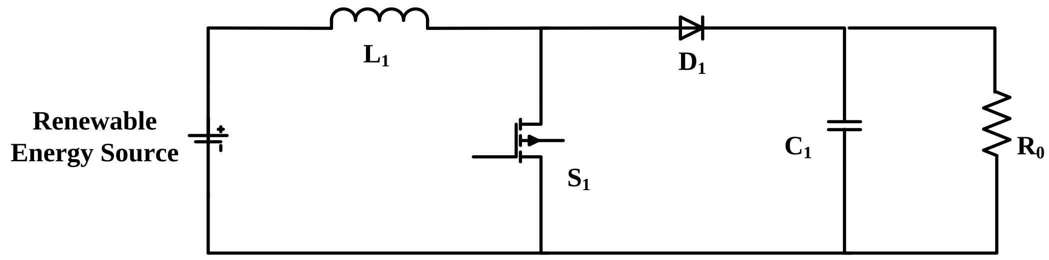


Figure 6. *Conventional Boost converter circuit*

Where, V_o: output voltage
I_o: output current
D: duty cycle
M: voltage transfer gain

The conventional Boost converter theoretical switching waveform and simulation parameters are given in Fig. 7. and Table. 3 respectively.

Table 3. *Boost converter parameter specifications*

Description	Ratings
Input voltage	$V_{in} = 24$ V
Output voltage	$V_{out} = 230$ V
Boost inductor	L = 16 e^{-3} H
DC link capacitors	C = 4.82 e^{-6} F
Load resistance	R = 97.5 Ω
Switching frequency	$f_s = 20$ kHz

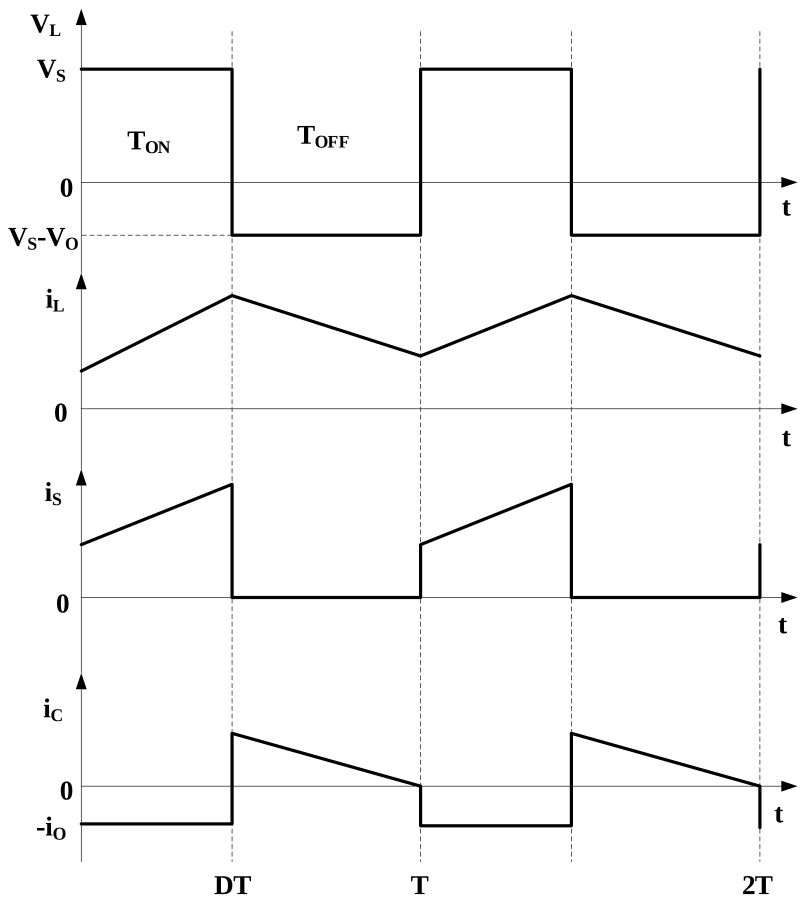


Figure 7. *Switching waveform of Boost Converter*

3. IMPLEMENTATION OF PROPOSED MODIFIED SINGLE P&O MPPT

MPPT algorithm is necessary for both PV and wind system, to yield maximum possible power from the dynamic wind speed and solar irradiation conditions. Amongst the all available MPPT algorithms in the literature, the most popular tracking algorithm is a P&O method, due to its simple structure and easy to implement [4].

