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POWER MANAGEMENT SYSTEM OF A MODIFIED PSO CONTROLLED GRID INTEGRATED HYBRID DISTRIBUTED GENERATION SYSTEM

[1]Sri. T. Praveen, [2]S. Uma Maheswari,[3]V. Ganesh,[4]B. Varun, [5]Ch. Akshay khanna
[1]Assistant Professor, Dept. of EEE, Kakatiya Institute of Technology & Science, Warangal,India
[2,3,4,5] EEE Dept.Kakatiya Institute of Technology & Science, Warangal,India

***Abstract* -** In this project, we suggest a power management system for a grid-integrated system having hybrid distributed generation system using the Modified Particle Swarm Optimization (MPSO) algorithm. The hybrid DG system incorporates solar PV panels, wind turbines, fuel cells, and batteries. Depending on the utilization of these hybrid sources and variations in power production, the DG system experiences fluctuations in power output. The main aim of our proposed method is to optimize the active and also reactive power flow (PF) between the source and grid. We achieve this by employing the MPSO method in the power system control, maximizing PF and ensuring efficient operation.

Our method also considers load requirements and maintains load sensitivity during battery charging and discharging. By allowing maximum power flow, the proposed MPSO method enhances the DG system's performance. To evaluate power flow (PF), we analyze equality and inequality constraints, which help to find availability of renewable energy sources (RES), power demand, and charge levels in storage devices. Additionally, the proposed PSO method contributes to power system protection. We validate our approach through MATLAB/Simulink simulations, comparing various parameters and efficiencies with existing algorithms.

***Keywords:*-** MICRO GRID, HYBRID DISTRIBUTED GENRATION, MPSO ALGORITHM

I. INTRODUCTION

In the production of energy system the power production and power management attains important concerns between several studies. In the production of electrical power the fossil fuels are considered as one of the most important source in the previous years. Moreover, the global warming can cause due to the emission of CO2 by fossil fuels. In context of environmental issues such as reduction of green-house gases, the utilization of renewable energy sources (RES) has increased remarkably and is being accepted comprehensively as a major alternatives for conventional fuel-based energy generation. In the production of electrical power the DG is one of the important components based on the RES. For the production of energy DG is modernized forms and also it has minimum power loss, high voltage profile and between feeders suitable balance of load.

These technologies incorporate renewable energy sources (RESs), for example, Wind plant (WT), Solar (PV), micro-Hydro (MH) and clean alternative energy (AE). Penetrations of renewable energy advantages incorporates reduction in external energy reliance, decline in transmission and transformation losses and further improve the reliability of the system. Double energy sources, for example, wind and solar energy are utilized to build the energy reliability. Be that as it may, the output of wind-solar energy is influenced because of the seasonal climatic and geographic conditions.

Accordingly, so as to improve the reliability of the energy supply a third energy system is required. Accordingly, the battery storage system ideally satisfies the requirement for any start up power.

II. HYBRID DISTRIBUTED GENERATION

In the production of energy system, the power production and power management attains important concerns between several studies. In the production of electrical power the fossil fuels are considered as one of the most important source in the previous years. Moreover, the global warming can cause due to the emission of CO2 by fossil fuels. In context of environmental issues such as reduction of greenhouse gases, the utilization of renewable energy sources (RES) has increased remarkably and is being accepted comprehensively as a major alternative for conventional fuel-based energy generation. In the production of electrical power the DG is one of the important components based on the RES.

For the production of energy DG is a modernized forms and also it has minimum power loss, high voltage profile and between feeders suitable balance of load.

Distributed generation involves the production and storage of electricity using small-scale devices connected to local grids or distribution systems. These devices are collectively called as distributed energy resources (DER). Unlike conventional power stations(like nuclear, coal, gas), which are centralized and transmit energy to longer distances, DER systems are flexible, and located close to the point of consumption. Although their capacity is typically limited to 10 megawatts (MW) or less, these systems combine various generation and storage elements, forming what we call hybrid power systems.

