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Efficient maximum power tracking technique in grid connected PV-wind system

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A R T I C L E I N F O

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A B S T R A C T

The sustainable energy resources are considered to generate the power without consumption of fuel. From that, the Photovoltaic (PV) and Wind Turbine (WT) are selected because of advantages such as pollution free and low computational cost. In the sustainable energy source, the partial shading is a main issue in the generating power. In literature, some of the methods are reviewed and it is not provided efficient results. This paper develops a design and analysis of the hybrid system with a DC-DC converter controlled by hybrid approach. This hybrid approach is a combination of Adaptive Neuro Fuzzy Interference System- Honey Badger Algorithm (ANFIS-HBA) for extracting maximum power and power compensation. The hybrid system is designed with PV and WT for compensating load demand in the grid side. The main objective of the proposed methodology is to extract the maximum power of the system (PV and WT). The proposed methodology is executed in the MATLAB and performances are evaluated with the performance metrices. The proposed method is achieved efficient results which concluded with the comparison analysis such as Adaptive Neuro Fuzzy Interference System -Genetic Algorithm (ANFIS-GA) and ANFIS- Particle Swarm Optimization (PSO) at various partial shading conditions. The proposed method is achieved the efficient maximum tracking in PV and WT systems under partial shading conditions.

1. Introduction

Due to the dramatic rot of petroleum products, sustainable energy sources are the main choice to satisfy the urgent interest in energy which focuses on PV, WT, power device, geothermal and many other environmentally friendly energy inventions [1]. Between each standard source, the improvements in PV and air are highly encouraging as a direct result of the green, easy access, pollution reduction and environmentally friendly nature. The current PV / wind structure has a very low conversion capacity as a result of the strange and fluctuating behavior of solar radiation and wind speed [2]. PV board and wind turbine yield mainly depend on the factors involved, for example, radiation level, temperature and wind speed. In this way, there is an urgent need for more Maximum Power Point Tracking (MPPTs) to get peak power from the PV board and wind turbine. MPPT complements a non-linear nature of a PV / air structure and is an effective innovation to combat vulnerability [3].

The PV board and wind turbine are connected using a normal dc bus and structure using a hybrid energy system [4]. The power generated from the hybrid energy system is incredibly factorial to the radiation level and wind speed. In these ways, the control calculation for MPPT and inverter control should be reasonable for the best current extraction and high current injection for lattice integration under factor environment changes [5]. There are some MPPT control calculations, for example, hill climbing, incremental conductance and perturb and observe (P&O)used by experts to get the best power out of the PV board and wind turbine. The importance of sustainable energy sources as opposed to ordinary petroleum products is illustrated. The constant energy discovery of PV and wind relies on the flying and fluctuating behavior of sunlight-based radiation and wind speed. In addition, the MPPT calculation defeats the nonlinear and fluctuations and vulnerabilities of the PV / wind turbine structure [6].

These MPPT techniques have the problems of a dynamic unique reaction and constant state oscillation problem and are incapable of following the maximum power when the natural state is inconsistent [7]. Scientists have developed intelligent sophisticated processing based on various MPPT techniques such as genetic algorithm (GA), neural network (NN), and fuzzy logic controller (FLC). FLC, GA and NN strategies for intelligent MPPT controllers, individually, are restricted to the use of hybrid PV/WT integrated framework, based on the largest fluffy

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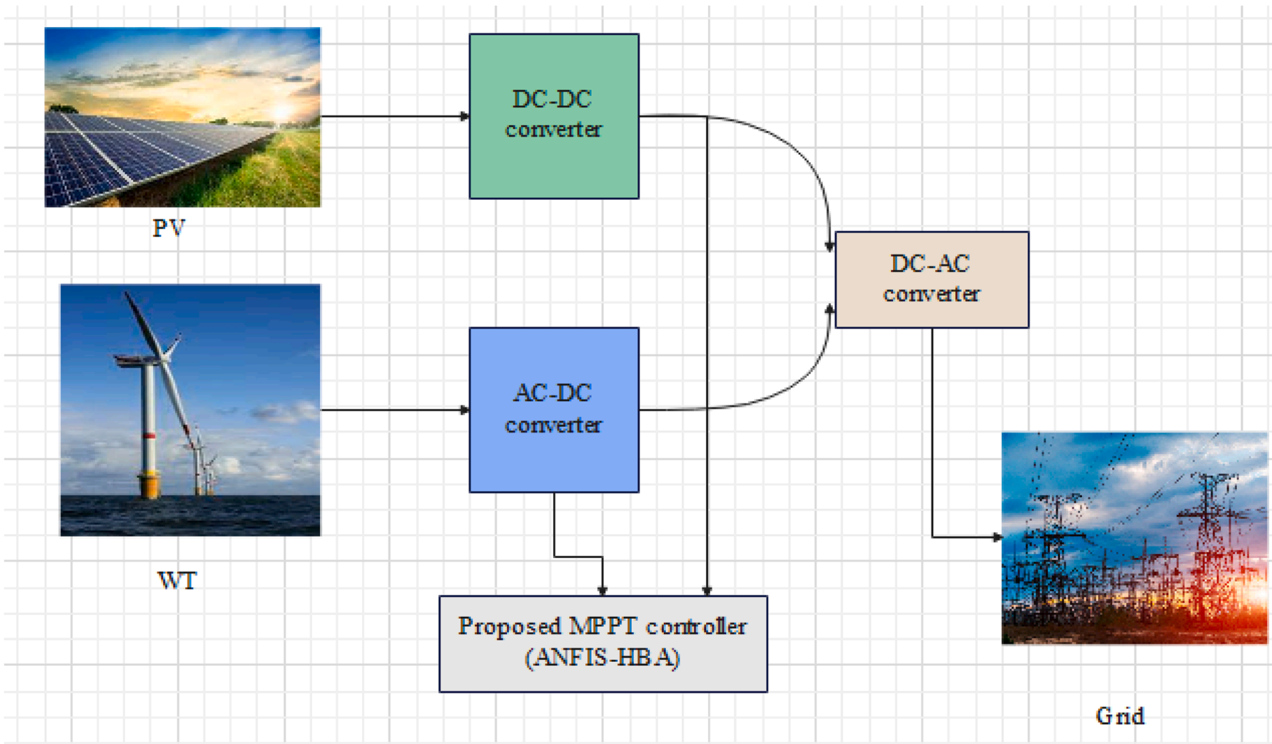

Fig. 1. Proposed System Model.

deduction rule [8], the largest size of the population and a few products information. These techniques give a decent display under the conditions surrounding the factors; however, the PV is incapable of following the Maximum Power Point (MPP) when a different maximum is found in the curve [9,10].The maximum power point should be extracted efficiently in PV/wind system. Hence, efficient method will be developed in this paper.