The PV output power is computed from Eq. (11) as

$$P_{PV} = V_{PV} * I_{PV} \tag{11}$$

The relation between DC link voltage and PV output voltages is given in Eq. (12)

$$V_{PV} = \left(\frac{1}{1-D}\right)V_{dc} \tag{12}$$

Similarly, the Wind output power is computed from Eq. (13) as

$$P_W = V_W * I_W \tag{13}$$

The relation between DC link voltage and PV output voltages is given in Eq. (14)

$$V_W = \left(\frac{1}{1-D}\right)V_{dc} \tag{14}$$

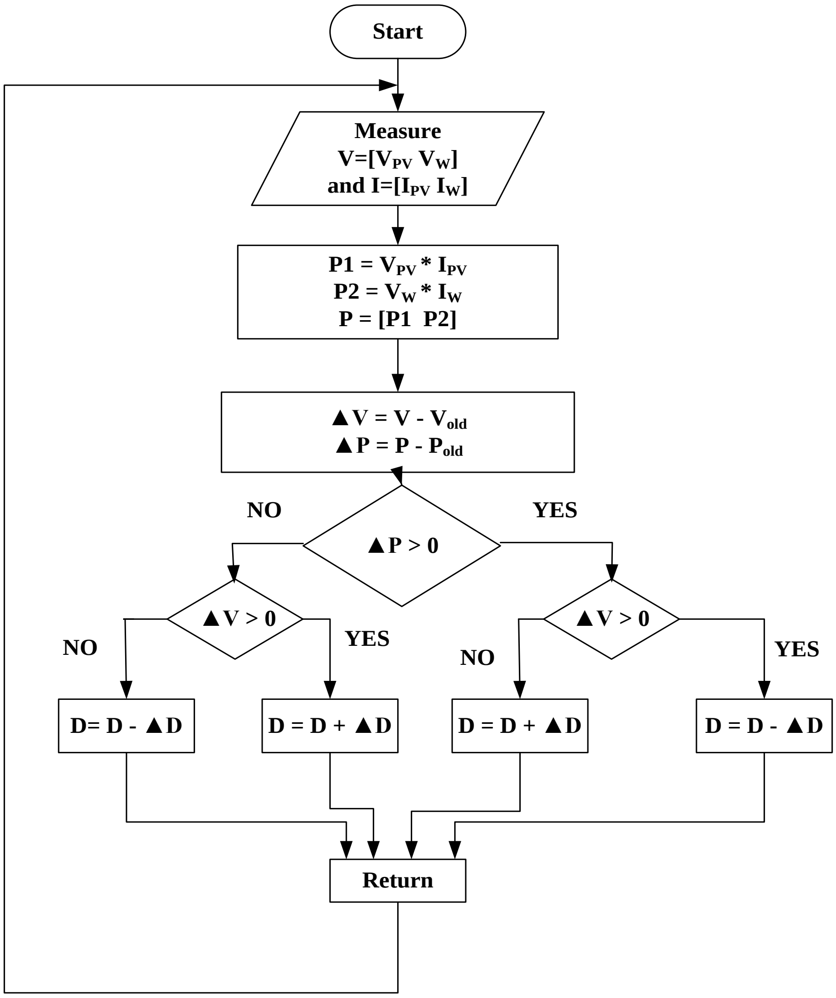


Figure 8. *Flow chart of modified P&O MPPT for hybrid system*

In this hybrid renewable energy system proposed in the paper, P&O MPPT control algorithm is considered to track maximum power from both the PV and wind energy system. So, it requires an individual P&O MPPT for each renewable energy sources, which increases the size and complexity in system implementation. Hence, this two MPPT's control algorithms are integrated together in the modified single P&O control algorithm. The flow chart for the modified single P&O MPPT control algorithm is as shown in Fig. 8. In this, the input variables for the proposed MPPT are V_{PV}, V_W, I_{PV} and I_W. The voltages of the both the sources are stored in the single voltage variable (V) in the form of a matrix and similarly, the currents are in a current variable (I) in the form of a matrix. In this method, voltage is considered as perturbing element and the output power (P) is calculated based on sensed voltage (V) and current (I) value from the renewable energy sources. The change in voltage (ΔV) and change in power (ΔP) are calculated by comparing the measured values with the previous values, to obtain the maximum power from the renewable energy source. If ΔP is positive, then it checks the ΔV value if it is also positive then it decreases the duty cycle (D) value with fixed step size (ΔD) and if ΔV is negative, then it increases D with ΔD. Similarly, if ΔP is negative, then it checks the ΔV value if it is positive then it increases the D value with ΔD and if ΔV is negative, then it decreases the D with ΔD and repeats the procedure until it reaches the maximum power point from both the PV and Wind sources concurrently and gives the corresponding duty ratios for each source.

