PERFORMANCE ANALYSIS OF SOLAR PV, WIND AND FUEL CELL USING FIREFLY MPPT

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ABSTRACT

The main objective of this paper is performance analysis of Solar PV, Wind and Fuel cell using Firefly MPPT technique. Among all the Renewable Energy sources, wind energy, fuel cell and solar cell plays a key role in the generation of electric power. Besides, the contributions of wind power, solar energy and fuel cell are properly integrated to ensure & sustain the continuity of the supply to load on the demand at every minute. The output of the solar cell, fuel cell and Wind systems are connected to BUCK-BOOST converter. In order to extract the maximum power from Fuel cell, solar and wind energy systems a new technique, called Maximum power point tracking. In this paper, Firefly Maximum Power Point Tracking method is used for controlling the BUCK-BOOST converter. Performance analysis of Firefly MPPT gives better performance compared to Fuzzy Logic Control, P & O and Incremental Conductance methods. The output of the Buck-Boost converter connected to grid by using three phase inverters. Using the MATLAB / Simulink platform, simulation of the proposed system are studies, carried out and the results are presented.

Keywords: Grid, Fuel cell, Solar cell, Wind Energy, BUCK BOOST converter, Firefly MPPT, Three Phase Inverter.

I.INTRODUCTION

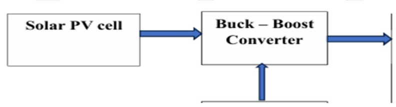
The extensive use of traditional energy sources results in significant environmental contamination and has detrimental effects on the health of living organisms. Several nations are actively seeking to promote sustainable green energy alternatives in order to safeguard the riches of future generations [1]. In addition to thermal power and hydro power, fuel cells, photovoltaic systems, and wind energy are widely accessible to supply the substantial energy demand. Wind production has the capacity to provide significant energy demands for end users. However, a major drawback of wind generation is the need for a suitable geographical location with consistently strong and unexpected wind forces to establish a wind power plant [3]. sun energy is consistently available throughout the day, despite variations in sun radiation levels caused by factors such as clouds, tall buildings, and birds. The primary limitation of these energy sources is their intermittent nature, which renders them unpredictable. In order to address the aforementioned challenges, a hybrid system is created by integrating wind, solar, and fuel cells as a third energy source, which are then linked to the grid. As a result of implementing this hybrid system [5-7], the dependability of the load side is enhanced, and there is a progressive improvement in power transfer capacity and efficiency. If any of the aforementioned resources are unable to maintain a continuous supply at the load side for various reasons, the shortfall will be compensated for by using other energy sources. The paper [3] discusses several hybrid systems that use various Maximum Power Point Tracking (MPPT) approaches. The study introduces a system that comprises wind energy, a photovoltaic (PV) system, and a fuel cell. In order to achieve optimal power output from wind, solar PV, and fuel cell systems, a Firefly MPPT (Maximum Power Point Tracking) is used.

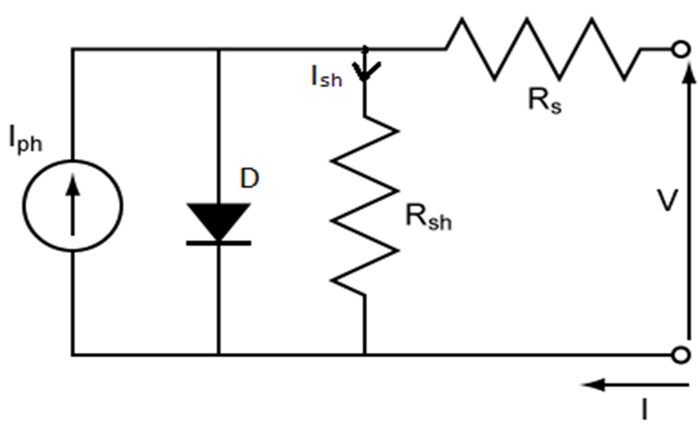
II. ARCHITECTURE OF THE PROPOSED SYSTEM

The building of the suggested system is shown in Figure 1. In wind power production, electricity is harnessed from a permanent magnet synchronous generator (PMSG) that is connected to the wind turbine. When the wind flow's strength rises and strikes the vanes of the wind blade, it causes the wind turbine to spin rapidly. This turbine is connected to a Permanent Magnet Synchronous Generator (PMSG) which produces electric power using the Firefly Maximum Power Point Tracking (MPPT) technique. By adjusting the duty ratio, the maximum power may be extracted from the grid. Additionally, the voltage output from the wind generator fluctuates in magnitude. Thus, by following this approach, the highest level of power will be achieved. The solar PV panel's output was connected to a Buck-Boost converter in order to increase the voltage using the Firefly maximum power point tracking technique. The output of the Buck Boost converter is transformed into alternating current (AC) using a three-phase inverter. The fuel cell provides direct current (DC) energy, which is then transmitted over the DC bus system. An inverter is used to link the dc bus to either the grid or a load. These three sources coordinate the load demand.

Fig. 1 Architecture of the proposed system

A. Solar PV Module





The PV (Photo Voltaic) cell equivalent circuit is shown below. The solar cell treated with the current source and parallel connected.

Fig. 2 Equivalent circuit of a solar cell

From Fig. 2, apply KCL (Kirchoff's Current Law), then

$$I_{ph} = I_d + I_{sh} + I \tag{1}$$

$$I = I_{ph} - (I_{sh} + I_d)$$

(2)

We have following equations for Solar cell current,

$$I = I_{ph} - I_o\left[e^{q\left(\frac{(V+I.R_s)}{nkt}\right)} - 1\right] - (V + IR_s)/R_{sh} \quad (3)$$

Where V_T represents Terminal Voltage
I_{ph} denotes isolation current
V represents the cell voltage
I represent the cell current
I_o denotes reverse saturation current
R_{sh} is Shunt Resistance
R_s denotes Series Resistance
q represents elementary charge
n denotes diode ideality factor
T represents absolute Temperature
K denotes Boltzmann's constant

B. Wind Turbine

Wind generator turbine rotates which is coupled to an alternator generates electrical energy. Electric power magnitude of speed changes with a given turbine is described as:

$$p_w = \frac{1}{2}\frac{m.v^3}{t} = \frac{\frac{1}{2}\rho.A.d.v_w^3}{t} = \frac{1}{2}\rho.A.v^3 \quad (4)$$

Where v_w = wind speed (distance/time) (m/s) = Wind Power (W)
ρ = Air density (kg/m3)
A = Area swept by the turbine blades (m2)
d = radius of the swept area of blades (m)
m = mass of the air m = air density X volume = ρ.A.d (Kg)

The generated mechanical power is expressed by

$$p_m = p_w.c_p(\lambda,\beta) = \frac{1}{2}\rho.A.v_w^3.c_p(\lambda,\beta) \quad (5)$$

Here C_p denotes power coefficient
λ represents tip speed ratio of the rotor blade
ω tip speed to wind speed
β represents the pitch angle

The power coefficient of the turbine is expressed by

$$c_p = c_1\left(\frac{c_3}{\lambda_1} - c_3\beta - c_4\right)e^{\frac{-c_5}{\lambda_1}} + c_6\lambda \quad (6)$$

Where,

$$\frac{1}{\lambda_1} = \frac{1}{\lambda+0.08\beta} - \frac{0.035}{\beta^3+1}$$

(7)

And also

$$C_p = \frac{P_m}{P_w}; C_p < 1 \quad (8)$$

$$P_m = C_p.\frac{\rho.A}{2}v_w^3 \quad (9)$$

The power produced P_m depends on the magnitude of C_p. The C_p is defined as a ratio of electric power generated by wind generator turbine to mathematical wind generator power.