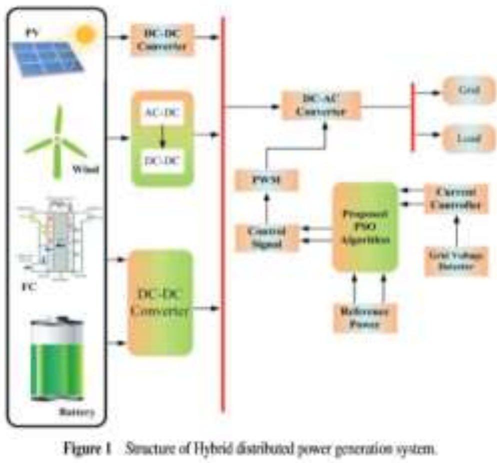

Fig.1 Structure of Hybrid Distributed Power Generation System

III. MODIFIED PSO ALGORITHM

The primary objective of the suggested method is to regulate the power factor (PF) by managing the interplay between active and reactive power at the interface among the energy source and the grid. In power system control, the proposed Modified Particle Swarm Optimization (MPSO) method is employed to optimize both active and the reactive power factors, enhancing overall system performance. In this study, we propose an approach that effectively manages load requirements, energy interactions, and maintains load sensitivity during battery charging and discharging. Specifically, in distributed generation (DG) systems, we introduce a Particle Swarm Optimization (PSO) method that optimizes power flow, allowing for maximum utilization. Additionally, we present a method for managing power flow for grid-connected Hybrid Renewable Energy Systems (HRES) using a modified strategy. The modified strategy is the execution of Modified Particle Swarm Optimization (MPSO) algorithm. The searching behavior of the swarm is modified by using the efficient neighborhood search functions like crossover and mutation. Here grid consists of Fuel cell, Wind plant, Solar plant, Battery for storage.

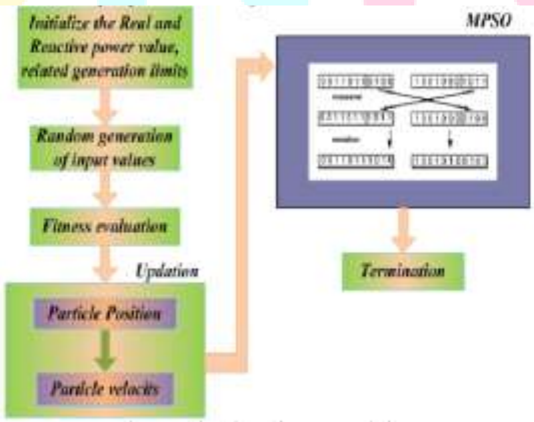

Fig.2 Modified PSO algorithm

A power management method is exhibited in this paper for grid connected HRES system incorporating different RES and storage units. This approach is executed in Matlab platform and their execution is verified and proposed technique result is compared with exiting strategies, for example, PI, GA and PSO respectively.

From the results we got economical power operating costs and usage of RES for the micro grid and it works great and it will provide power strategy to the generators subsequent to considering the objective functions. On the overall analysis, the proposed approach gives optimal solution than the other existing techniques.

IV. MATHEMATICAL MODELLING

4.1 MODELLING OF PV CELL

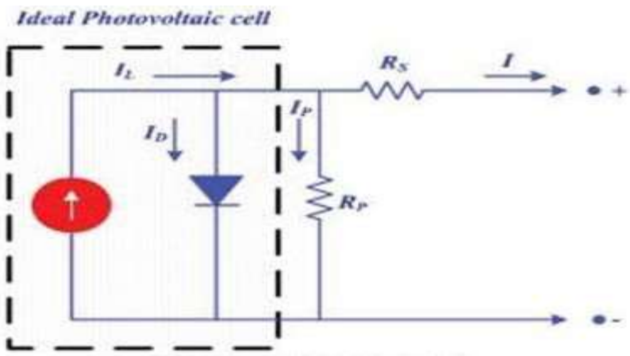

Fig 4.1 Solar array equivalent circuit

The equations of PV system is given as follows,

$$I_{pv}(V_{pv}) = I_{PH} - I_D - I_P \qquad (1)$$

$$I_{PV_v}(V_{PV}) = I_{PH} - I_S\left[Exp\left(\frac{Q(V_{PV}+R_S I_{PV})}{A_C K_B t} - 1\right)\right] - \left(\frac{V_{PV}+R_S I_{PV}}{R_P}\right) \qquad (2)$$

From the above equation, I_P denotes leakage current of shunt branch, I_D is produced current, I_S indicates saturation current, Q implies electron charge, K_B denotes Boltzmann's constant, AC indicates ideality factor.

T indicates temperature of PV system, I_{PV} indicates PV cell current, V_{PV} indicates voltage in PV unit.