The step by step procedure to extract maximum power by using the proposed single MPPT control algorithm from the renewable energy sources is presented.
Step-1: Start the process
Step-2: Sense Voltages V_{PV}, V_W and Currents I_{PV}, I_W for initial conditions
Step-3: Stores Voltages in [V] = [V_{PV} V_W] and current in [I] = [I_{PV} I_W]

Step-4: Calculates powers $P_{PV} = V_{PV} * I_{PV}$ and $P_W = V_W * I_W$ and stores in $[P] = [P_{PV}\ P_W]$
Step-5: Calculates change in power ΔP and change in voltage ΔV
For i=k (Maximum number of iterations)
If change in power, ΔP is positive;
If change in voltage, ΔV is positive;
Decreases the duty cycle, D = D - ΔD
Else if change in voltage, ΔV is negative;
Increase the duty cycle, D = D + ΔD
End
Else
If change in voltage, ΔV is positive;
Increase the duty cycle, D = D + ΔD
Else if change in voltage, ΔV is negative;
Decreases the duty cycle, D = D - ΔD
End
Step-6: Update V(k−1)=V(k); I(k−1)=I(k)
Step-7: End
Step-8: Stop the process

4. SIMULATION AND RESULT DISCUSSION

To inspect the suitability of modified single P&O MPPT, a hybrid PV and wind system with conventional Boost converter is considered and simulated in the MATLAB/Simulink environment.

4.1. PV System with Boost Converter and P&O MPPT

As reported in Table. 1, A BP Solar SX3190 PV Module has been used for the construction of hybrid renewable energy system. The basic PV system with Boost converter along with dedicated P&O MPPT control algorithm is implemented in MATLAB/Simulink model as shown in Fig. 9. The inputs to the P&O MPPT controller are V_{PV} and I_{PV} and it gives the corresponding variable duty cycle to extract maximum available power from the renewable PV source.

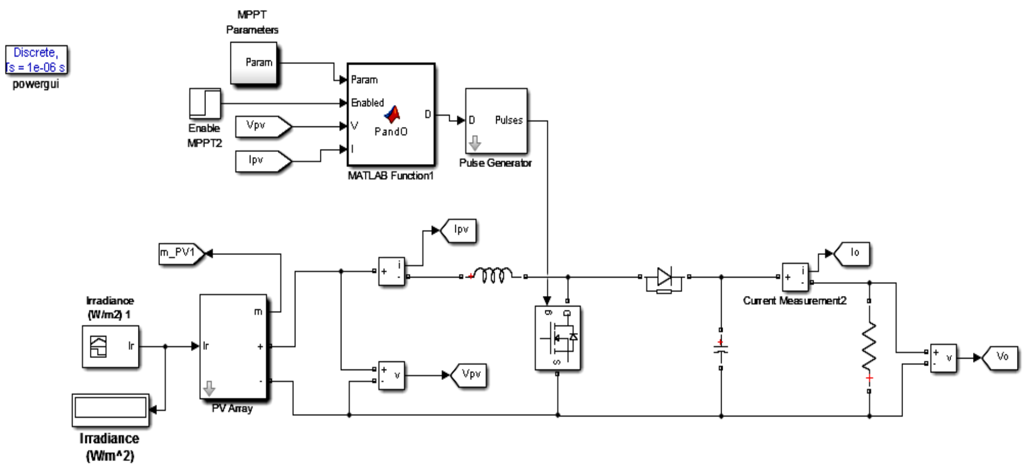


Figure 9. *Simulation of PV system with Boost converter and P&O MPPT*

The availability of solar irradiation of the proposed system are considered as follows: G= 600 W/m^2 for a period of 0 to 0.3 sec, G= 800 W/m^2 for a period of 0.3 to 0.6 and G= 1000 W/m^2 for a period 0.6 to 0.9 by assuming 40%, 20% and 0% shading effect on the solar irradiation respectively as in Fig. 10.

