

# An effective renewable X-boosting detection using Super hybrid energy micro grid application

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**Abstract** — The capacity of the global energy organisation to boost the use of renewable energy sources, such as solar and wind, in smart power networks will continue until 2050. Uncertainty is inherent in using a renewable-based grid, and this might lead to unique grid operational difficulties. Efforts to identify the best feasible answer to a given issue are of crucial significance in business and applications. A meta-heuristic inspired by grey wolf leadership hierarchy and hunting behaviour is proposed for fuzzy controller optimization for mobile autonomous robots in this study. A simulation of two wheeled autonomous mobile robots based on MOGWO is used to demonstrate the effectiveness of the suggested approach. Power grid optimization requires a combination of storage units to assist adjust the framework while regulating various sources of vulnerability, with the primary aim being to find the best solution feasible to a given situation. PI controllers for mobile autonomous robots may be optimised using MOGWO, a meta-heuristic inspired by grey wolf leadership hierarchy and hunting behaviour. Further evidence that the suggested technique based on MOGWO is effective is provided by simulation results for a two-wheeled autonomous mobile robot.

**Keywords-** PV model, energy management, MOGWO, artificial neural network (ANN), smart distribution grid (SDG), distribution grid (DG)

## Introduction

These days, respect to exhaustibility of concerted attempts and fossil fuels to diminish the use of these sources, numerous nations have been planned to utilize renewable energy sources those are utilized fundamentally in active distribution and micro grids. The micro grids are comprised of little generation units in medium and low voltage levels that incorporate sources like fossil-based DGs, renewable energy sources like photovoltaic, wind, and energy storage frameworks. The micro grids have been deployed to supply an assortment of demand kinds like industrial, residential, and agricultural consumptions, and resultant expenses and costs are acquired in consistence with market structure instructions [1], [2]. The optimal activity of micro grids gives high power quality to providing loads, increments dependability of system, and diminishes power losses, functional expenses, and discharge. Respect to advances in renewable generation methods like in photovoltaic panels and wind turbines those are inconceivably utilized in micro grids, and contemplating to stochastic behavior of solar and wind energy. The estimation of behaviors of these sources to accomplish much proficient activity might be directed to extensive environmental and economic advantages. Various purposes like environmental limitations, economic restrictions, and loss decrease objectives have been deliberated in activity of active distribution and micro grids [3-5]. There are different examinations about active distribution and micro grids operation those are assessed as follows:

In [6-7], just the expense decreases relating to fuel utilization of thermal units are researched. In these works, furthermore electrical power balance, the imperative of thermal energy balance needed for micro grids' warming applications are considered. In [7], the impact of weather predicting blunder on operation outcomes of micro grids comprises of solar cell, battery bank, fuel cell, and thermal tank, are deliberated. The works [8-12], the functional expenses are also deliberated subject to limit them. In [10], the yearly fuel price of micro grid incorporating a fuel cell, micro-turbine, and "piston-based generator" is limited dependent on "Berkeley laboratory method" for distributed generation.

The work [11] suggested a "smart energy management" framework is utilized for optimization cost of a micro grid that is associated with fundamental grid. In this framework, the o/p power of solar cells is anticipated by ANN. As for past segments, optimization of smart grids and micro grids require much examination. In this manuscript, an alternate objective function is introduced. The suggested objective function prompts to reduction of complete grid loss, decrease of framework contamination, decrease of voltage deviation, and reduction of complete energy prices within operation horizon. Moreover, stated objectives, MOGWO have been utilized to optimize the suggested optimization method. To accomplish the referenced points, the methods of micro grid's component have been introduced in segment 2. Then, in segment 3, the equations, objective function, and limitations of micro grid are portrayed. In 4<sup>th</sup> section, the optimization strategy of MOGWO method is described.