2. Literature Review

In this section, the related works of the MPPT technique in PV/wind system are reviewed.

Ait Kaki Lamia Ghanima *et al.,* [11] have introduced a research experiment on disconnected composite structures (photovoltaic and wind battery stock) to meet the demand for energy used in open space (2000Wh / day / day) in Constantine-Algeria. For a test, March and April 2018 in the long run was considered. This study explored another method to find out how the MPPT charge regulator (FLEX max60) controls the energy applied to batteries powered by the sun to reduce the use of conventional sources. Since then, the proposed framework has been re-implemented under HOMER (star x64); the control process was carried out on an experimental basis and the results introduced showed that the cross-ethnic structure was achieved regardless of atmospheric conditions.

A. S. Mahdi *et al.,* [12] have introduced the MSX-64 PV module and boost DC-DC converter for entertainment and to demonstrate the MPPT structure. This work presents a presentation of those three types of MPPT strategies, a partially concealing example and revealing that the profile of real weather conditions is obscure and obscure. These MPPT strategies were analyzed as energy dissipation, MPPT efficiency, rising time, ability to follow global MPP and reaction to volatile climate. The reproducible effects of subtle figuring MPPT practices demonstrate the ability to mimic MPP during incomplete concealment situations. Furthermore, the reaction to weather conditions changes when shady actual weather conditions are applied to the structure.

Muhammad Hamza Zafar *et al.,* [13] have introduced two multitude insight (SI) based novel MBPD techniques in specific marine predator algorithm (MPA) and mayfly optimization algorithm (MFA). These procedures overcome the previously mentioned drawbacks. This article presents three cases: specific rapid fluctuating radiation, incomplete hiding conditions, and complex half-hiding conditions. The merging season was upgraded to 45% and efficiency above 99.9% was seen as proposed. The movements are reduced to 1W with a drastic decrease in power misfortune. Faster MPPT, lower computational power and higher efficiency are the primary components of the proposed practices.

Cristian Napole *et al.,* [14] have presented fuzzy logic method which could be accomplished through MPPT, which was being tested because it required a complex project because the solar-powered energy oscillates over the course of the day. The PV used in this study gave a low-end voltage and, as a result, a lift converter with a non-straight control regulator was carried out to reach a reasonable end-applied voltage. The primary commitment of this test is an ingenious MPPT technique that is integrated with a fuzzy logic controller (FLC) to obtain the maximum power from the PV board in the light of the voltage reference estimator (VRE). This design was implemented on the d Space 1104 board for the Business PV board PEIMAR SG340P.

Carlos Munoz *et al.,* [15] have introduced a control process for injecting power from a photovoltaic power plant into a power structure via a two-stage voltage source inverter two-level-type (VSI-2L). This calculation combines current-based optimal power point-following (current-based MPPT) with model precise control (MPC) technology, allowing the use of PI regulators to be avoided and reducing the reliability of high-capacity capacitors. Portions of this paper depict pieces of the structure, control calculations and reflection and test results that allow understanding the behavior of the proposed technique.

Lucas Gao KingChai *et al.,* [21] have presented a Particle Swarm Optimization based Fire Works Algorithm (PS-FW) for managing MPPT in PV system. This algorithm was utilized to empower the extracting maximum power tracking from the PV panel. Vasantharaj Subramanian *et al.,* [22] have presented a fuzzy logic MPPT method for a DC microgrid with the consideration of variable atmospheric behaviour. This technique also utilized to extracting the maximum power from the PV

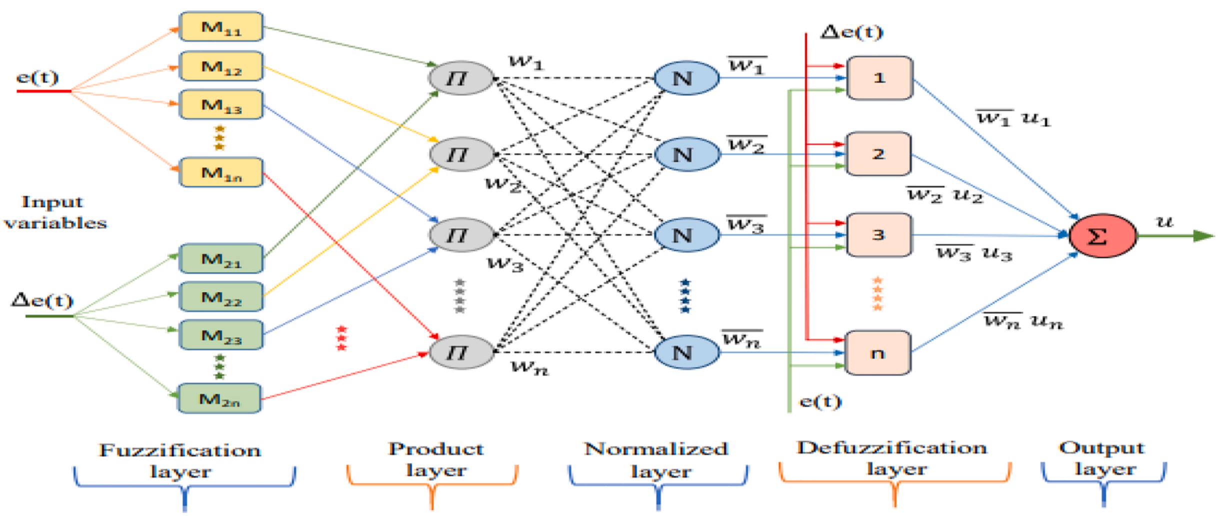

Fig. 2. ANFIS structure.