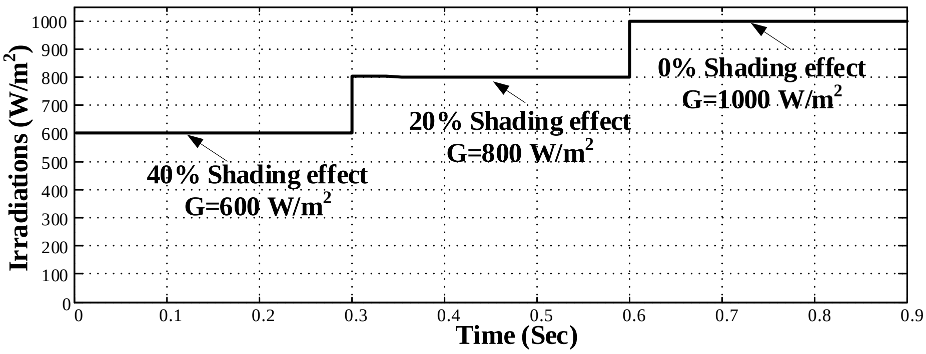


Figure 10. *Considered solar irradiation pattern*

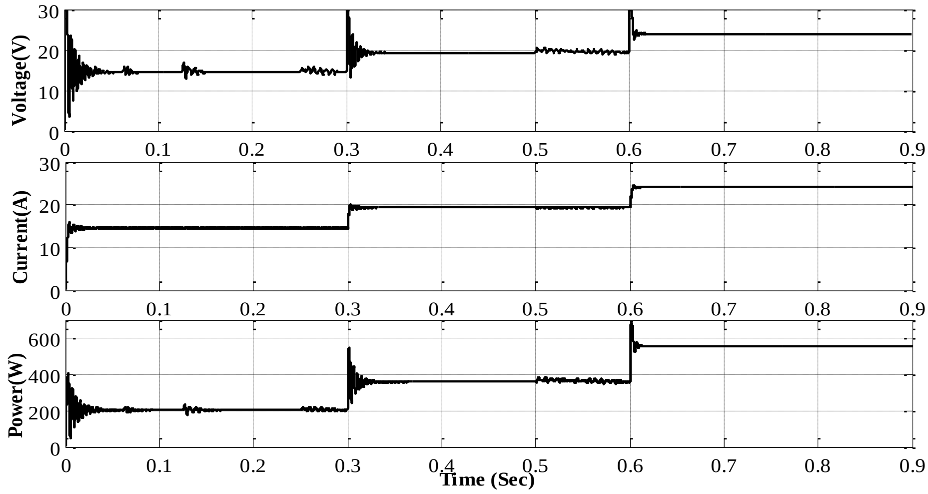


Figure 11. *PV panel output voltage, current, and power at different irradiation levels*

The PV panel output voltage, current and power waveforms are shown in Fig. 11, as per the consideration of available solar irradiation. PV system with Boost converter output voltage, current, and power are shown in Fig. 12. The summary of PV system with the Boost converter output voltage, current, and power at different irradiations are listed in Table. 4, it gives average power of 232 W for a period of 0 to 0.3 sec (with PV 600 W/m^2), 391 W for a period of 0.3 to 0.6 sec (with PV 800 W/m^2) and 558 W for a period of 0.6 to 0.9 sec (with PV 1000 W/m^2). It is observed that based on the availability of solar irradiations corresponding output voltage, current and power are obtained and we achieved a maximum average power of 558 W for a period of 0.6 to 0.9 as the solar irradiation availability is 1000 W/m^2, which is the rated solar irradiation for the PV system.