TSR denotes relation among wind speed angular speed which is expressed by

$$\lambda = \frac{w.d}{V_w}$$

(10)

Here ω is the rotor speed expressed in rpm

For a gearless wind turbine, the mechanical torque is expressed as

$$T_m = P_m\frac{d}{\Lambda v_w} = {}^1/_2\, p.A.C_p(\lambda,\beta)\frac{R}{V_w} = \frac{P_m}{W}$$

(11)

C. Fuel Cell

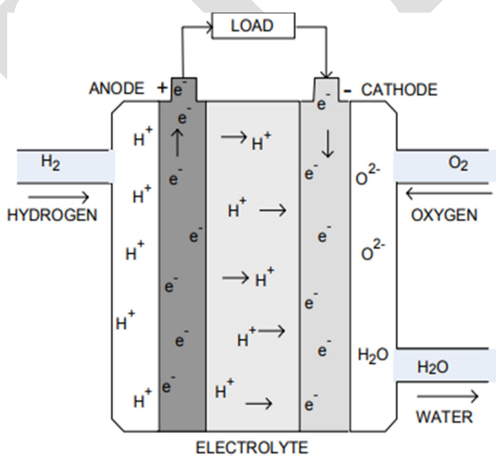
Fuel cell mainly consists of 3 sections:

a) Fuel reformer

b) Power section (contains stacks of fuel cells)

c) Power conditioner

Fuel cells are categorized according to the specific kind of electrolyte they use. In this sort of process, either hydrogen or oxygen ions are responsible for ionizing or initiating the movement of electrons. These electrons are then decomposed and flow through the load. Hydrogen is derived from the enhanced Fuel with a higher concentration of hydrogen is introduced into the fuel cell. The free electrons are released from the hydrogen molecules at the anode and then go via an external circuit. The hydrogen ions are released and enter the cathode. The oxygen is separated from the air at the cathode terminals, while the hydrogen ions and electrons combine to produce water and heat in the presence of an external circuit.



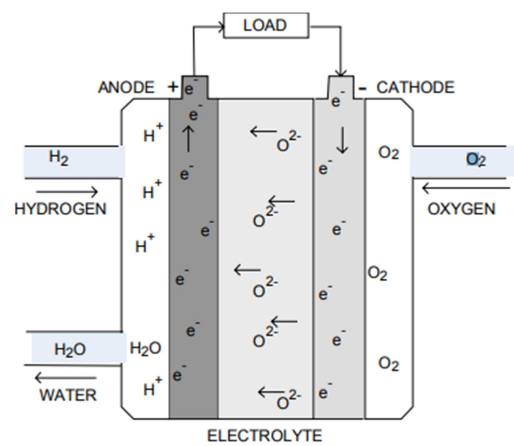


Fig. 3 Fuel cell with Hydrogen ions At anode terminal

Fig. 4 Fuel cell producing negative ions

$$H_2 = 2H^+ + 2e \quad (12)$$

At cathode terminal

$$\frac{1}{2} O_2 + 2H^+ + 2e = H_2O \quad (13)$$

III. CONVERTERS

A. DC-DC Converter (Buck-Boost Converter)

The DC-DC converters are also known as Choppers. Buck boost converter which could operates as DC-DC Step Down or Step-Up converter depending upon duty cycle, D. These converters convert from fixed DC voltage to variable DC voltage that may be less or more voltage depends upon the duty ratio

If V_{input} is greater than the V_{ouput}(V_i>V_O) i.e. Buck converter. In this situation, the electric V_{ouput} is expressed by

$$V_o = DV_i \quad (14)$$

If V_{input} is lesser than the V_{ouput} (V_i <V_o) then it was called Boost converter. So, the o/p voltage is expressed by

$$V_o = DV_i \quad (15)$$

For Buck and Boost converters, the output voltage is expressed by

$$V_o = \frac{D}{1-D} V_i \quad (16)$$

Here Vo = DC output voltage across terminals.

V_i = Input DC voltage

D = Duty ratio

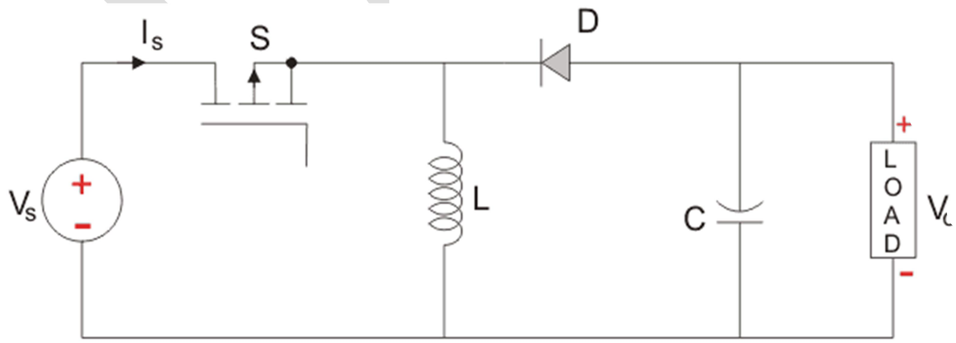


Fig. 5 Buck-Boost converter

By varying the duty ratio D, the maximum power can be extracted from the wind by utilizing MPPT method continuously can be achieved.

B. DC-AC Converter (Inverter)

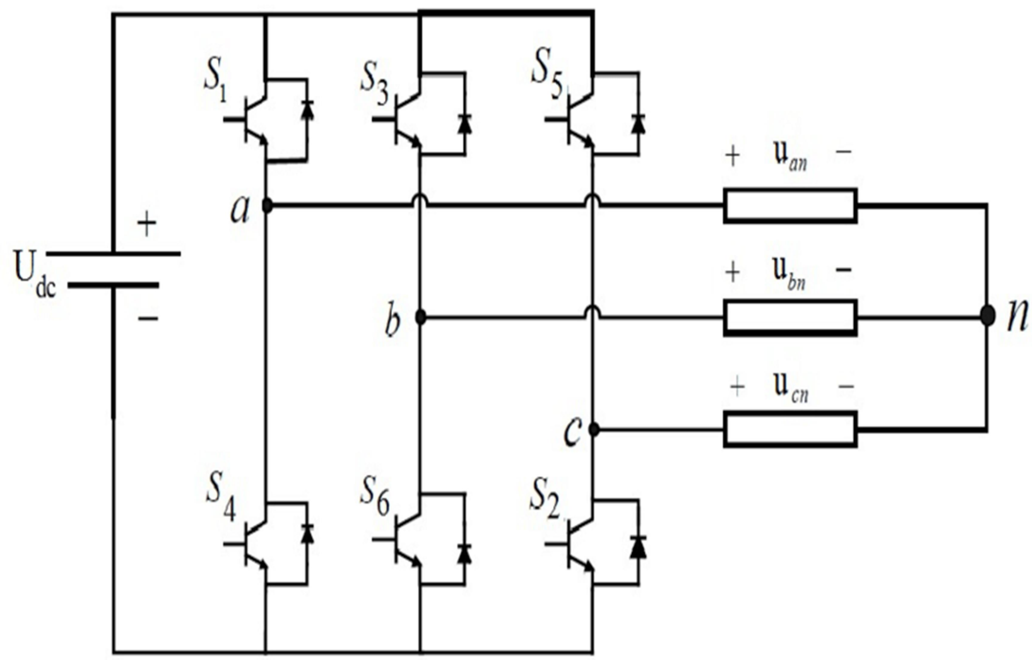


Fig. 6 Three Phase Inverter

From the DC-DC buck-boost converter, output DC voltage is connected to the grid via DC-AC converter i.e. Inverter. Generally, 3-phaseinverter which is utilized for the conversion of DC-AC so it was called as (GSC) Grid Side Converter. The three-phase inverter as shown in above Fig. 6.