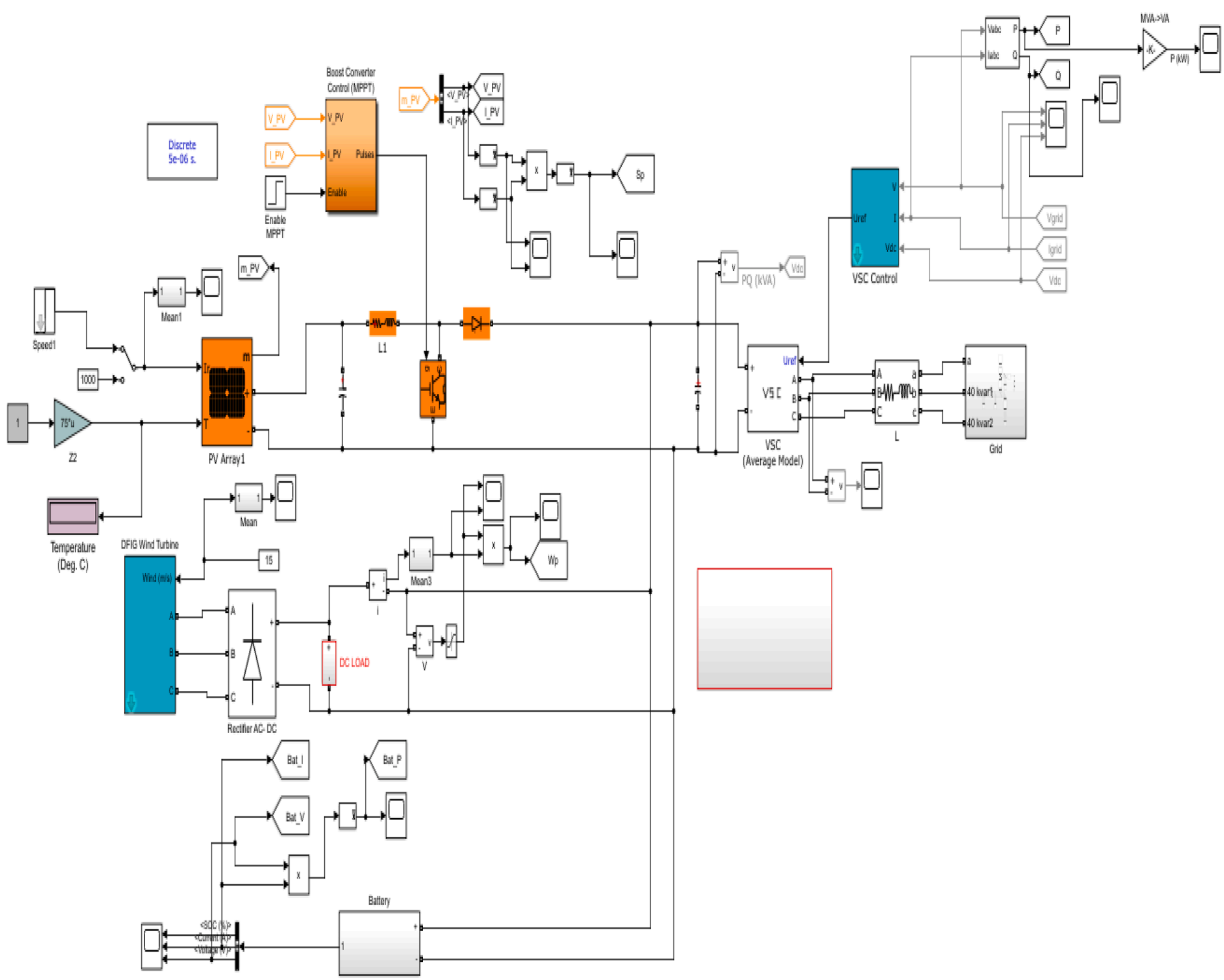

Fig. 3. Simulink diagram of the proposed methodology.

system. This paper was analyzed with different PV partial shading conditions.

3. Proposed System Model

In this paper, the ANFIS based HBA has been developed to extract the maximum power of the hybrid PV/Wind system. In this ANFIS, the HBA

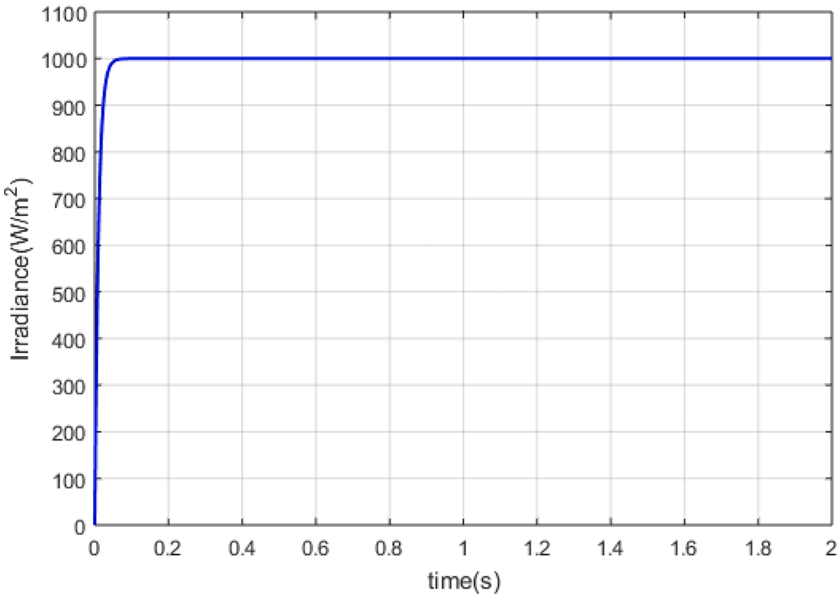

Fig. 4. Irradiance of PV system.

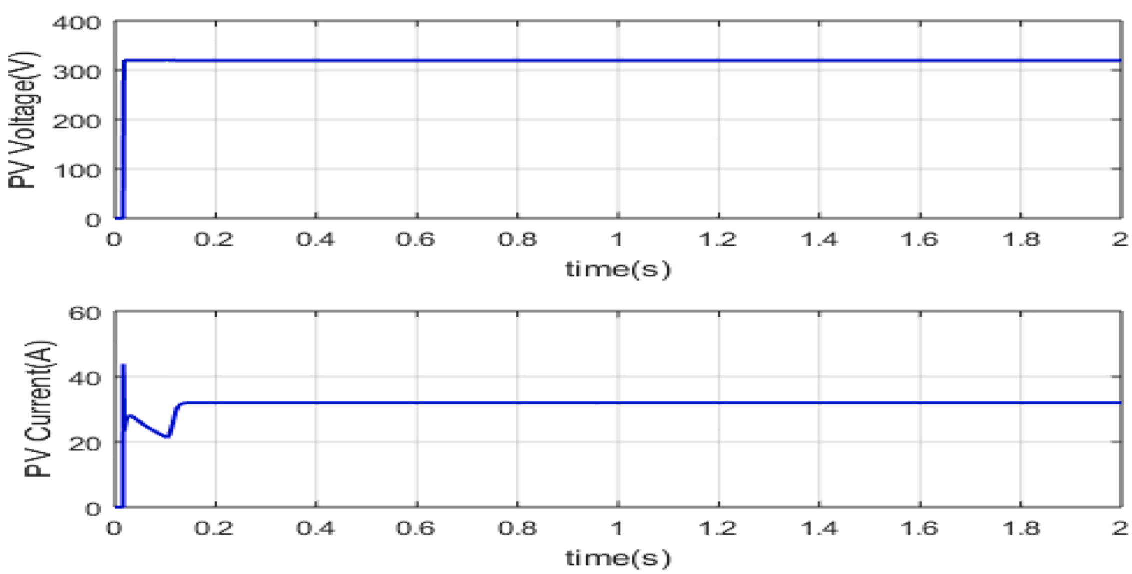

Fig. 5. PV voltage and current.