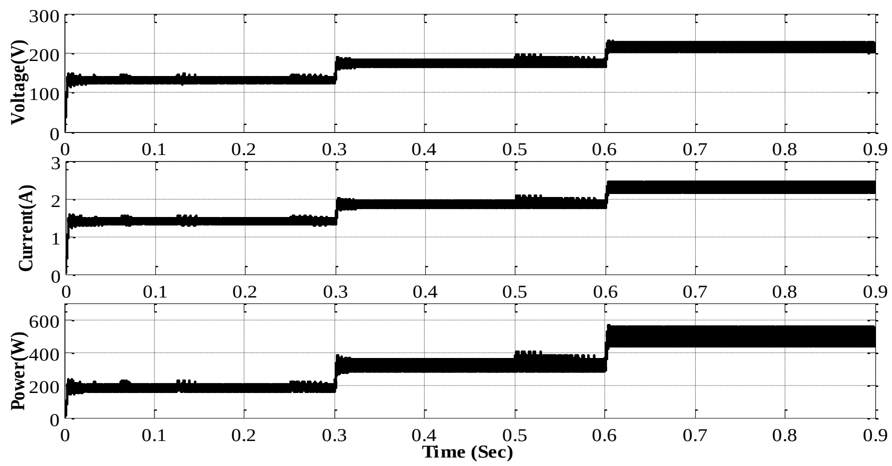


Figure 12. *Boost converter output voltage, current, and power*

4.2. Wind system with Boost Converter and P&O MPPT

A 500 W wind system as reported in Table. 2, is implemented in Matlab/Simulink model with dedicated P&O MPPT control algorithm as shown in Fig. 13. It takes V_W and I_W as input variables for P&O MPPT system and produces the corresponding variable duty cycle for obtaining the maximum power from the renewable wind energy source.

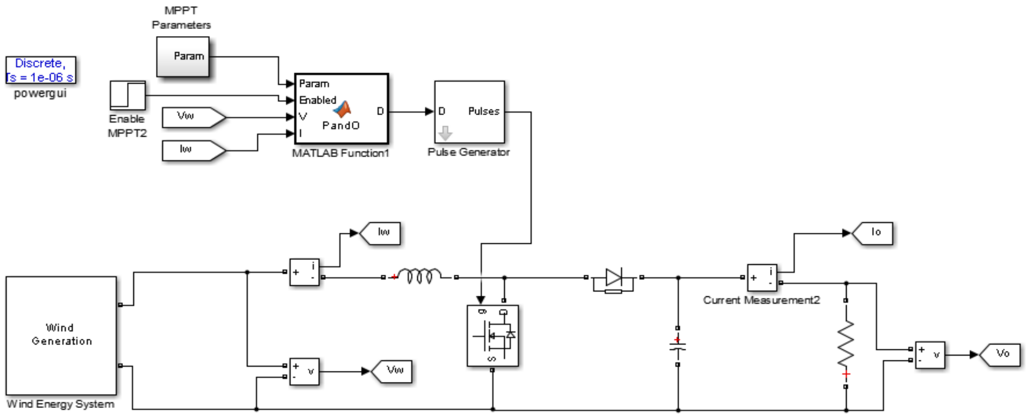


Figure 13. *Simulation of Wind system with Boost converter and P&O MPPT*

The availability of the wind velocity data for the developed system are considered as follows for a period 0 to 0.3 sec as 8 m/s, 0.3 to 0.6 sec as 10 m/s and for the period 0.6 to 0.9 sec as rated wind speed 12 m/s as clearly shown in Fig. 14.