C. SPWM TECHNIQUE

Sinusoidal PWM is a typical PWM technique. In this PWM technique, the sinusoidal AC voltage reference v_{ref} is compared with the high-frequency triangular carrier wave v_c in real time to determine switching states for each pole in the inverter. After comparing, the switching states for each pole can be determined based on the following rule:

- Voltage reference v_{ref}>Triangular carrier vc: upper switch is turned on (pole voltage=V_{dc}/2)
- Voltage reference v_{ref}<Triangular carrier vc: lower switch is turned on (pole voltage=$-V_{dc}$/2)

Here, the peak-to-peak value of the triangular carrier wave is given as the DC-link voltage V_{dc}. In this PWM technique, the necessary condition for linear modulation is that the amplitude of the voltage reference v_{ref} must remain below the peak of the triangular carrier v_c, i.e., v_{ref}≤V_{dc}/2. Since this PWM technique utilizes a high-frequency carrier wave for voltage modulation, this kind of PWM technique is called a carrier-based PWM technique. Especially, this carrier-based technique is called SPWM since the reference is given as the shape of a sine wave. This is also called the triangle-comparison PWM technique since this uses the carrier of a triangular wave.

In the carrier-based PWM techniques, the desired voltage reference waveform is referred to as *modulating wave*. In addition, a wave which is modulated with the modulating wave is referred to as *carrier wave* or *carrier*. The carrier wave usually has a much higher frequency than the modulating wave. The triangular waveform is the most commonly used carrier in the PWM technique for modulating AC voltage. On the other hand, different forms of modulating wave can be used according to the PWM technique. Typical SPWM technique uses the sinusoidal modulating waveform.

In this PWM based on comparison with the triangular wave, if the ratio of carrier frequency to fundamental frequency is large enough (greater than 21), then the fundamental component of the output voltage varies linearly with the reference voltage v_{ref} for a constant DC-link voltage as

$$v_{o1} = v_{ref} sin\omega t \quad (17)$$

In addition, the fundamental frequency of the output voltage is identical to that of the reference voltage. The output voltage equation can be rewritten in terms of the modulation index MI as

$$v_{o1} = v_{dc} MI sin\omega t v_{o1} \quad (18)$$

Here, since $v_{ref} \leq V_{dc}/2$, so $0 \leq MI \leq 1$.

The range of $0 \leq MI \leq 1$ is called the *linear modulation range* because, in this range, the inverter can generate an output voltage linearly proportional to the reference voltage. In this case, the PWM inverter is considered to be simply a voltage amplifier with a unit gain.

IV. FIREFLY MXIMUM POWER POINT TRACKING METHOD

To takeout the higher power from the output, a new strategy method implemented is known as MPPT method which continuously tracks maximum power so that the reliability of the system is enhanced. Various techniques are available viz. Incremental conductance (IC) Hill-Climbing Search (HCS), Perturb and Observe (P&O) and Fuzzy Logic Controller (FLC). In this paper Firefly MPPT is implemented for controlling the respective buck boost converters.

Firefly algorithm is based on a meta-heuristic swarm intelligence algorithm for limited optimization tasks, that was introduced by Yang. This algorithm is an inspiration of the behaviour of firefly glow and applies a population-based iterative procedure by numerous factors as fireflies. These factors can check the cost function more effectively compared with the distributed random search. Intensity of light and brightness is determined by inverse square law and fitness function respectively. This MPPT algorithm is more powerful method because of its ability to obtain MPP with high convergence speed. It is based on flashing of firefly which depends on relative brightness of two fireflies. The firefly with less brightness will follow the brighter one. Moreover, firefly with equal brightness will move randomly which is evaluated by the objective function. The population size, FA constants and termination inertia have been fixed during implementation of this algorithm. Moreover, the position and brightness of the firefly has been treated as duty ratio of buck-boost converter and power generated from PV, wind, fuel cell respectively. The position of the fireflies lies in the range d^{min} and d^{max} of the duty cycle of buck-boost converter. Also brighter firefly remains in the position while other firefly updates their positions. In first step of FA based MPPT algorithm the control parameters as reference voltage (V_{ref}), size of population etc. are set. Also, the initial populations of fireflies are generated in second step. The fitness function is determined to evaluate the brightness of the firefly. Moreover, the Euclidean distance equation is used to find the update position of firefly. Best global position is obtained once the termination criterion has been achieved else go to step 3 and determine fitness function. FA algorithm again restarts as sensor detects the change in irradiance level.

Consider D_i and D_j are the positions of two fireflies, respectively. The distance (d_{ij}) between two fireflies can be calculated mathematically as

$$d_{ij} = \| D_i - D_j \| = \sqrt{\sum_{K=1}^{r} \left(D_{ik} - D_{jk}\right)^2} \quad (19)$$

Also, the degree of attractiveness α can be expressed as a function of distance with initial attractiveness (α_0) and absorption coefficient (β) as

$$\alpha(d) = \alpha_o * e^{-\beta^2}, 0 < \beta < 10 \quad (20)$$

Let the i^{th} firefly has less brightness compared to the j^{th} firefly's new position can be calculated mathematically as

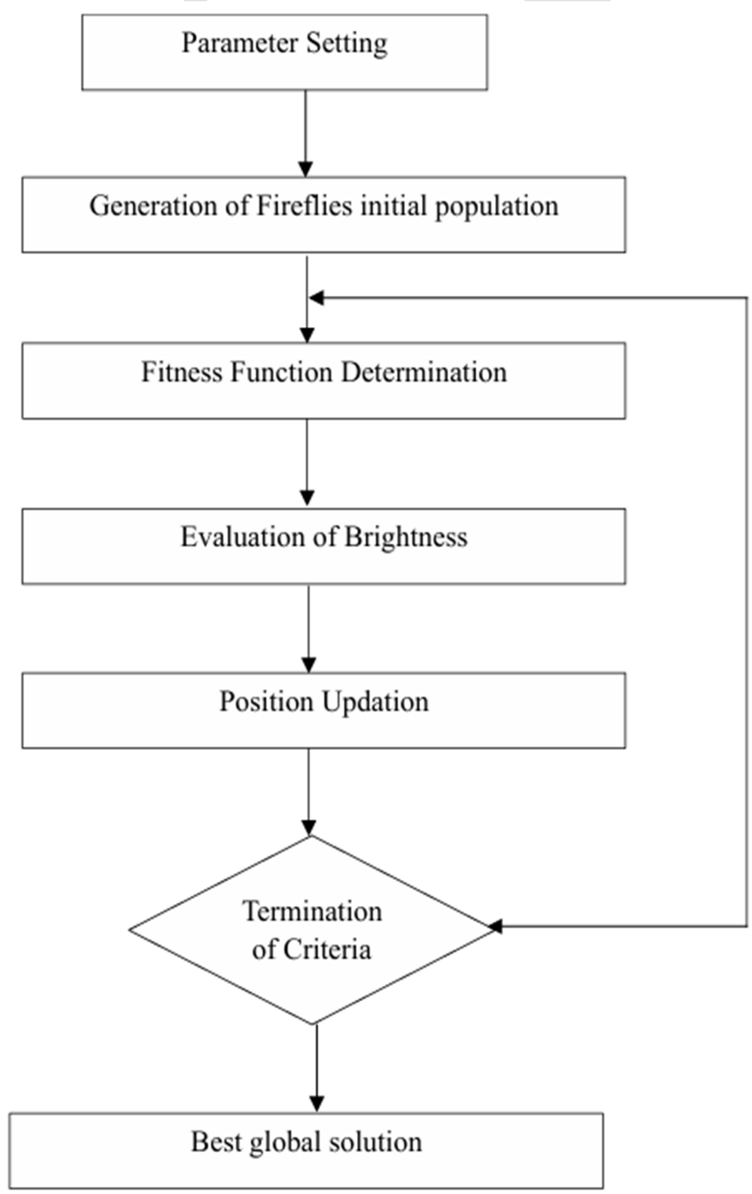
$$D_i - D_j + \alpha_o * e^{-\beta d^2}(D^T - D^T) + \beta(Rand - 0.5)$$