The output performance of photovoltaic unit is evaluated based on short circuit current (SC), open circuit (OC) voltage, maximal power point current and voltage. Under specified conditions then linear interactions of PV systems is developed as following.

$$I_{PV}(V_{PV}) = I_{SC}\left[1 - C_1\left\{Exp\left(\frac{V_{PV}}{C_2 U_{OC}}\right) - 1\right\}\right] \qquad (3)$$

$$C_1 = \left(1 - \frac{I_{MPP}}{I_{SC}}\right) Exp\left(-\frac{U_{MPP}}{C_2 U_{OC}}\right) \qquad (4)$$

$$C_2 = \left(\frac{U_{MPP}}{U_{OC}} - 1\right)\left[\ln\left(1 - \frac{I_{MPP}}{I_{SC}}\right)\right] \qquad (5)$$

4.2 MODELLING OF FUEL CELL

Unit voltage of FC us given by:

$$V_{FC} = No\left[E_O + \frac{rt}{2F}\ln\left(\frac{Ph_2 P_{O2}^{0.5}}{Ph_2 O}\right)\right] - Ri_{FC} \qquad (6)$$

R is universal gas constant, t indicates as the temperature of stack temperature in the context of fuel cell (FC), several key parameters play a crucial role.

The Faraday constant(F) represents the charge transferred during electrochemical reactions. The reaction free energy voltage (EO) is an expression of the cell's potential. The stack internal resistance R accounts for losses within the FC stack. The cell count in the stack is denoted by NO. Additionally, PFC signifies the system current, while Ph_2O, Ph_2 and PO_2 represent the partial pressures of water, hydrogen and oxygen, respectively. These parameters collectively contribute to the dynamic modelling of fuel cells. Modelling of FC:

$$Qh_2^{in} = \frac{1}{1+ST_F}\left[\frac{2KR}{U_{OP1}} i_{FC}\right] \quad (7)$$

$$Q_{O_2}^{in} = \frac{1}{Rho} Qh_2^{in} \quad (8)$$

$$Ph_2 = \frac{1/Kh_2}{1+S_T K_2}\left[Qh_2^{in} - 2KRi_{FC}\right] \quad (9)$$

$$P_{O_2} = \frac{1/KO_2}{1+S_{TO_2}}\left[\frac{1}{Rho} Qh_2^{in} - Kri_{FC}\right] \quad (10)$$

$$Ph_2O = \frac{1/Kh_2O}{1+S_T h_2O}\left[2Kri_{FC}\right] \quad (11)$$

Here Kh_2 tells hydrogen (H) molar index valve, QH_2 indicates flow rate of hydrogen, Th_2 is indicates as the hydrogen time constant, KO_2 is explained as the oxygen molar index valve, flow rate for oxygen (O) as Qo_2, TO_2 is constant time of oxygen, Kh_2O is expressed as the water molar index valve, Th_2O as water constant time as, constant.

4.3 MODELLING OF BATTERY CELL

In battery internal resistance, open circuit voltage and two series RC circuits are presented.

$$V_{OC} = 338.8 * \left(0.94246 + SOC(0.05754)\right) \quad (12)$$

$$R_a C_p \frac{DE_a}{DT} + E_a\left(\frac{R_a + R_b}{R_b}\right) = V_{oc} + E_b \frac{R_a}{R_b} \quad (13)$$

$$R_b C_i \frac{DE_b}{DT} + E_b = E_a - R_b I_{tb} \quad (14)$$

$$\frac{DSOC}{DT} = \frac{I_{tb}}{Qm} \quad (15)$$

Here equation, V_{OC} is the open circuit voltage, R_a is internally it have resistance, R_b as terminal resistance, C_P denotes polarization C_1 denotes incipient capacitance, Q_M implies optimal battery charge.

V. ENERGY MANAGEMENT OF GRID CONNECTED MICRO GRID

In this proposed work, a method of controlling is proposed for better management of energy in the DG connected system. The control scheme is the Modified Particle Swarm Optimization Algorithm (MPSO). The MG connected system used here includes the PV, wind plant and the energy storing mechanism. The suggested control method is the power flow management among the sources and the grid. Likewise, to keep up the grid energy demand from the grid operator and to meet the accessible RES is the present technique. By the grid operator the reference to the input of MG is given as the electric power required.