is utilized to select optimal training system. This proposed methodology is utilized to extract the maximum power from the PV/Wind system. The proposed methodology is utilized to enable high tracking performance, and compute MPP and fast convergence speed because of low computational burden and simple design structure. The pulse width modulation (PWM) pulses are selected with the consideration of hybrid approach. The hybrid approach is utilized to select efficient duty ratio to the power switch of bidirectional dc-dc converter. Additionally, this hybrid PV/Wind is connected with the utility grid which is a required requirement of the MPPT control system. Recently, the grid connected system with hybrid PV/Wind is an essential design for meeting the required load demand. The complete proposed architecture is illustrated in Fig. 1.

Initially, the PV and wind turbine is connected with the converter to boost the input generated power. The PV and wind turbine may be affected because of its partial shading conditions. Hence, the efficient MPPT technique is developed in this paper. The detail description of the proposed methodology is presented in the following section.

3.1. Modelling of PV system

The PV is utilized to generate the power to meet load demand. The PV cell current source is interconnected with the diode with anti-parallel that is generated by using PN junction. The generated power is depending on the irradiation and temperature [16]. V-I characteristic is analyzed with the consideration of using below equation,

$$i_{pv} = i_{sh}\left[1 - k_1\left(e^{v_{pv} - \frac{dv}{k_2} \times v_{open}} - 1\right)\right] + di \tag{1}$$

$$k_1 = \left(1 - \frac{i_{max}}{i_{sh}}\right) e\left(-v_{max} / k_2 \times v_{open}\right) \tag{2}$$

$$k_2 = \frac{\left(\frac{v_{max}}{v_{open}} - 1\right)}{ln\left(1 - \left(\frac{i_{max}}{i_{sh}}\right)\right)} \tag{3}$$

$$di = i_{ph} - i_{sh} \tag{4}$$

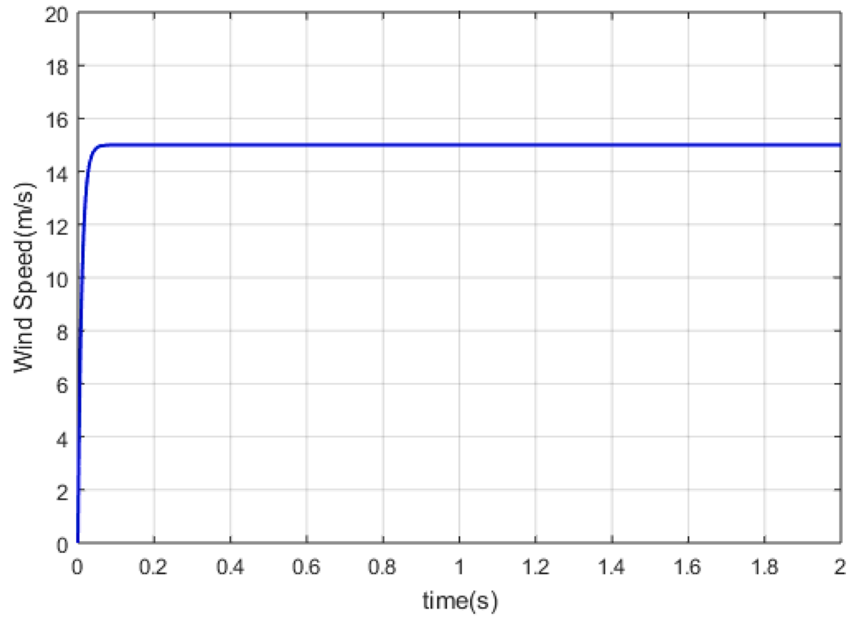

Fig. 6. Wind speed.

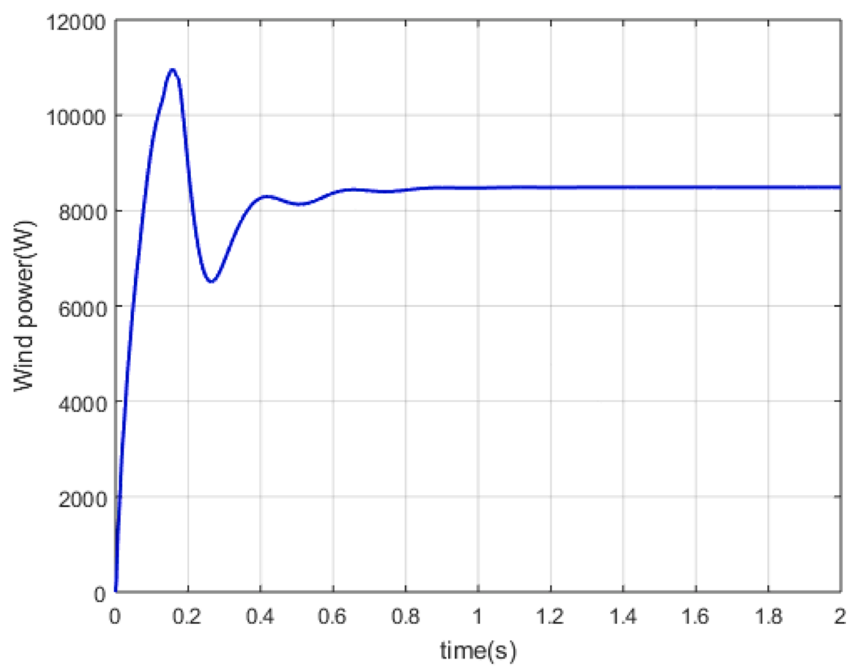

Fig. 7. Wind power.

Where,i_{max} can be considered as the maximum current, v_{max} can be considered as maximum voltage, v_{open} can be considered as open circuit voltage, i_{pv} can be described as PV current, i_{sh} can be considered as short circuit current.