## Modeling of Solar Cell

The power-radiation linear feature of solar cell might be reached by Eq. (1)

$$P_{pvy}(R_{ay}) = N \times FF \times V_y \times I_y \quad (1)$$

$$T_{cy} = T_A + R_{ay} [N_{OT} - 20/0.8] \quad (2)$$

$$I_y = R_{ay} [I_{sc} + k_i (T_c - 25)] \quad (3)$$

$$V_y = V_{oc} - k_v \times T_{cy} \quad (4)$$

$$FF = \frac{V_{MPP} \times I_{MPP}}{V_{oc} \times I_{SC}} \quad (5)$$

In Eqs. (1)-(5),  $T_A$  be the ambient temperature in terms of Co,  $T_{cy}$  be the temperature of cell within the yth interval in terms of Co,  $K_i$  signifies the coefficient of current temperature regarding A/Co,  $K_v$  signifies coefficient of voltage temperature regarding V/Co,  $V_{oc}$  is open circuit voltage in V,  $N_{OT}$  be the nominal cell temperature in Co,  $I_{sc}$  signifies the short circuit current in A,  $FF$  signifies fill factor,  $V_{MPP}$  displays the panel voltage while power is in highest point regarding V,  $I_{MPP}$  stands for current while power is in highest point regarding A,  $R_{ay}$  signifies average sun radiation in yth interval, and  $P_{pvy}$  is o/p module power in yth interval. Hence, average solar cells power might be estimated by Eq. (6):

$$P_{Ave,pv} = \sum_{Ry1}^{Ry2} P_{pvy}(R_{ay}) \times P_R \{G_y\} \quad (6)$$

$$P_R \{G_y\} = \int_{Ry1}^{Ry2} f_b \{R\} dr \quad (7)$$

In Eq. (7),  $f_b(R)$  be the probability “distribution density function” of sun radiation, and  $\Pr\{G_y\}$  be solar radiation probability in  $y$ th interval; and  $R_{y1}$  and  $R_{y2}$  signifies start and end borders of targeted interval [22], [23].

## Optimal Management of SDG

These days, optimal activity of SDG utilizing multi-objective functions is main challenge. In these methods, various objectives must be processed and optimized in equal. For best optimization of these sorts of functions, inequalities, equalities, and limitations of issue must be deliberated. The optimal activity of SDGs is portrayed in accompanying parts:

### A. Suggested objective function

1) Diminishing complete grid loss for any SDG, establishment of DG will lead to variance in power losses profile in grid. Certainly, in DG, the element of “power loss curve” might be demonstrated by quadratic capacity that has been reliant upon “active power generation” [28].

$$P_{Loss} = \sum_{j=1}^{N_{br}} R_j (I_j)^2 \quad (8)$$

$$f_1 = \text{Min} \sum_{t=1}^{N_t} P_{Loss}^t \quad (9)$$

Where  $N_{br}$  be the number of branches,  $R_j$  and  $I_j$  are the opposition and current of  $j$ th branch separately. As indicated by what referenced, the transmission misfortune has direct a connection with  $RI^2$ . Hence, expansion in DG limit in any bus of SDG prompts decline of complete loss of framework. It must be seen that if number of DGs excesses from specific sum, the loss will increment once more.

2) Limiting voltage deviation of load assesses the voltage amplitude deviation of buses from its nominal value [29].

$$|\Delta V_2| = \sum_{i=1}^{N_d} |V_i - V_{base}| \quad (10)$$

$$f_2 = \text{Min} \sum_{t=1}^{N_t} |\Delta V_2^t| \quad (11)$$

In Eq (10) and (11),  $N_{br}$  is the number of buses,  $V_{base}$  and  $V_i$  standard voltage of system and stand for  $i$ th bus voltage, correspondingly.

## The GWO Method

### A. Overview

Grey wolf is a type of social life creature and has a strict hierarchical method displayed in Figure 1.