Crossover: The crossover rate is achieved between the two particles which generate a new set of salps. into the particles fitness value and new generated population, the process is performed.

Mutation: A randomly mutation occurs for particles by Particular mutation rate in the mutation process. For calculating the crossover CO and mutation MU rate of salps are calculated. The process until it reaches reaches the maximum number of iterations or the minimum error value. In Microgrid power management is controlled by varying parameters at source and load side. Also, to generate the power demanded by grid proposed methodology, it is responsible for controlling the energy sources using both HRESs and energy storage elements. the flowchart of suggested technique. The experimental evaluation outcome of the suggested algorithm over existing techniques are presented in this section.

The performance analysis of the proposed method and the present techniques such as proportional integral (PI) controller, GA, PSO are investigated. The system is tested under three test case conditions:

Case 1: Load Fault

Case 2: Step Irradiation

Case 3: Zero Irradiance

5.1 Under Load Fault Condition

This section examines the suggested technique's performance analysis in the event of a load fault. .Whenever there is a load fault, the solar energy's irradiance is set to a constant 1000 W/m2 for a time intervals of 0 to 1 second. It displays the performance analysis using the suggested technique for wind, PV, battery, and FC power. It can be seen that the wind power changed between 0.02 and 0.1 seconds at a maximum power of 3400 W. The maximum power of 5800 W is reached by the PV power during load fault situations when the recommended approach is used to the system. The electricity resumes to its regular flow of 4800 W after 0.2 seconds. The system resumes its typical power flow of 6000 W at intervals of 0.25 to 1 sec when the recommended method is used. At a time interval of 0.001 seconds, the battery power at beginning state yields a peak power value of 11000 W

Use of this approach, the system abruptly fixes the problem and efficiently controls the input power flow, delivering a maximum power of 3500 W at a time instant of 0.3 to 1 second. The suggested approach is then introduced into the system, and it evidently mitigates the load fault instantaneously at the time instant of 0.3 to 1 sec with a maximum power of 1.9*104 W. The load fault happens in the system's inception stage

With the aid of the suggested approach, the system's total power demonstrably reduces error and efficiently controls the power flow. The solution of the PI controller converged at the count of 35 iterations. At the 38 iteration range, the GA solution converged. At 33 iterations, the PSO solution converges. However, when compared to the current methods with the iteration count at 30, the suggested strategy is more optimum and converged instantaneously.

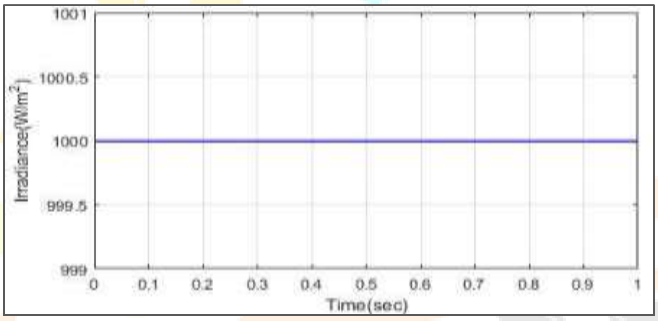

Fig 5.1.1 Constant Irradiation

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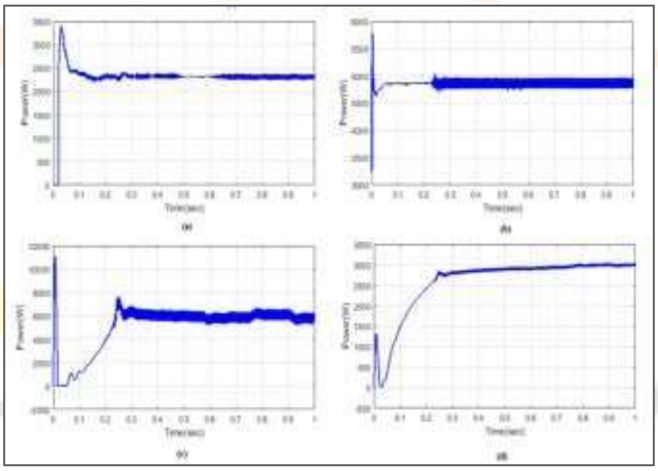