(21)

Where β_j = Random movement factor = constant

$$0 \leq \beta_j \leq 1, 0 < Rand < 1$$

Fig. 7 Flowchart for firefly algorithm



ISSN 2277-2685
IJESR/Apr-Jun. 2024/ Vol-14/Issue-2/783-802
Dr. G. Tejaswi *et. al.*, / International Journal of Engineering & Science Research

V. SIMULATION & RESULTS

MATLAB/Simulink software is used to investigate the circuit behaviour of the proposed Solar PV, Wind and Fuel cell hybrid system with Firefly MPPT technique. The simulation model of the hybrid system with Firefly MPPT is shown in below Fig.

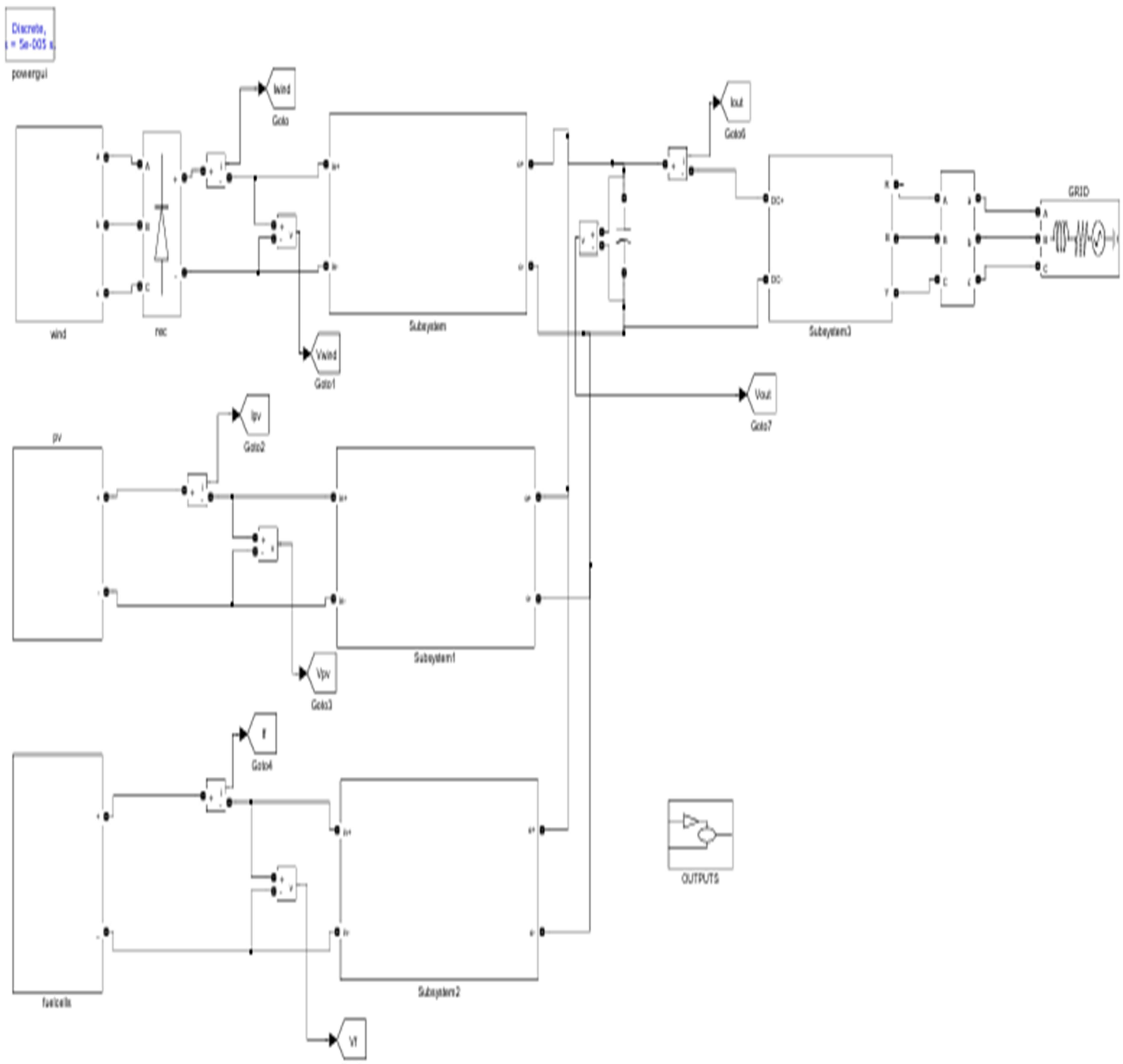
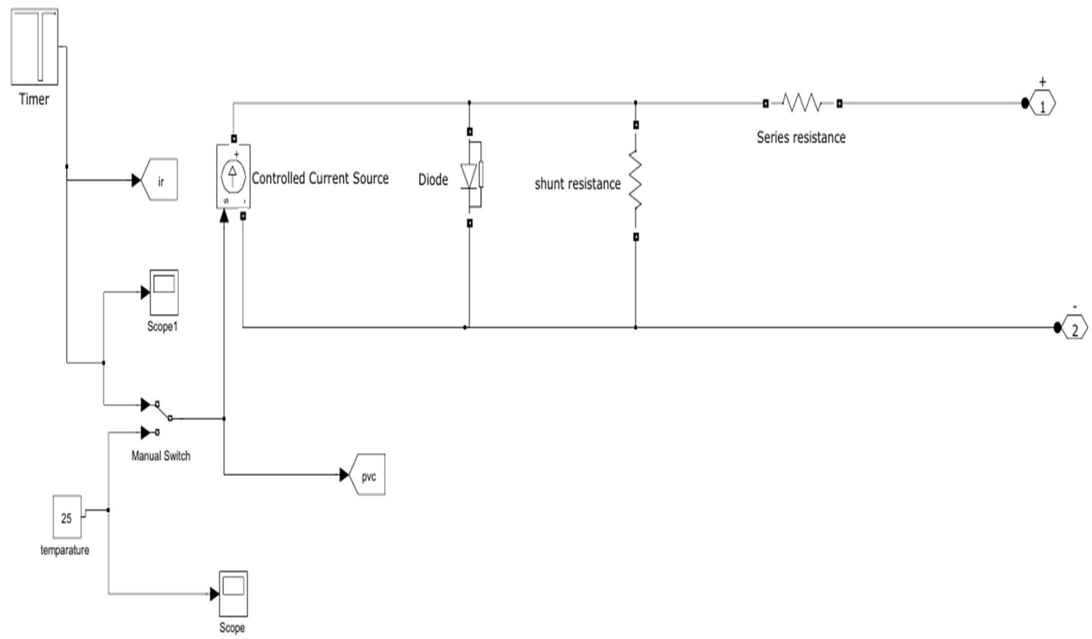


Fig. 8 Simulation model of proposed method

The suggested system simulation model is made up of a PV module, wind, fuel-cell, buck-boost converters, inverter and grid or load. The output of the Hybrid system is connected to three phase inverter which converts to AC. Fig.10 indicates the solar PV subsystem and Fig. 11 indicates the wind



subsystem with Firefly maximum power point technique.