3.2. Modelling of WT system

In the wind turbine, the mechanical power is generated and it is also utilized to compensate load demand. The generated power is formulated as follows,

$$P_{Mech} = \frac{1}{2} c_p(\lambda, \beta) \rho_{a.D} A t V^3 wind \tag{5}$$

$$P_{WT} = \frac{1}{2} A t \rho_{a.D} A t V^3 wind \tag{6}$$

$$TSR(\lambda) = \frac{\omega R_{Rotor}}{V_{wind}} \tag{7}$$

$$c_p(\lambda, \beta) = c_a \begin{bmatrix} \frac{c_b}{\lambda_j} \\ -cc \times \beta \\ -c_d \end{bmatrix} e^{\left(\frac{c_b}{\lambda_j}\right)+c_f\lambda} \tag{8}$$

$$\frac{1}{\lambda_j} = \frac{1}{(\lambda + 0.08\beta)} - \frac{0.035}{1 + \beta^3} \tag{9}$$

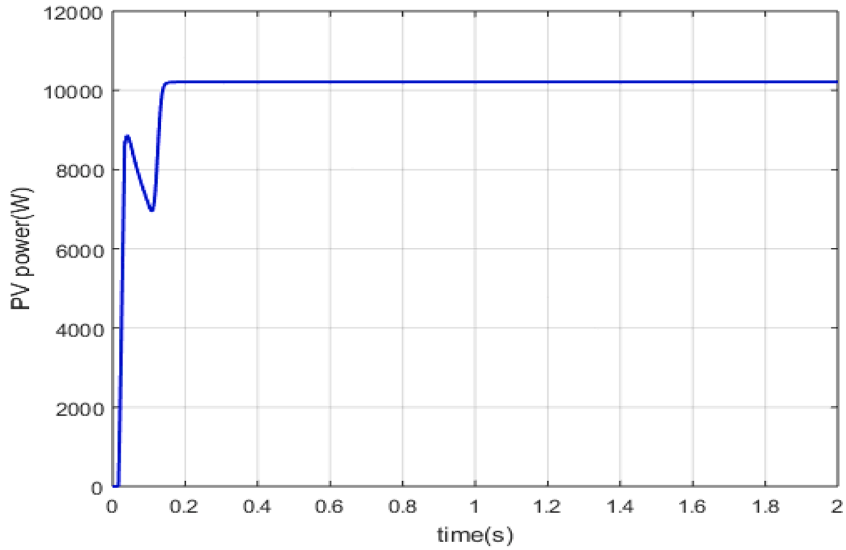

Fig. 8. PV generated power.

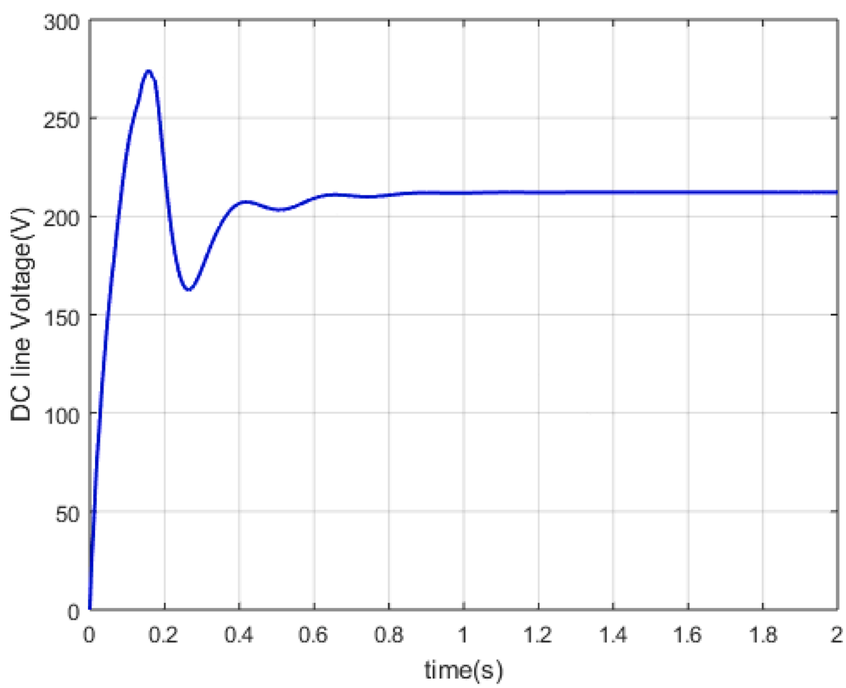

Fig. 9. DC link voltage.

$$At = \pi(R_t)^2 \tag{10}$$

Where, V_{wind} can be described as wind speed, $\rho_{a.D}$ can be described as air density, R_t can be described as turbine blade radius, β can be described as pitch angle, c_p can be described as the power coefficient,ω can be described as angular speed, R_{Rotor} can be described as radius rotor.

3.3. Bidirectional DC-DC converter

Recently, the DC-DC converter is utilized for different applications. MPPT algorithm we utilized in the DC-DC converter to extract the maximum power from PV panels. This converter is compared the output voltage of the PV and reference voltage. The error voltage is reduced by selecting optimal pulses of DC-DC converter [17]. The mathematical formulation of the DC-DC converter is formulated as follows,

$$Z_{source} = \frac{v_i}{I_i} \tag{11}$$

$$V_o = \frac{V_i}{(1-d)} \quad 0 < d < 1 \tag{12}$$

$$I_i = \frac{V_0}{(1-d)} \tag{13}$$

$$Z_{source} = \frac{v_o}{I_0}(1-d)^2 = z_o(1-d)^2 \tag{14}$$

Where, d can be described as the duty cycle xero and one (null implies which MOSFET is off condition and MOSFET is on condition).

$$Z_{source} = Z_{MPP} \tag{15}$$

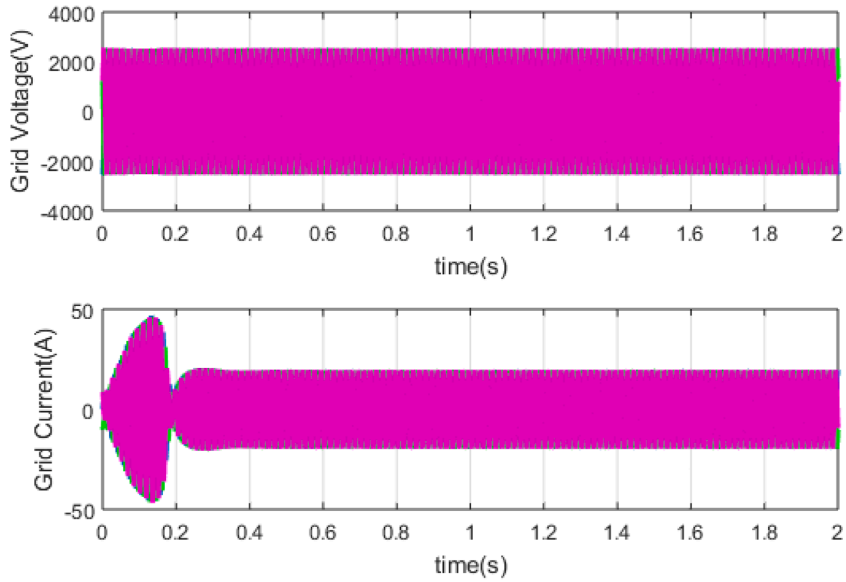

Fig. 10. Grid voltage and current.