Fig 5.1.2 Performance analysis of Wind power, PV power, Battery, FC power

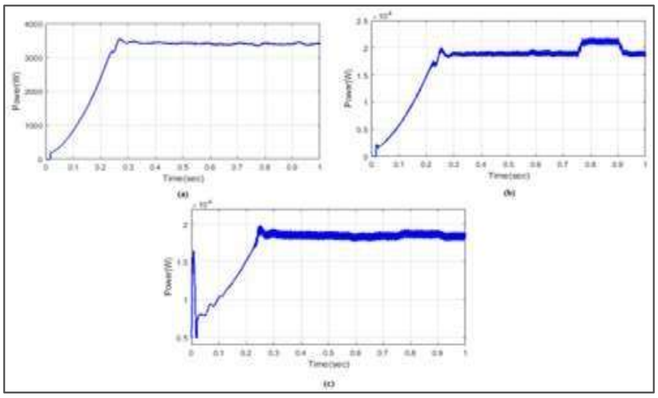

Fig 5.1.3 Performance Analysis of Grid power, Load power, Total power

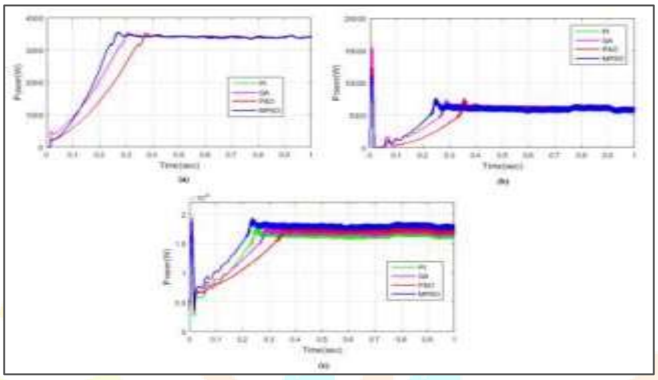

Fig 5.1.4 Comparison Analysis of Battery power, Grid power, Total power

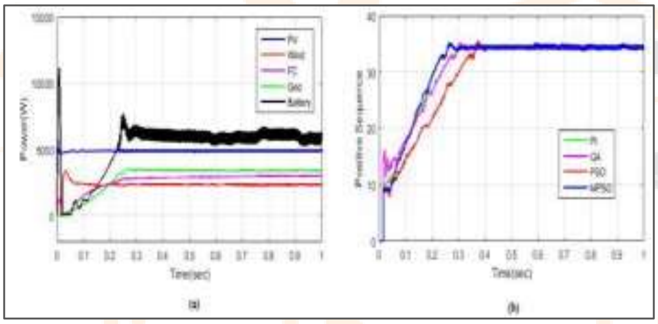

Fig 5.1.5 Comparison Analysis of (a) Individual power (b) Inverter voltage

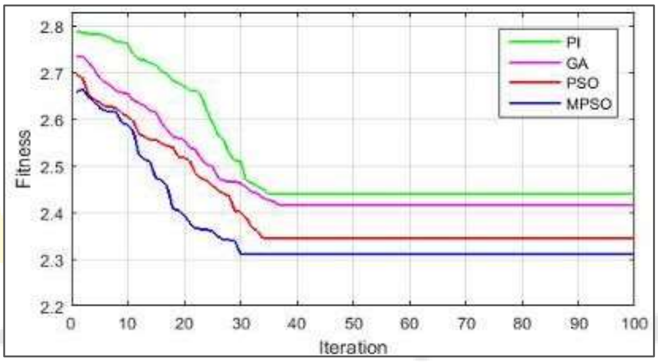

Fig 5.1.6 Fitness comparison

5.2 Under Step Irradiation Condition

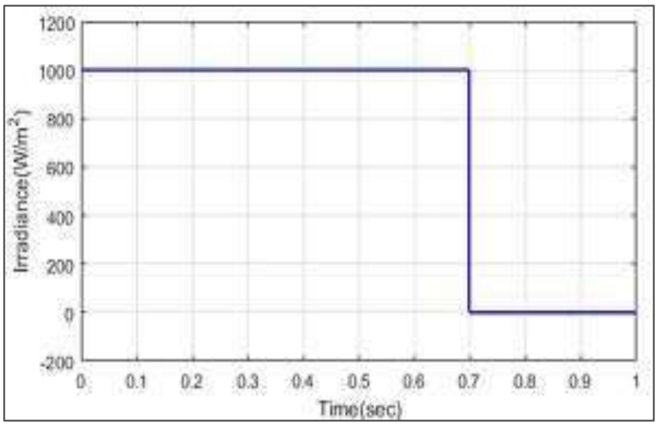

Fig 5.2.1 Irradiance vs Time

This section looks at the proposed technique's performance analysis under step irradiation conditions. The proposed technique have working analysis of battery, wind, PV, and FC power. The chart shows that the wind power fluctuated between 0.3 and 0.1 seconds, with a maximum output of 3450 W. When the suggested approach is implemented into the system, the PV power under load fault conditions achieves its maximum power of 4300 W. After 0.3 seconds, the power reaches the normal flow of power with a value of 3500 W.