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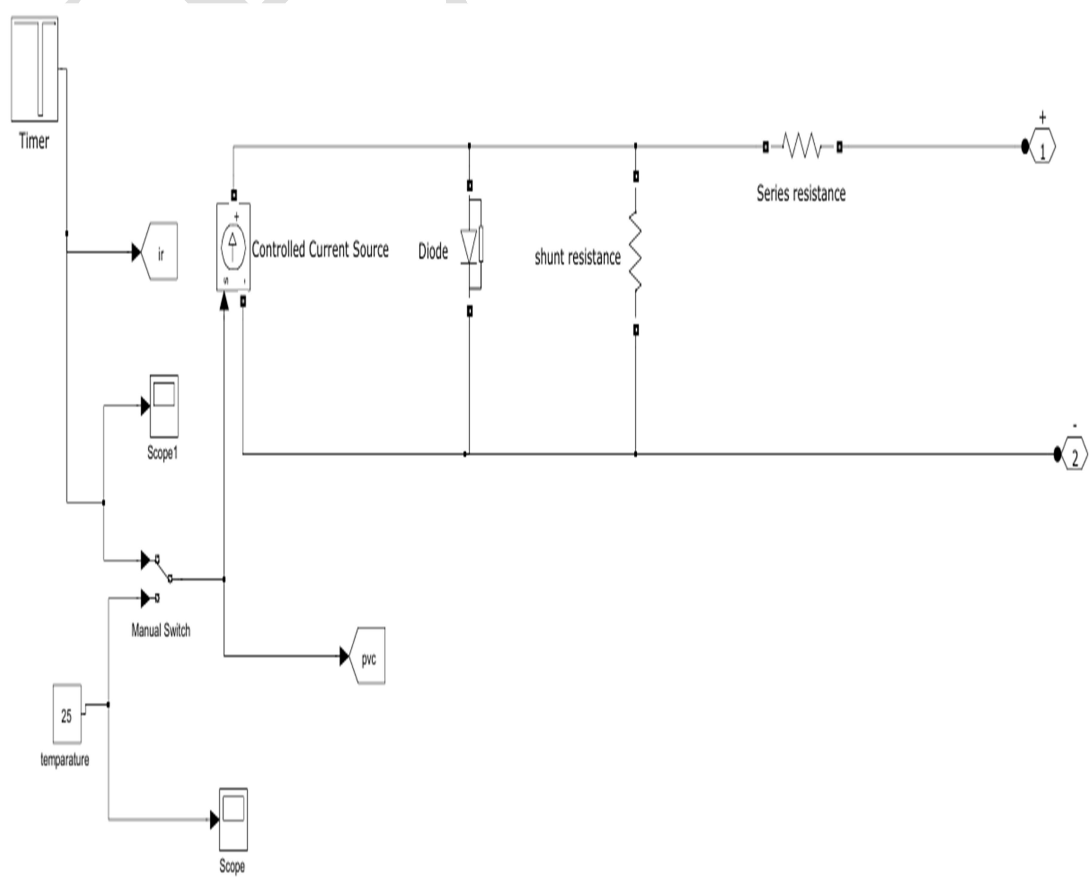
Fig. 9 Simulink model of PV subsystem