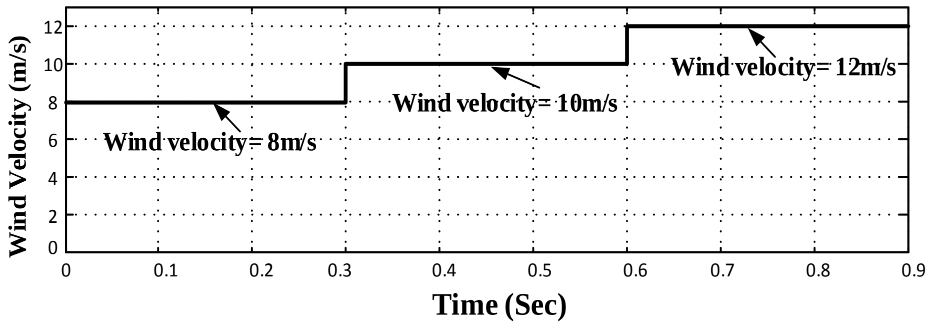


Figure 14. *Considered wind velocity data pattern*

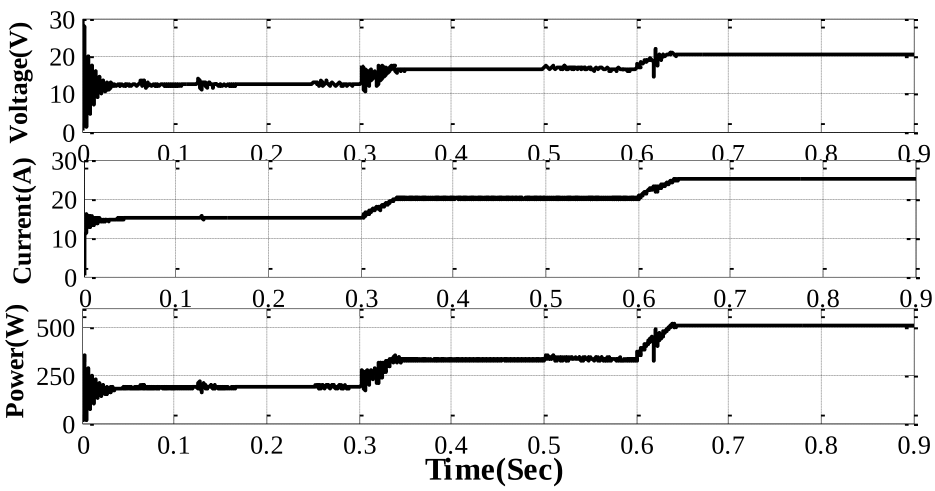


Figure 15. *Wind system output voltage, current, and power at different wind velocity levels*

Fig. 15 shows the wind system output voltage, current and power waveforms as per the consideration of the availability of the wind speed data. The wind system with the boost converter output voltage, current, and power are shown in Fig. 16. The summary of wind system with the Boost converter output voltage, current, and power at different wind speed are listed in Table. 4, it gives average power of 190 W for a period of 0 to 0.3 sec (with wind 8 m/s), 373 W for a period of 0.3 to 0.6 sec (with wind 10 m/s) and 494 W for a period of 0.6 to 0.9 sec (with wind 12 m/s). From the table, it is observed that the wind system output voltage depends on the availability of wind speed and we obtain a maximum average power of 494 W during the period 0.6 to 0.9 as the available wind speed is 12 m/s, which is the rated wind velocity for the wind system.

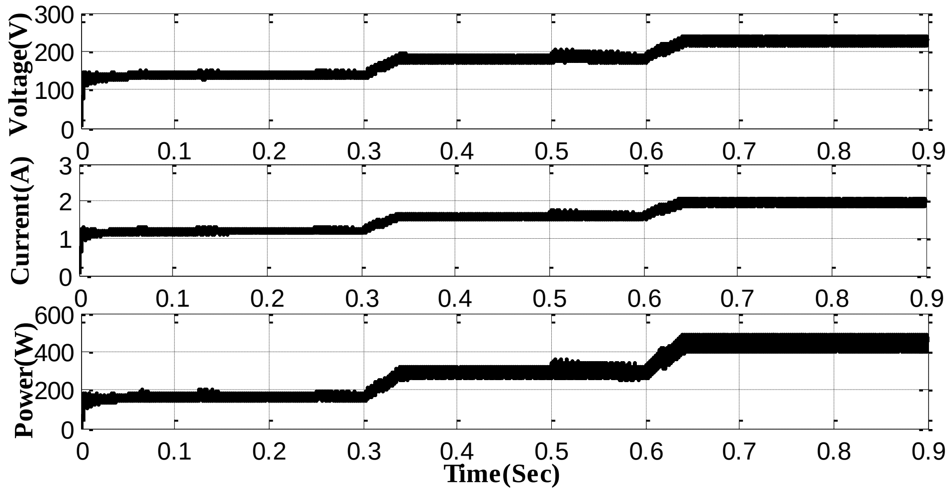


Figure 16. *Boost converter output voltage, current, and power*

4.3. Hybrid PV and Wind System with Common Modified Single P&O MPPT

The Simulink model of the hybrid PV and Wind system with individual Boost converter along with the modified single P&O MPPT control algorithm is shown in Fig. 17. The V_{PV}, V_W, I_{PV}, and I_W are the input parameters to the proposed control system which in turn gives specific corresponding duty cycle based on the requirement.