When the suggested strategy is used, the system returns to its regular power flow of 6000 Wat time intervals of 0.3 to 1 seconds. At first, the battery power provides a peak power value of 11000 W at 0.001 seconds. It shows the FC power versus time graph. The chart shows that, undernormal power flow conditions, the FC produces the maximum power of 3000 W in 0.25 to 1 seconds at the time instant.

Therefore, it illustrates how the suggested approach's integration withthe system's PV, wind, battery, and FC power produces a regular power flow in the grid-connected HRES system. It has been noted that the load fault status causes a minor interruption in the grid power duringstartup.

With the use of the suggested approach, the system abruptly fixes the problem and efficiently controls the input power flow, delivering a maximum power of 3500 W at a time instant of 0.3 to 1 second. The suggested approach is then introduced into the system, and it evidently mitigates the load fault instantaneously at time instant of 0.3 to 1 sec with a peak power of 1.98*104 W. The load fault happens in the system's inception stage.

With the aid of the suggested approach, the system's total power demonstrably reduces error and efficiently controls the power flow. The suggested and current approaches' inverter voltage comparison. With a maximum voltage value of 34, the suggested approach provides the voltage value ideally at time instants ranging from 0.3 to 1 sec. It shows the suggested technique's fitnesscomparison with the current methods. According to the figure, the solution of the PI controller converged at the 42nd iteration count. The GA's solution reached convergence at the 39 iteration range. The iteration count converges at 35 in the PSO solution. In contrast to the current methodsand its 32 iteration count, the suggested approach is more optimum and converges instantaneously.

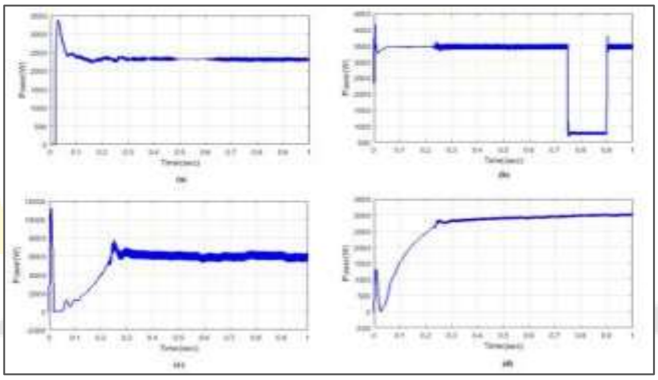

Fig 5.2.2 Performance Analysis of (a) Wind power (b) PV power (c) Battery power (d) Fc power

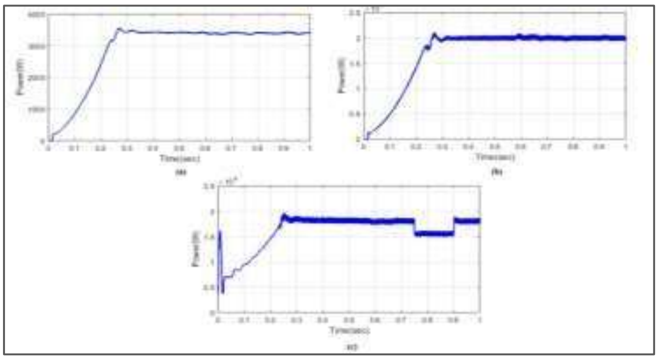

Fig 5.2.3 Performance Analysis of (a)Grid power (b)Load power (c)Total power

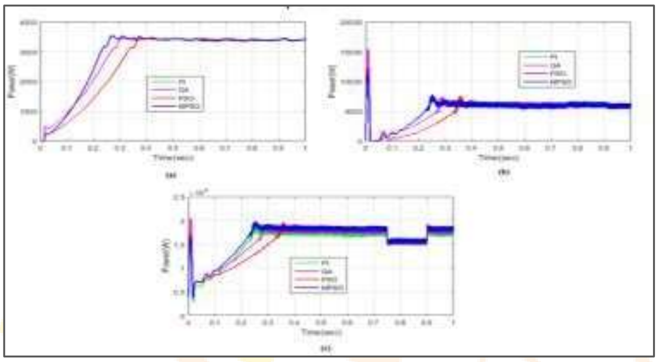

Fig 5.2.4 Comparison analysis of (a) Battery power (b) Grid power (c) Total power