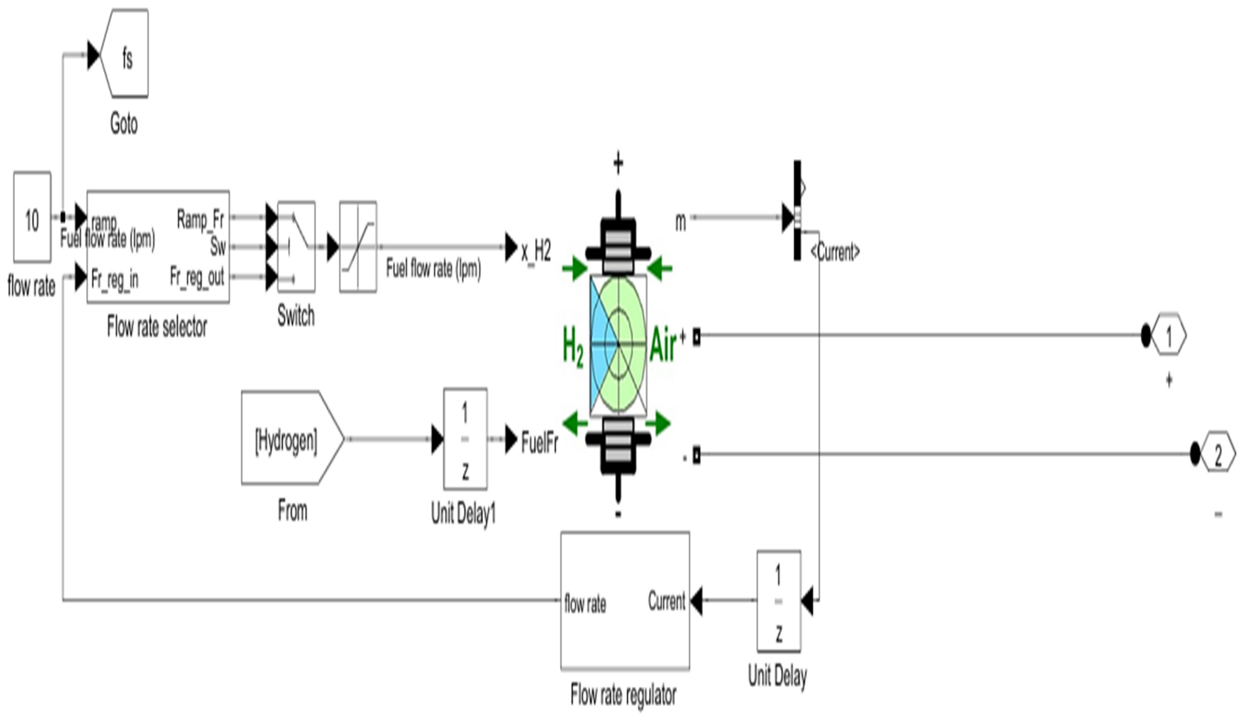


Fig. 10 Simulink model of Wind subsystemFig. 11 Simulink model of Fuel cell

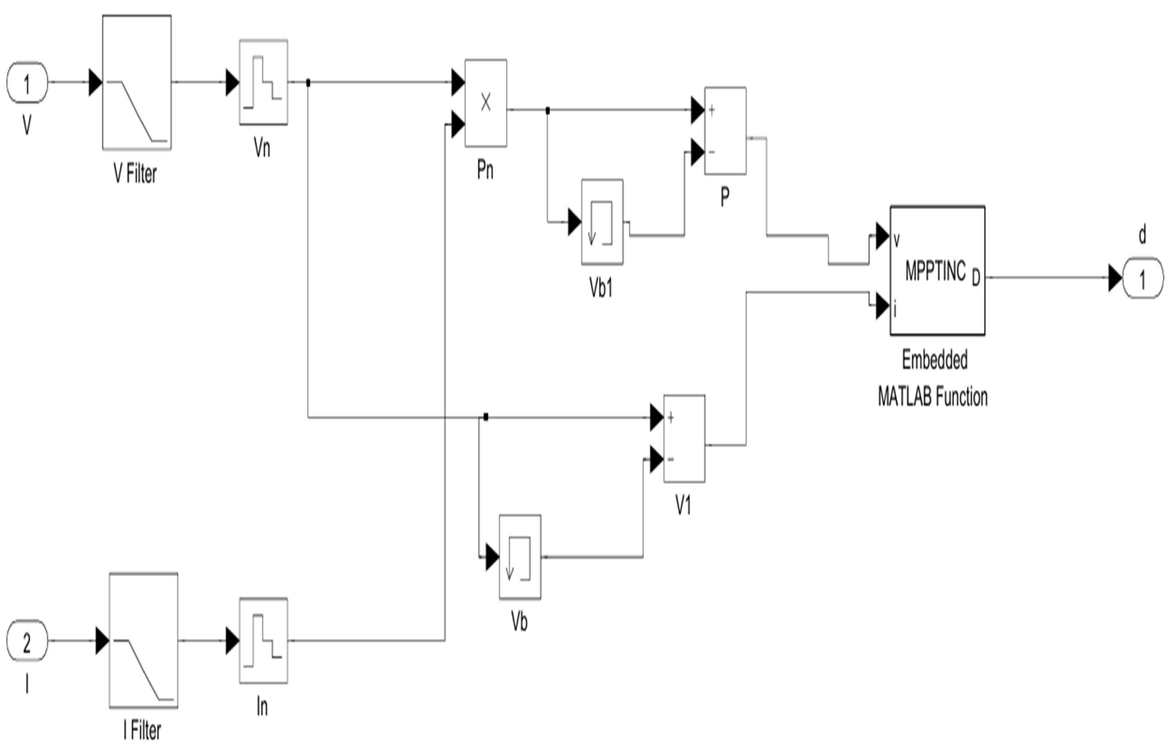
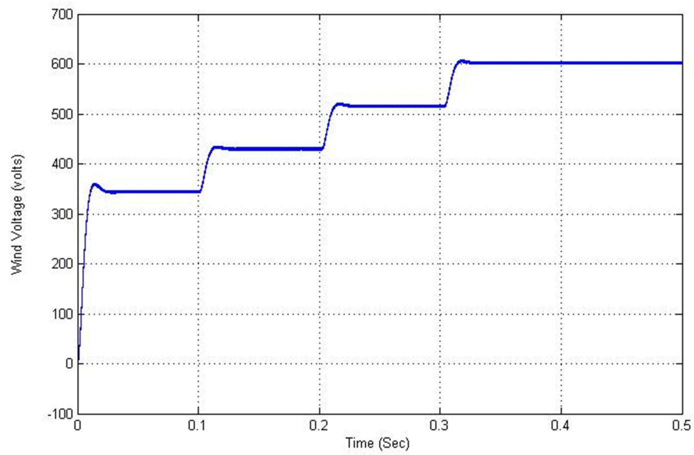
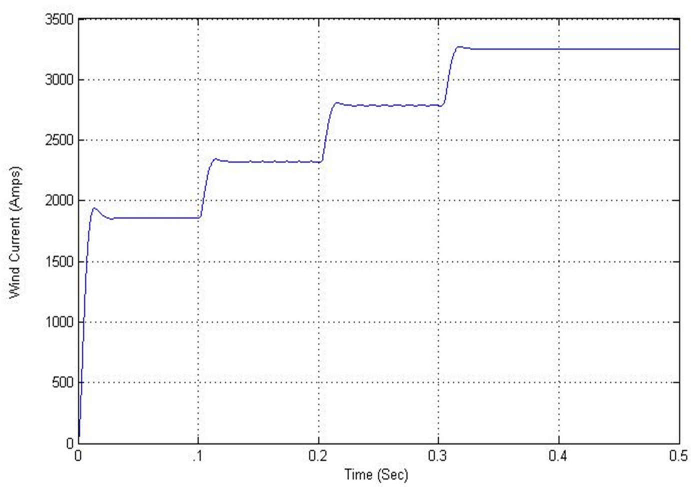


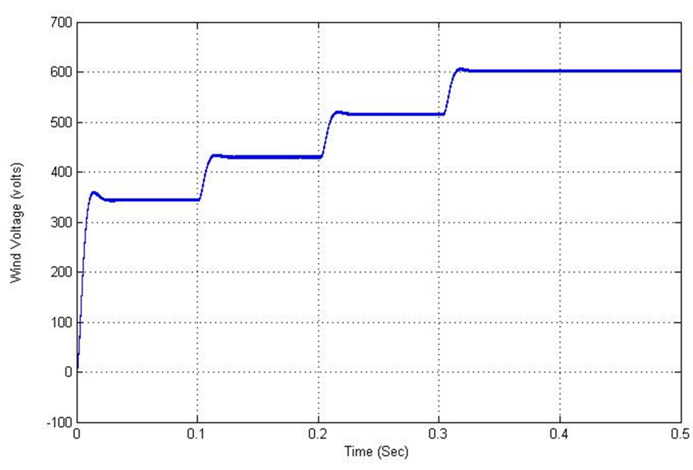
Fig. 12 Simulation subsystem circuit of Firefly MPPT

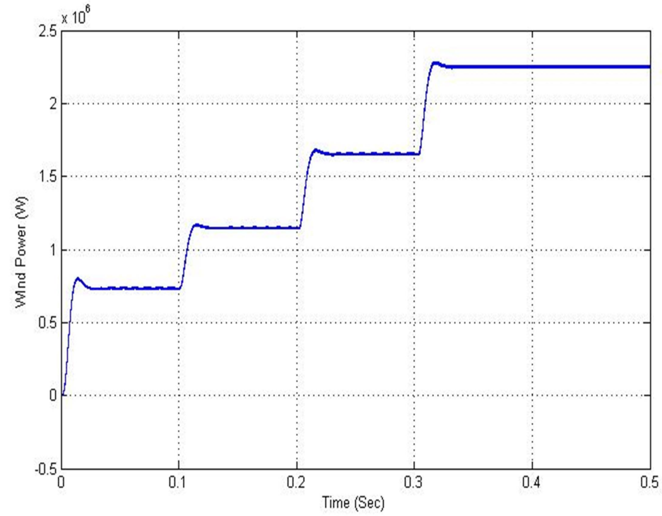
SIMULATION CODING FOR FIREFLY MPPT TECHNIQUE



ig. 13 Output voltage of Wind







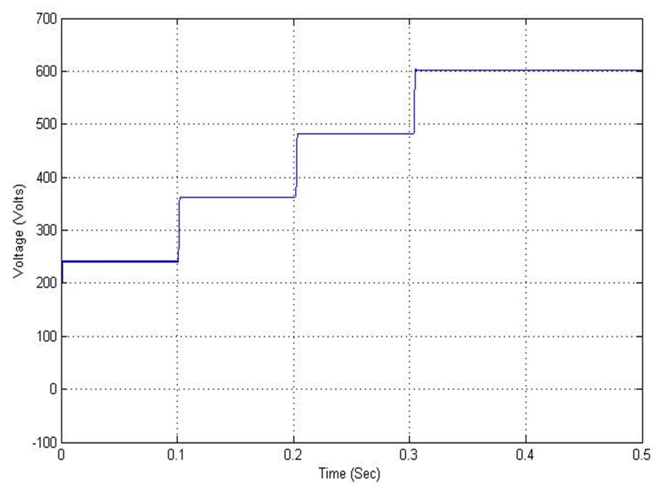
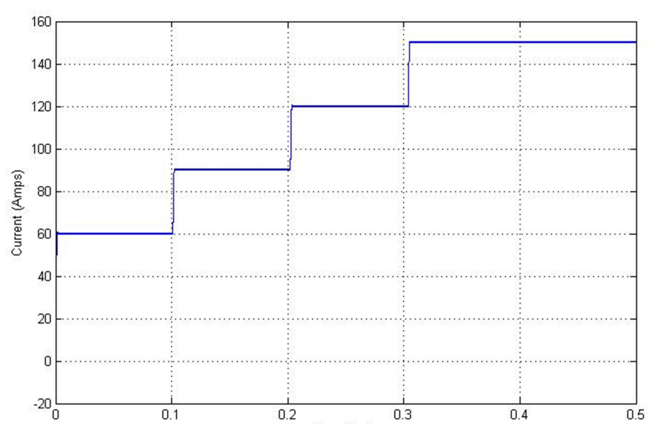