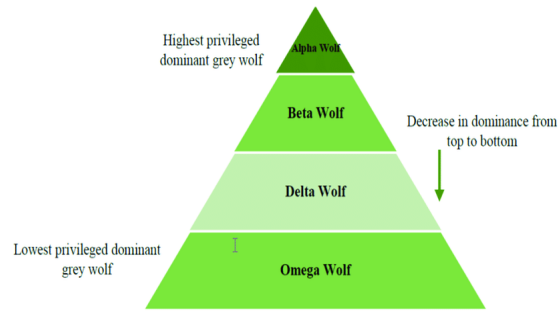


Figure 1: Grey wolves hierarchical structure

In nature, the grey wolves normally live in groups. As displayed in Figure 1, 4 sorts of wolves have been living in group. The Leader wolf in group is named as alpha ( $\alpha$ ) that is placed at highest point of pyramid. The alpha might not be robust wolf in group; however it should be good leadership manager. It is answerable for making significant decisions for group like food distribution or predation conduct. Situated on 2nd floor of pyramid is named as beta ( $\beta$ ) that performs the part of alpha. It only requires regarding alpha and it might command others. The 3rd level wolf is delta ( $\delta$ ) that should submit to guidelines of beta and alpha. The lower part of pyramid named as omega ( $\omega$ ). The omega has to submit to every other person in group.

#### B. Mathematical method

The grey level is defined by fitness function. As indicated by fitness value, the good fitness result is the delta\_wolf, beta\_wolf, and alpha\_wolf. In this manuscript, these 3

results have been set as key-bunch. The remaining wolves are omega\_wolf. The procedure of predation is isolated into 3 procedures as follows.

##### 1) Encircling prey

$$\vec{D} = \left| \vec{C} \cdot \vec{X}_p(t) - \vec{X}(t) \right| \quad (12)$$

$$\vec{X}(t+1) = \vec{X}_p(t) - \vec{A} \cdot \vec{D} \quad (13)$$

In these 2 formulas, T+1 the subsequent iteration. X signifies location of one wolf. X p signifies the location of prey, D and A are coefficient vectors. The estimation model is modeled by subsequent formulas.

$$\vec{A} = 2\vec{a} \cdot \vec{r}_1 - \vec{a} \quad (14)$$

$$\vec{C} = 2 \cdot \vec{r}_2 \quad (15)$$

$$\vec{X}(t+1) = \frac{\vec{X}_1 + \vec{X}_2 + \vec{X}_3}{3} \quad (16)$$

$$\vec{X}_1 = \left| \vec{X}_\alpha - \vec{A}_1 \cdot \vec{D}_\alpha \right| \quad (17)$$

$$\vec{X}_2 = \left| \vec{X}_\beta - \vec{A}_2 \cdot \vec{D}_\beta \right| \quad (18)$$

$$\vec{X}_3 = \left| \vec{X}_\delta - \vec{A}_3 \cdot \vec{D}_\delta \right| \quad (19)$$

$$\vec{D}_\alpha = \left| \vec{C}_1 \cdot \vec{X}_\alpha - \vec{X} \right| \quad (20)$$

$$\vec{D}_\beta = \left| \vec{C}_2 \cdot \vec{X}_\beta - \vec{X} \right| \quad (21)$$

$$\vec{D}_\delta = \left| \vec{C}_3 \cdot \vec{X}_\delta - \vec{X} \right| \quad (22)$$

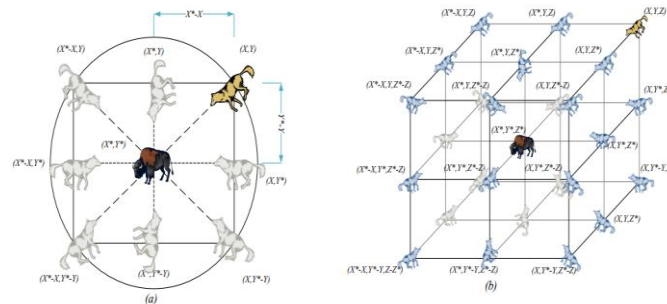


Figure 2: 2D and 3D position vectors and their possible next locations

Here, random numbers are r1 and r2 are in [0,1].

## 2) Hunting prey

At the point when the wolf group has defined prey location, delta wolf, beta wolf, and alpha wolf lead the wolf group to surround the prey. Expect that they identify place of prey. Therefore, store the best 3 results, which are acquired so far as key-group and upgrade the place of every wolf in group as per key-group. These formulas for position have been displayed as follows.