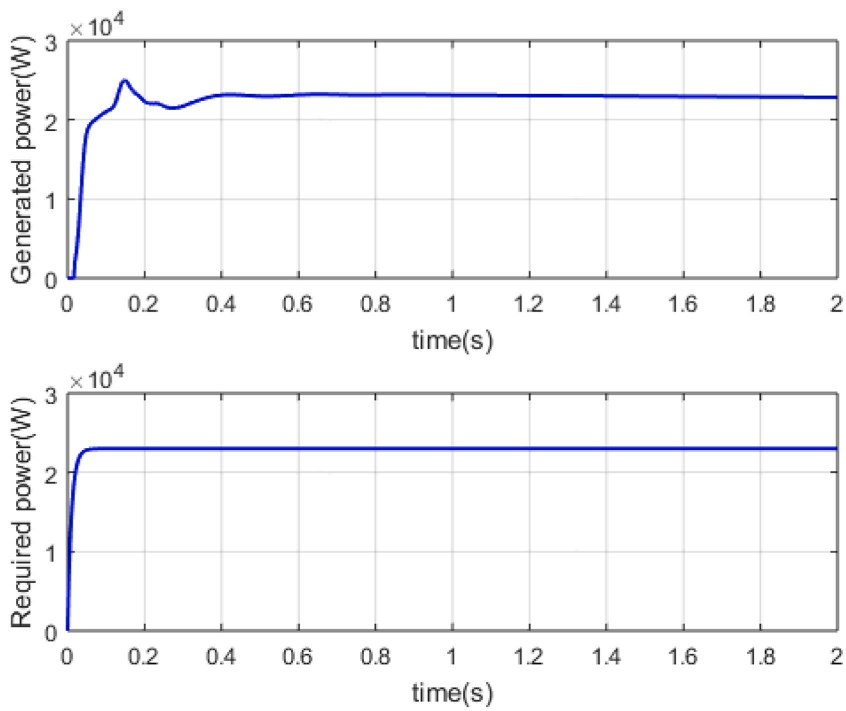

Fig. 11. Total generated and required power.

$$Z_{MPP} = \frac{V_{MPP}}{I_{MPP}} \tag{16}$$

After that, the duty ratio is changed and presented as follows,

$$D = 1 - \sqrt{\frac{Z_{MPP}}{Z_0}} \tag{17}$$

The hybrid PV/WT is designed for compensating load demand in the grid side. The hybrid system may be affected by partial shading condition. Hence, the proposed controller is developed to manage the partial shading condition in hybrid PV/WT system. The detail description of the proposed controller is explained in the below section.

4. Proposed Controller

In the proposed methodology, the hybrid approach is utilized to select optimal pulses of the DC-DC converter which managing the power demand in grid side. In the ANFIS, the weight parameter is selected with the help of HBA.

4.1. ANFIS

After simulating the hybrid PV/Wind module, the specifications data is collected for training the ANFIS during original weather profile and partial shading pattern. To attain training information during a non-shaded weather condition, the process can be simulated offline

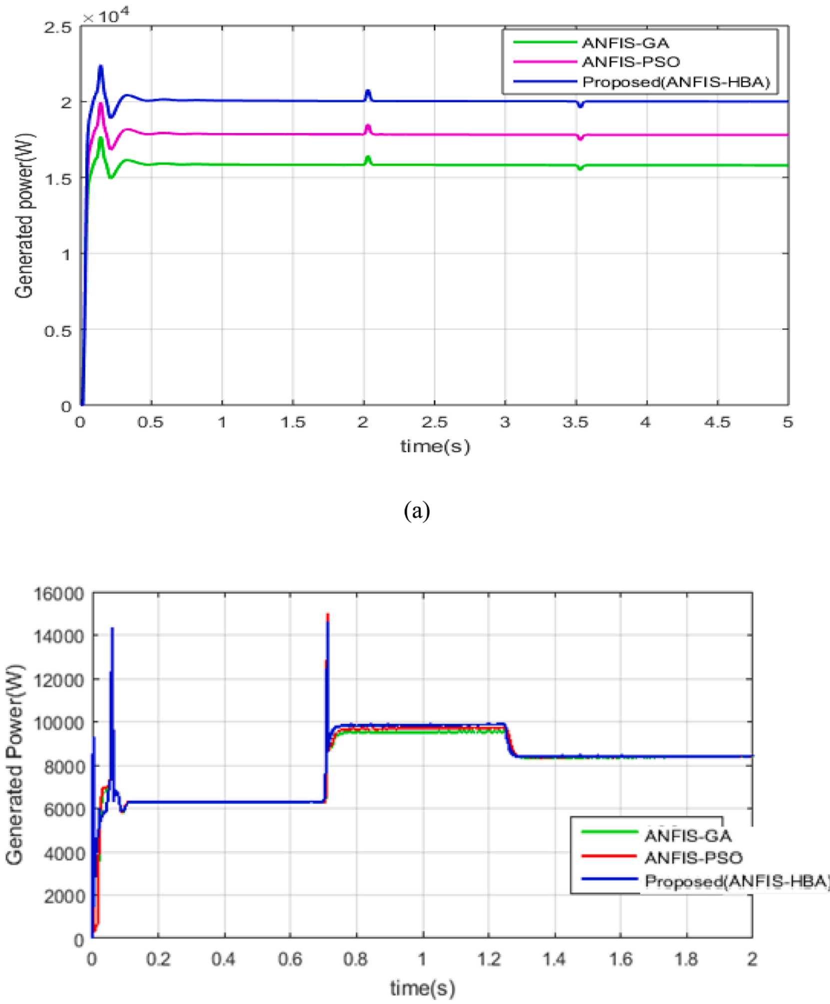

Fig. 12. Comparison analysis of (a) stable irradiance and (b) variable irradiance.

Algorithm 1
Pseudocode of the proposed methodology.

Initialization of population "(present weight parameter of ANFIS)
Compute fitness function
Store optimal position and assign fitness function
While$T \le T_{MAX}$**do**
Decreasing factor updating
For I=1 to N **do**
Compute the intensity values
If R<0.5 then
Update the position based exploration
Else
Update the position based exploitation
End if
Compute new position
End for
end while stop condition satisfied
save the optimal parameter
Return

Table 1
Simulation parameters.