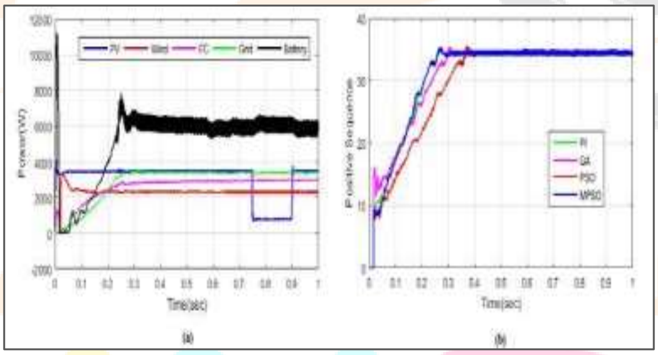

Fig 5.2.5 Comparison analysis of (a) Individual power (b) Inverter voltage

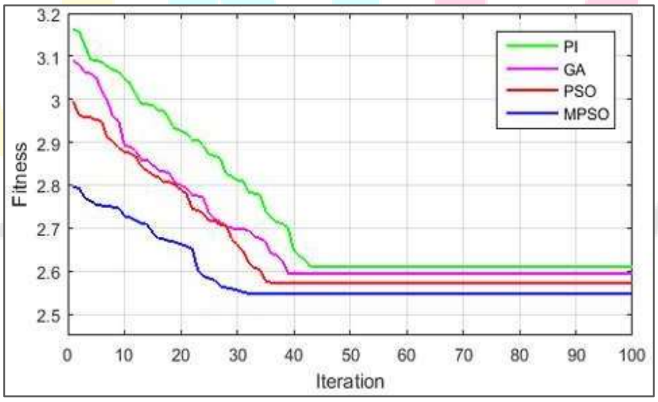

Fig 5.2.6 Fitness comparison

5.3 Under Zero Irradiation Condition

This section looks at the suggested procedure's performance analysis at the time of a load fault. Shows irradiance versus time graph. When there is a load failure, the solarenergy's irradiance is set to be constant at 1000 W/m2 for 0 to 1 second, and it transitions to zero irradiation for 0.7 to 1 second. Uses the suggested approach to demonstrate the performance analysis of battery, wind, PV, and FC power. It can be observed that there was a difference in windpower between 0.3 and 0.1 seconds at the highest power of 3480 W. When there is a load fault, the PV control reaches its maximum power of 4900 W, and it reaches zero power with a value of0 W in 0.7 to 1 seconds.

When the suggested strategy is associated, the system returns to its usual power flow of 6000 W at time periods of 0.3 to 1 seconds.The battery power at initial conditiondelivers the highest power value of 11050 W at time interval of 0.001 sec. The graphic illustrates how the FC produces the most power under typical power flow conditions, with a power value of2800 W, at a time interval of 0.25 to 1 second.

This illustrates how the suggested approach's integration with the system's PV, wind, battery, and FC power sources allows the grid-connected HRES system to function normally. The graph efficiently controls the power flow throughout the system and displays the maximum power output from the MG system.

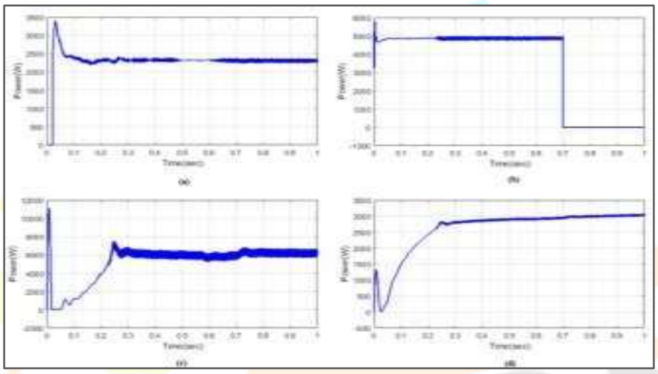

Fig 5.3.1 Performance Analysis (a) Wind power (b) PV power (c) Battery power (d)FC power