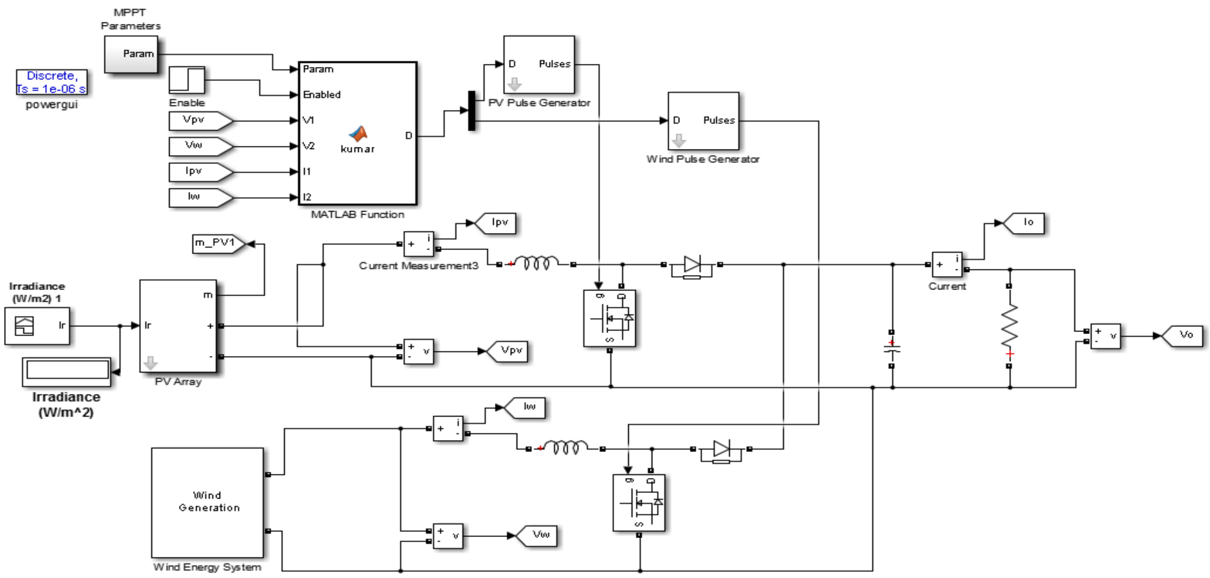


Figure 17. *Simulation of hybrid PV and wind system with modified single P&O MPPT technique*

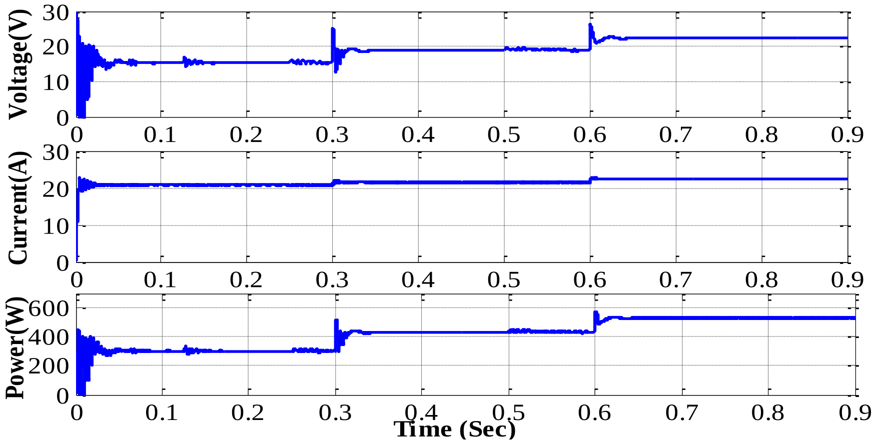


Figure 18. PV panel output voltage, current, and power at different irradiation levels

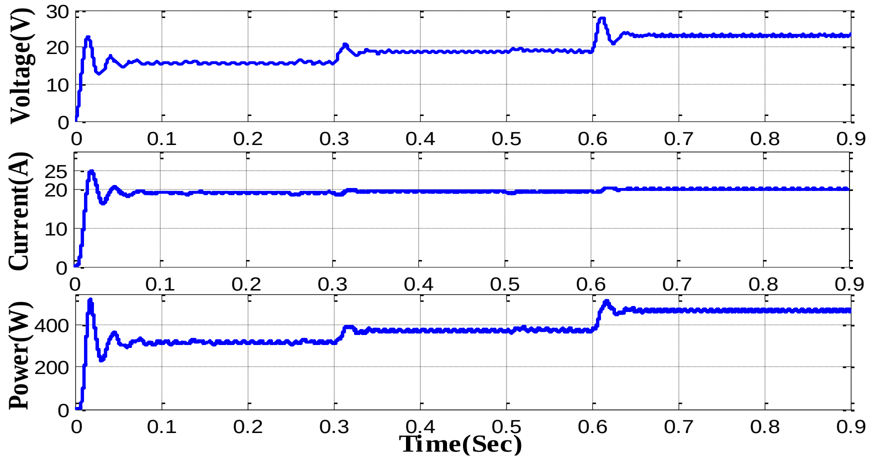


Figure 19. *Wind system output voltage, current, and power at different wind velocity levels*