Fig. 14 Output Current of WindFig. 15 Output Power of Wind

Fig. 16 Output Voltage of Solar PV array

Fig. 17 Output current of Solar PV array



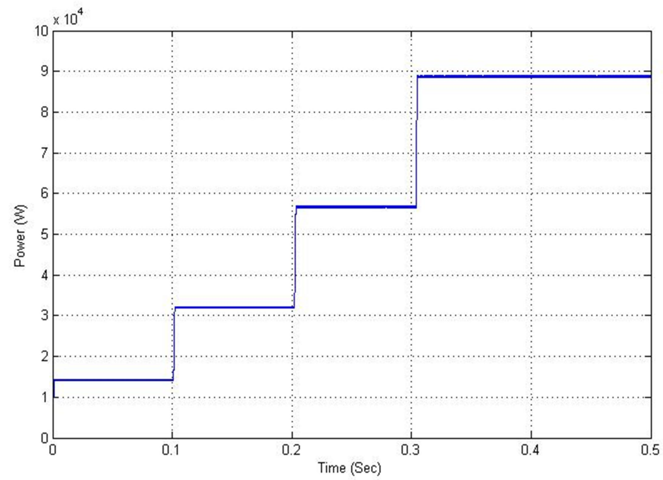


Fig. 18 Output Power of Solar PV arrayFig. 19 Output Voltage of Fuel cell

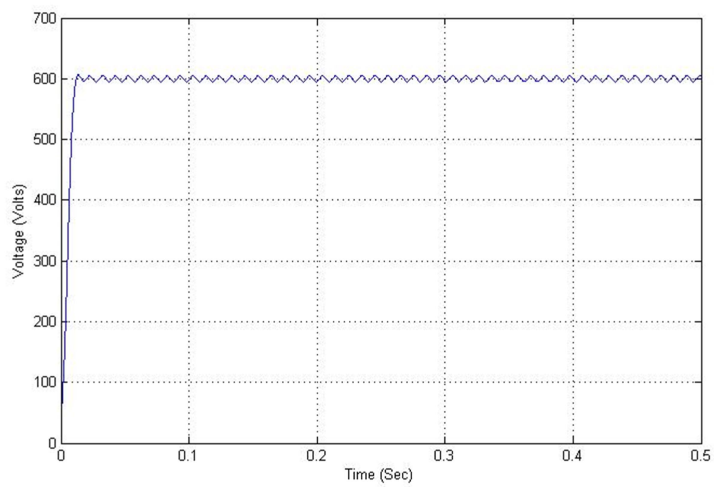
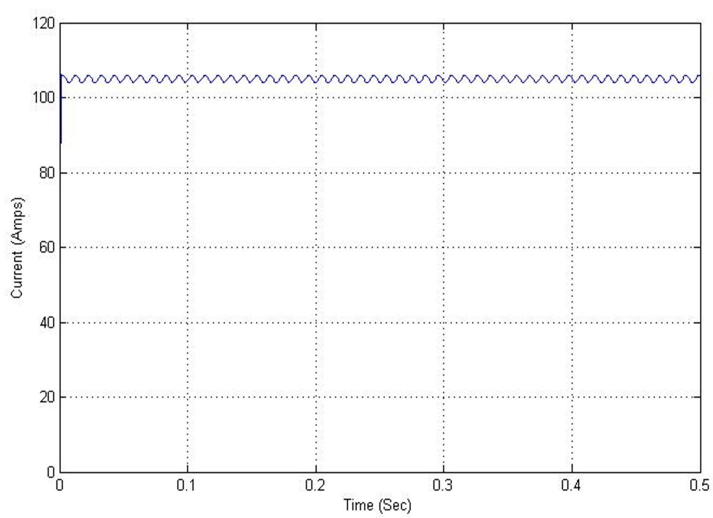