S. No	Method	Description	Parameters
1	PV	Irradiance	1000W/m^2
2		PV voltage	300V
3		PV current	25A
4	WT	Wind speed	15m/s
5		Wind power	8000W
6	PV	PV power	10000W
7	Grid	DC link voltage	220V
8		Grid voltage	2000V
9		Grid current	25A

without considering any MPPT controller by applying different parameters of duty cycle to the DC-DC converter and output power observation until it achieves the maximum parameter and saves the related duty cycle at specific input parameters for temperature and irradiance [18]. This is necessary accuracy by changing the duty cycle from 0 until 1 to achieve the maximum output power to empower the efficient training data. In the ANFIS training, these data are utilized and it arrangement with temperature and irradiance which represents ANFIS training. The duty cycle of the output is considered as the ANFIS. The ANFIS system is trained up to 50 epochs in addition achieved training error. Similarly, the 85% data is utilized to training the ANFIS and 15% data is utilized to testing purpose. The ANFIS is a combination of fuzzy interference system and artificial Neural Network (ANN). An artificial NN is utilized to gather the parameters of the human brain and gathering of artificial neurons. The ANFIS technique is considered a Sugano fuzzy model and if then rules are given as,

$$r_n = ifm_{ii}(E)andm_{2i}(\Delta E),\ thenf = p_N E(t) + Q_N \Delta E(t) + r_N \quad (18)$$

Where, r_N can be described as the linear parts of the related nth rule, m_{2i} and m_{ii} can be described as the fuzzy membership function and N can be described as the number of rules.

Table 2
Comparison analysis.

Method	Variables	Parameters	Method	Variables	Parameters
Proposed	Computed global power	42.2W	Ait Kaki LamiaGhanimaet *al.*,[11]	Computed global power	28W
	Tracking efficiency	97%		Tracking efficiency	91%
	Convergence time	8ms		Convergence time	15ms
	Measured variables	PV voltage and current		Measured variables	PV power
	Observed information	Irradiance		Observed information	Temperature
A. S. Mahdi *et al.*, [12]	Computed global power	45W	Muhammad Hamza Zafar *et al.*, [13]	Computed global power	45W
	Tracking efficiency	88%		Tracking efficiency	80%
	Convergence time	18ms		Convergence time	22ms
	Measured variables	PV current		Measured variables	PV current and voltage
	Observed information	Irradiance		Observed information	Irradiance

The ANFIS layer is consists of normal fuzzification in the input layer with the consideration of membership function which is shown in Fig. 2. Normally, each node in the layer describes the adaptive function is described as follows,

$$m_{ii} = \frac{1}{1 + \left[\frac{x - c_i}{a_i}\right]^{b_i}} \tag{19}$$

Where, a_i, b_i, c_i can be described as parameter set. In the next layer, the product inference layer is considered at every named as π with the consideration of firing strength with a specific fuzzy rule operation. The output of this layer is formulated as follows,

$$w_i = m_{ii}(E) \times m_{2i}(\Delta E) \tag{20}$$

In the next layer, the normalization function is described here, the computation of firing strength forms the last layer is normalized which presented as follows,

$$\overrightarrow{w_i} = \frac{w_i}{\sum_i (w_i)} \tag{21}$$

In the next layer, the normalized parameters are sent to the next layer. Each node is related with the corresponding layer which represented as adaptive node of defuzzification with a node function is described as,

$$\overrightarrow{w_i} u = \overrightarrow{w_i}(p_i e + q_i \Delta e + R_i) \tag{22}$$

Where, p, q, r can be described as the consequence parameter set. In the final layer, it is needed to calculate the computation of complete inward signals to gather the output section of rules.

$$\sum_i \overrightarrow{w_i} = \frac{\sum_i w_i u}{\sum_i w_i} \tag{22}$$

With the help of ANFIS, the optimal pulses are selected in the DC-DC converter which reduces the partial shading condition. The ANFIS may be affected because of random weight generation. To solve this problem in ANFIS, the HBA is utilized which explained in the following section.

4.2. Honey badger Algorithm

In the ANFIS, the weight parameter is selected with the help of HBA. The detail description of the HBA is presented in this portion. The stimulation in addition mathematical modelling of the HBA that reduces the characteristics of honey badger in generally. The Honey Badger is a warm-blooded animal found regularly in the rainforests in addition semi-deserts of Africa, Indian subcontinent in addition Southeast Asia-defined for its bold environment. This reef size (60 to 77 cm in body length in addition 7 to 13 kg body weight) is a brave foraging animal that hunts sixty unique creatures, including hazardous serpents. It can be a brainy creature, ready to utilize devices, and it loves honey. It can be designed to be alone in self-drilled openings and encounters different badgers for mating. There can be a 12-honey badger category. Honey badgers have no exact upbringing season because the cubs are constantly being brought into the world. A honey badger will use its mouse-smelling mouse skills to find its prey by gradually navigating [19]. It begins to compute the estimated area of prey by drilling in addition eventually obtains it. In one daytime, it would drill more than fifty openings in forty kilo meters or additional. The honey badger catches honey, nonetheless it can not the best at finding bee colonies. Again, the honey guide (a bird) detects rashes nonetheless is unable to obtain honey. These peculiarities make a connection between the two, where the bird chases the badger to the bee colonies and uses its long pause to open the hives, and then, at that point, the two cooperate in compensation.

Normally, the HBA is alienated into two stages such as digging stage in addition honey stage which presented in this portion. The mathematical preparation of the HBA can be presented in this section. Additionally, the HBA is proceeding with exploitation and exploration stage and it is considered as a global optimization algorithm.

Step 1: Initialization phase

The initialization of the candidate solution can be formulated in the below equation,

$$InitialPopulation = \begin{bmatrix} X_{11} & X_{12} & X_{13} & \ldots & X_{1D} \\ X_{21} & X_{22} & X_{23} & \ldots & X_{2,D} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ X_{N1} & X_{N2} & X_{N3} & \ldots & X_{N,D} \end{bmatrix} \tag{23}$$

$$honeybadgeri^{th}position,\ X_I = \left[X_I^1, X_I^2, \ldots, X_I^D\right] \tag{24}$$

The initialization of the honey badges and with the positions are formulated as follows,

$$X_I = LB_I + R_1 \times (UB_I - LB_I) \tag{25}$$

Where, R_1 can be described as the random number among 0 and 1, UB_I can be described as the upper bound, LB_I can be described as lower bound and X_I can be described as the honey badger position.