Fig. 18 and Fig. 19 show the output voltage, current, and power of PV and wind sources respectively. The hybrid PV and wind system output voltage, current and power waveforms as per the consideration of available input data from each source are shown in Fig. 20. It gives the maximum of power 837.4 W for duration 0.6 to 0.9 sec as each of the sources is available at its rated capacity. Table 4 shows the results obtained from the PV system, wind system and a hybrid PV and wind system with proposed single P&O MPPT at three different time regions with available solar irradiation and wind velocity data. It gives a maximum average power of 837.4 W for a period of 0.6 to 0.9 sec as the availability of the sources is at its maximum limit.

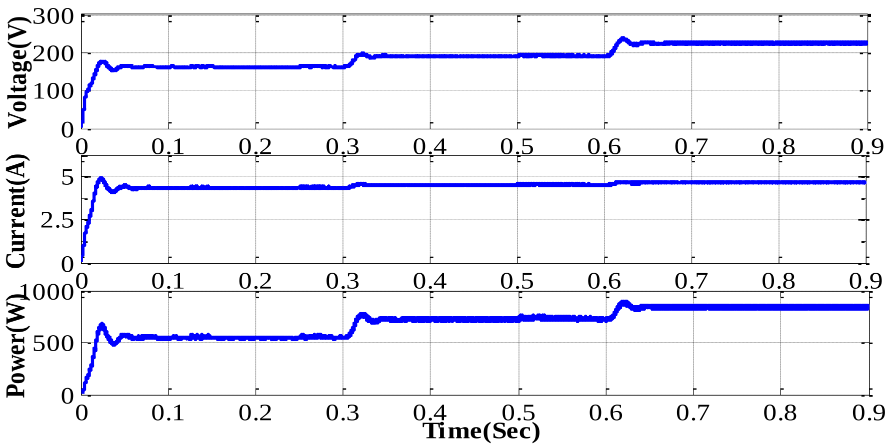


Figure 20. *Output DC link capacitor voltage, current, and power*

Table 4. *Output obtained from PV, wind and hybrid renewable energy systems*

	PV system= 560 W, Output			Wind system= 500 W, Output			Hybrid PV and wind system with modified single P&O MPPT		
Period (Sec)	0 to 0.3	0.3 to 0.6	0.6 to 0.9	0 to 0.3	0.3 to 0.6	0.6 to 0.9	0 to 0.3	0.3 to 0.6	0.6 to 0.9
Input weather data	Solar irradiations (W/m^2)			Wind velocity (m/s)					
	600 W/m^2	800 W/m^2	1000 W/m^2	8 m/s	10 m/s	12 m/s			
Voltage (V)	14.4	19.2	24	15.8	19.6	24	158	194.8	229
Current (A)	21.3	22.1	22.4	19.3	19.2	20.1	3.56	3.62	3.65
Power (W)	308	425.6	537.6	305	376	484	563	705.2	837.4

5. CONCLUSION

A single modified P&O MPPT control algorithm was presented for hybrid PV and wind system. The various MPPT methods available in the literature for extracting maximum power in the hybrid system are discussed. The modified single P&O MPPT control algorithm is implemented in hybrid renewable energy system consists of 560 W PV system and 500 W wind system with a basic Boost converter to track maximum power from both the sources concurrently. The performance of the developed MPPT is analyzed by considering the change in solar irradiations and wind speed data with respective time. The simulation results are validated with individual MPPT for each (PV and wind) source. The proposed MPPT technique is implemented for a hybrid system which comprises only one MPPT technique for both the solar and wind source. The developed hybrid system with single modified MPPT gives the average power 563 W for a period of 0 to 0.3 sec (with PV 600 W/m^2 and wind 8 m/s), 705.2 W for a period of 0.3 to 0.6 sec (with PV 800 W/m^2 and wind 10 m/s) and 837.4 W for a period of 0.6 to 0.9 sec (with PV 1000 W/m^2 and wind 12 m/s). From the results obtained, it can be stated that the proposed MPPT technique reduces the complexity of the overall system and extracts maximum available power from the hybrid solar and wind system.

CONFLICTS OF INTEREST

No conflict of interest was declared by the authors.

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