Fig. 20 Output Current of Fuel cell



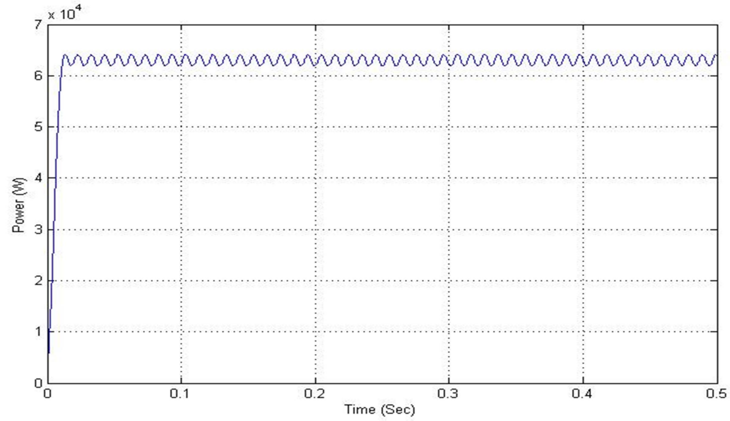


Fig. 21 Output Power of Fuel cell

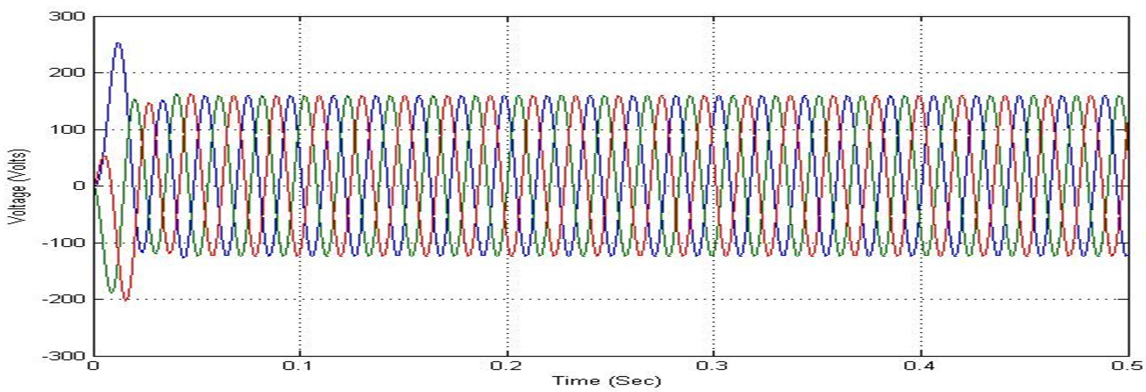


Fig. 22 Output Voltage of Grid Connected Inverter

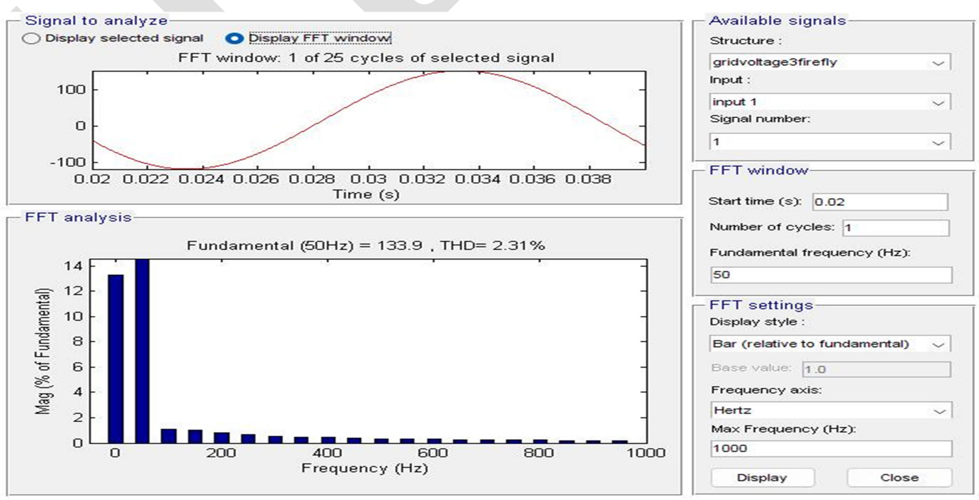


Fig. 23 FFT analysis

Table - 1 Outputs for proposed Scheme

Source	Voltage(volts)	Current (amps)	Power (W)
Solar PV	600	150	$2.25*10^6$
Wind	600	3250	$8.9*10^4$
Fuel cell	600	105	$6.3*10^4$
THD = 2.31%			

VI. CONCLUSION

This paper mainly explained the hybrid grid with an integration of PMSG for the wind power generation, Solar PV cells and Fuel cells are implemented based MPPT technique. In this paper Firefly MPPT method has been implemented to track the maximum power from the Solar PV, Wind, Fuel cell hybrid system. Proposed model gives less THD compared to the Fuzzy MPPT and conventional MPPT models. The suggested results were simulated in the Simulink of Platform and Waveform has been analyzed and plotted. The future scope of the paper is to get less THD from the ANFIS and FOPI based Multilevel Inverter.

REFERENCES

1. S. Padmanaban, N. Priyadarshi, J. B. Holm-Nielsen, M. S. Bhaskar, F. Azam, A. K. Sharma, and E. Hossain, ‘‘A novel modified sine-cosine optimized MPPT algorithm for grid integrated PV system under real operating conditions,’’ IEEE Access, vol. 7, pp. 10467–10477, 2019
2. Mastromauro, T. Kerekes and M. Liserre, “A Single-Phase Voltage-Controlled Grid-Connected Photovoltaic System With Power Quality Conditioner Functionality” The transactions IEEE reference on Industrial Electronics, volume Number 56, Number 11, and Part Percent. 4436–4444, November 2017.
3. High-performance adaptive perturb and observe MPPT technique for photovoltaic-based microgridsAK Abdelsalam, AM Massoud, S Ahmed, PN EnjetiIEEE Transactions on power electronics 26 (4), 1010-1021.
4. Elgendy and Atkinson, “Calculation forperturbing and analyses MPPTmethod used to estimate the PV (PhotoVoltaic) pumping applications& methods,” The IEEE Transactions on the Supportable Energy, volume 3, Number. 1, pp. 21–33, January 2012.
5. Comprehensive Studies on Operational Principles for Maximum Power Point Tracking in Photovoltaic Systems, Xingshuo Li Qi Wang 1, Huiqing Wen AndWeidong Xiao3, Volume 7, 2019.
6. K. Rajesh, A.Kulkani and T.Ananthapadmanabha, “Modeling and Simulation of Solar PV and DFIG Based Wind Hybrid System”, Procedia Technology, Vol.21, pp.667-675, 2015.
7. S. Jain and V. Agarwal, “A Single-Stage Grid Connected Inverter Topology for Solar PV Systems with Maximum Power Point Tracking,” IEEE Transactions on Power Electronics, vol. 22, no.5, pp. 1928-1940, September 2007.
8. N. Femi and M. Vitelli, “The accrue of perturbing& observe analyses the electric maximum power value method,” The IEEE Transactions on EPE, vol. 20, no. 4, pp. 963–973, Jul. 2005.
9. Ishita Biswas, Prabodh Bajpai, “Control of PV-FC-Battery-SC Hybrid System for Standalone DC load”

The IEEE Transactions, 2014.

10. N.Mezzai, DjamilaRekioua, ToufikRekioua, Ahmed Mohammedi "Modeling of photovoltaic/wind/fuel cells power system, September 2014, International Journal of hybrid Hydrogen Energy 39(27):15158–15168.
11. Mohammad Junaid Khan, Lini Mathew "Fuzzy logic controller-based MPPT for hybrid photo-voltaic/wind/fuel cell power system", March 2018, Neural Computing and Applications.
12. Prashanth, V. et al. Implementation of high step-up power converter for fuel cell application with hybrid MPPT controller. Sci. Rep. 14, 3342. 2024.
13. Hussaian Basha, C., Palati, M., Dhanamjayulu, C., Muyeen, S. M. & Venkatareddy, P. A novel on design and implementation of hybrid MPPT controllers for solar PV systems under various partial shading conditions. Sci. Rep. 14, 1609. (2024).
14. Zaghba, L., Khennane, M., Borni, A., Fezzani, A., Bouchakour, A., Mahammed, I.H. et al. An enhancement of grid connected PV system performance based on ANFIS MPPT control and dual axis solar tracking, in 2019 1st International Conference on Sustainable Renewable Energy Systems and Applications (ICSRESA), 1–6 (IEEE, 2019).
15. Zaghba, L., Khennane, M., Borni, A., Fezzani, A., Bouchakour, A., Mahammed, I. H., et al. A genetic algorithm based improve P&O-PI MPPT controller for stationary and tracking grid-connected photovoltaic system, in 2019 7th International Renewable and Sustainable Energy Conference (IRSEC), 1–6 (IEEE, 2019).
16. Padmanaban, S. et al. A hybrid ANFIS-ABC based MPPT controller for PV system with anti-islanding grid protection: Experimental realization. IEEE Access **7**, 103377–103389.
17. Zaghba, L., Khennane, M., Borni, A. & Fezzani, A. Intelligent PSO-fuzzy MPPT approach for stand alone PV system under real outdoor weather conditions. Alger J. Renew. Energy Sustain. Dev. 3, 1–12. (2021).
18. Mao, M. et al. Classification and summarization of solar photovoltaic MPPT techniques: A review based on traditional and intelligent control strategies. Energy Rep. 6,1312–1327. (2020).
19. K.Teja Power Control of a Grid Connected Hybrid Fuel Cell, Solar and Wind Energy Conversion Systems by Using Fuzzy MPPT Technique pp.223-23.May 2022
20. G.Tejaswi, S. Ramesh Kumar and Ch. Ravi Kumar, Integration of Power Grid Associated Wind, Fuel Cell & Solar Energy Systems Implementing Fuzzy MPPT Technique ISSN: 0976 – 0997 Vol.12 / Issue 70 / February / 2022.
21. Farzaneh J, Keypour R, Khanesar MA (2018) A new maximum power point tracking based on modified firefly algorithm for PV system under partial shading conditions. Technol Econ Smart Grids Sust Energy 3(1):9
22. Saad, W., Hegazy, E. & Shokair, M. Maximum power point tracking based on modified firefly scheme for PV system. *SN Appl. Sci.* 4, 94 (2022).
23. X. S. Yang, "Firefly algorithm, stochastic test functions and design optimization", Int. J. Bio-inspired Computation, 2, 78-84 (2010).
24. Abo-Khalil, A.G.; Alharbi,

24. W. Al-Qawasmi, A.-R. Alobaid, M. Alarifi, I.M. "Maximum Power PointTracking of PV Systems under PartialShading Conditions Based onOpposition-Based Learning Firefly Algorithm. Sustainability" 2021, 13,2656.

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