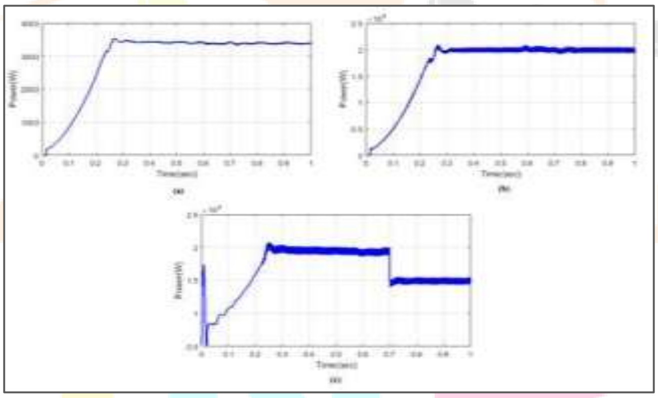

Fig 5.3.2 Performance Analysis (a)Grid power (b)Load power (c)Total power

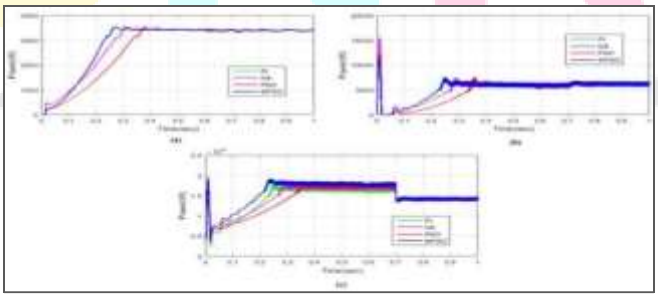

Fig 5.3.3 Comparison Analysis of (a) Battery power (b) Grid power (c) Total power

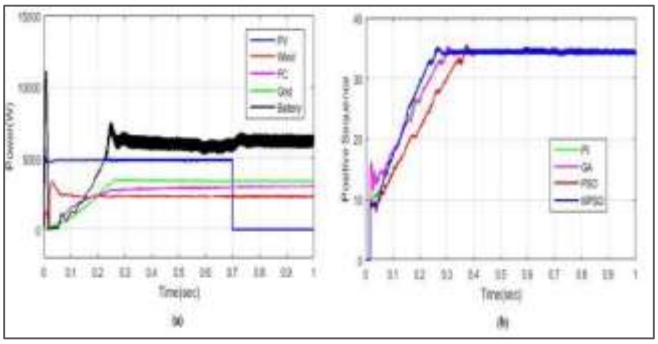

Fig 5.3.4 Comparison Analysis of (a) Individual power (b) Inverter voltage

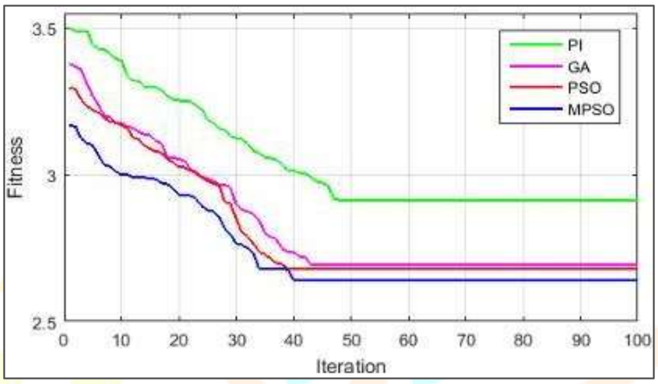

Fig 5.3.5 Demonstrates the graph of Grid power, Load power

VII. CONCLUSION

A power management scheme is exhibited in this paper for grid connected HRES system incorporating different RES and storage units. The suggested approach is executed in Matlab. The proposed method performance is compared with exiting strategies, for example, PI, GA and PSO respectively. From the results got, plainly from the economical power operating costs and usage of RES for the MG that the optimization will works effectively and they provide best optimal power strategy to the generators subsequent to considering the objective functions. On the overall analysis, the proposed approach gives optimalsolution than the other existing techniques.

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