Represent the best three  $\delta$ ,  $X_\beta$ ,  $X_\alpha$  Where  $X$  solutions so far through iteration procedure that are the key-group. The other factors have been provided by subsequent formulas.

## 3) Attacking prey

In common, grey wolves typically attack the prey while it stops moving. Thus, grey wolves' behavior approaching the prey is modeled by subsequent formula.

$$A = 2 - 2 \left( \frac{t}{Max} \right) \quad (23)$$

Here, t means the number of times the current method is running that is integer value among 0 and Max.

The pseudo code of GWO method is displayed in Table 1.

**Table: 1**

Initialize the grey wolf population $X_i$ ( $i = 1, 2, \dots, n$ ) Initialize $a$ , $A$ , and $C$ Calculate the fitness of each search agent $X_\alpha$ =the best search agent $X_\beta$ =the second best search agent $X_\delta$ =the third best search agent while ( $t < \text{Max number of iterations}$ ) for each search agent Update the position of the current search agent by equation (19) end for Update $a$ , $A$ , and $C$ Calculate the fitness of all search agents Update $X_\alpha$ , $X_\beta$ , and $X_\delta$ $t=t+1$ end while return $X_\alpha$
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## Results & Discussions

Two thoughts are converged for procedure of multi-objective advancement by GWO. These 2 thoughts have been much same to “multi-objective optimization” in PSO method. In primary thought, the objective is to archive optimal responses of leading place of Pareto optimality. In subsequent thought, the objective is to decide the method of picking a leader that might assist to select Delta, Alpha, and Beta as leaders of hunting. The main piece of archive is its control unit that might control the procedure of archiving while solution is going into archive or while archive is full. It must be observed that always particular members have been deliberated for archive. Through iteration procedure, prevailing responses are contrasted with archive members. If archive is full, for eliminating a response, one of individuals in any piece of archive that has most individuals is eliminated randomly. On basis of component of leader selecting, 3 responses have been selected among optimal dominant responses to guide different specialists to investigate optimal response in search region. Selecting procedure will be completed by Rolette wheel method [34]. The flowchart of MOGWO method is represented in Figure 3.