Step 2: Defining intensity phase

Intensity function is connected with the prey concentration strength and distance among it. This formulation is presented below,

$$I_i = R_2 \times \frac{s}{4\pi D_i^2},\ R_2 \tag{26}$$

$$s = (X_i - X_{i+1})^2 \tag{27}$$

$$D_i = X_{prey} - X_i \tag{28}$$

Where, D_i can be described as distance function of prey, s can be described as source strength or concentration strength and R_2 can be described as random number among 0 and 1.

Step 3: Update density factor

The density factor is control time changing generalization towards empower smooth conversion from exploitation towards exploration. To updating process of decreasing factor which diminishes with iteration functions to reduce the time randomization based on below equation,

$$\alpha = c * exp\left(\frac{-t}{t_{max}}\right) \tag{29}$$

Where, t_{max} can be described as maximum number of iterations and c can be described as constant parameter.

Step 4: Local optimum escaping scenario

This step is utilized to local optima conditions with a specified region. In this step, this algorithm is utilized a flag F to change the search way aimed at consuming high suggestions aimed at search agent to find the optimal space.

Step 5: Updating process

In the HBA algorithm, the position is updated with the consideration of two sections such as honey stage and digging stage.

Digging stage:

$$X_{\text{new}} = X_{\text{prey}} + F \times \beta \times I \times X_{\text{prey}} + F \times R_3 \times \alpha \times D_I \times |\cos(2\pi R_4) \times [1 - \cos(2\pi R_5)| \tag{30}$$

Here, F can be described as flag which change the search direction, D_I can be described as distance among prey, R_4, R_5 can be described as random numbers among 0 and 1, β can be described as random number with the random numbers.

$$F = \begin{cases} 1 & if R_6 \leq 0.5 \\ -1 & else \end{cases} \tag{31}$$

Where, R_6 can be described as haphazard variable among 0 and 1. In the digging stage, the honey badger deeply presented in the small intensity function which denoted as I and X_{prey} can be described as distance among badger and prey.

Honey phase:

In this case, the honey badger shadows honey leader bird towards spread apiary which formulated as follows,

$$X_{new} = X_{prey} + F \times \beta \times R_7 \times D_I \tag{32}$$

Where, X_{new} can be described as the new position. Normally, the proposed algorithm is related with the global optimization algorithm becasue of exploitation and exploration stages. To achieve the easy implemet and understanding purposes, the number of operators to be minimized or adjusted [20]. With the help of hybrid apporach, the efficient pulse of DC-DC converter is achieved which extracting the maximum power from the PV/Wind grid connected system.

5. Results and discussion

The proposed methodology is validated and justified in this section. To evaluate the projected technique, it is implemented on MATLAB/ Simulink. In this proposed methodology, the hybrid PV/WT is considered to compensate the load demand during the partial shading conditions. The designed hybrid PV/WT is connected with the grid. The main objective of this research is to extract maximum power from the hybrid system. To extract the maximum power from the hybrid system, ANFIS-HBA algorithm is utilized. In the ANFIS, efficient weighting parameter is selected with the help of HBA. The Simulink diagram of the projected technique is illustrated in the Fig. 3. The proposed methodology is developed to select optimal pulses of DC-DC converter.

In this proposed methodology, the hybrid PV/WT is utilized to compensate the load requirements in grid side. The interconnected PV/ WT is affected because of partial shading condition and maximum power extraction. To solve this problem, the proposed methodology is designed with the DC-DC converter. The PV is generated the power based on irradiance which is illustrated in Fig. 4. The output voltage and current from PV system is shown in Fig. 5.

In this system, the irradiance is fixed to 1000W/m2 for generating power from the PV system. The generated voltage and current of the PV are 320V and 25A. The generated power of PV is utilized to compensate the load demand. Because of the proposed methodology, the constant power is sent to the grid side for compensating the load requirements. In the proposed methodology, the wind also considered to compensate the load requirements in the grid side. The wind speed is considered 15m/s for generating wind power which illustrated in Fig. 6. The generated wind power is 9000W which illustrated in Fig. 7. The generated power of PV is illustrated in Fig. 8. The generated power of PV is 10000W. The DC link voltage of the proposed design is illustrated in Fig. 9. The DC link voltage should be maintained in constant to enable efficient operation in the proposed design. The DC link voltage also maintain constantly in the proposed design with the help of proposed controller.

The generated power of PV and WT is sent to the grid side for compensating the required power of the consumers in the grid side. The grid side voltage and current is illustrated in Fig. 10. The grid voltage of the proposed methodology is 2000v and current is 25A. The main purpose of the proposed methodology is extracting the maximum power from the PV and WT system for managing the required power in grid side power. The proposed controller is designed to managing the power and extraction of the power. The required and generated power of the proposed methodology is presented in Fig. 11. In Fig. 11, the generated power of PV and WT is 2.1KW and required power of grid is 2.1KW. Hence, the proposed methodologies are compensating the grid side required power and extract the maximum power from the PV and WT system. The comparison analysis of the proposed methodology is presented in Fig. 12. The proposed methodology is compared with the conventional methods such as ANFIS-GA and ANFIS-PSO. The required power of the grid side is 2.1KW. In Fig. 12, the proposed methodology is achieved 2.1KW. Similarly, the conventional methods are achieved 1.8KW and 1.6KW. Hence, the proposed methodology is compensating the grid required power. From the analysis, we can conclude, the proposed methodology is achieved efficient results in maximum power extraction and power compensation in grid side (Algorithm 1).

6. Conclusion

This paper develops a design and analysis of the hybrid system with a DC-DC converter controlled by hybrid approach. This hybrid approach is a combination of ANFIS-HBA for extracting maximum power and power compensation. The hybrid system is designed with PV and WT for compensating load demand in the grid side. The main objective of the proposed methodology is to extract the maximum power of the system (PV and WT).The proposed methodology is executed in the MATLAB and performances is evaluated with the performance metrices. The proposed method is achieved efficient results which concluded with the comparison analysis such as ANFIS-GA and ANFIS- PSO at various partial shading conditions. The proposed method is analysed with performance measures such as voltage, current, power, irradiance, wind speed. The proposed methodology is compared with the conventional methods. Based on the comparison analysis, the proposed methodology is achieved efficient results because it compensates the load demand in the grid side. The proposed methodology is extracting the maximum power from the PV and WT which results the effective compensation. Additionally, different parameters are utilized to analyse for the validating the proposed methodology (Tables 1-2).

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Declaration of Competing Interest

I declare that here no conflict of interest.

Data availability

No data was used for the research described in the article.

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