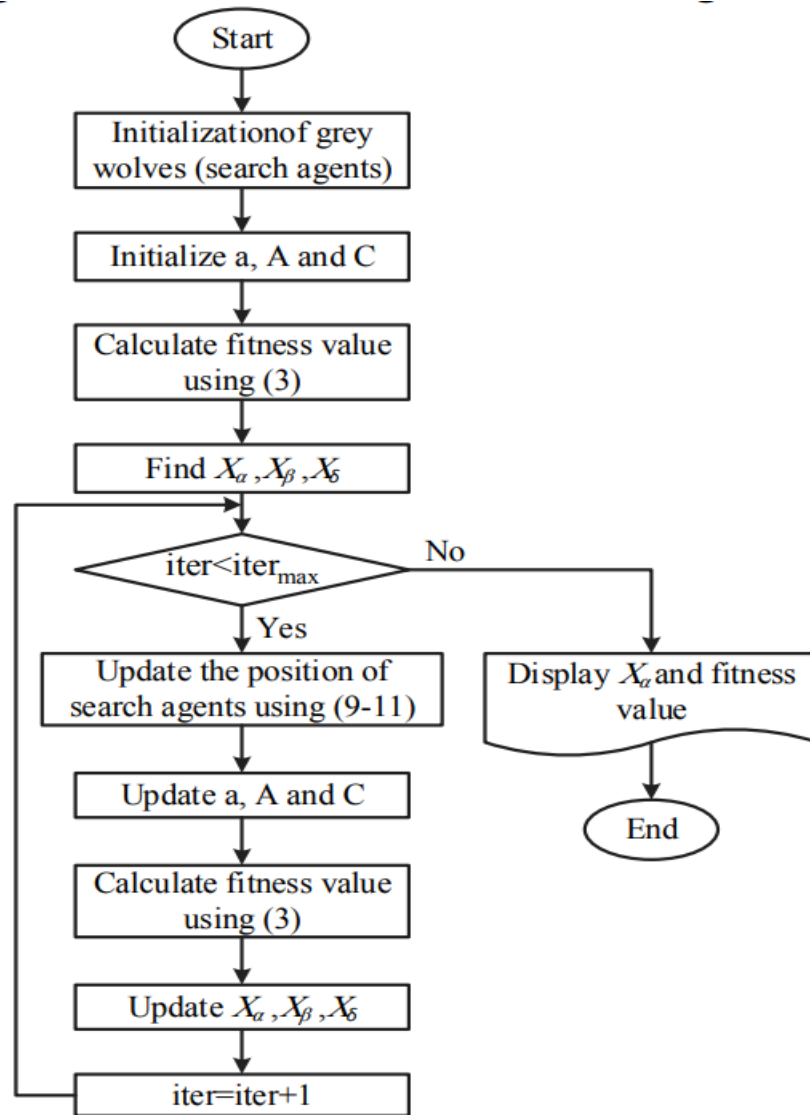


Figure 3: Flowchart of MOGWO

The best solution obtained by GWO is : 2.9686e-014 2.4602e-014 -2.5034e-014 1.9399e-014 -2.466e-014 2.8115e-014 -4.2258e-014 2.4027e-014 2.7615e-014 1.5778e-014 -3.0816e-014 2.2721e-014 -2.8189e-014 -1.4455e-014 -2.505e-014 2.2569e-014 -3.6548e-014 -3.5761e-014 2.6273e-014 -1.7823e-014 1.9959e-014 3.0448e-014 3.9185e-014 3.0614e-014 2.7735e-014 -2.8993e-014 -2.3489e-014 1.6077e-014 -2.7423e-014 -3.3372e-014

The best optimal value of objective function found by GWO is: 1.1102e-013

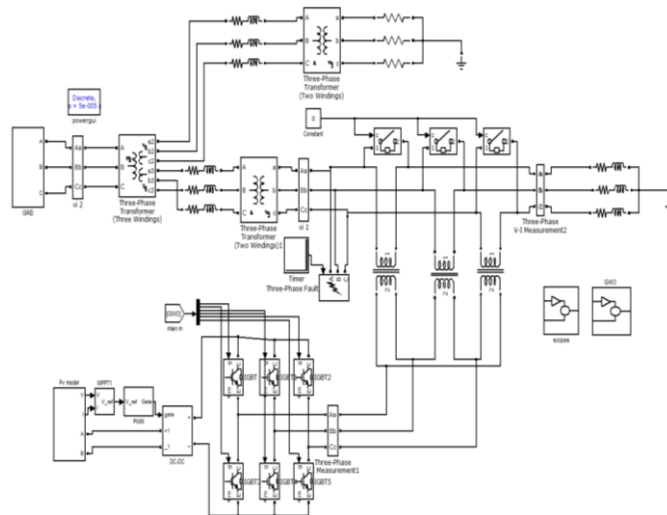


Figure 4: Simulation model of ABC based PV grid system

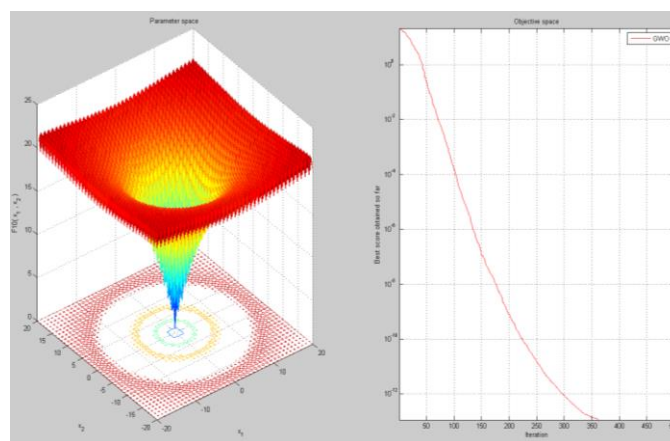


Figure 5: 2-D versions of multimodal benchmark function



Figure 6: Voltages swell (LLLG Fault) (a) voltage of grid (b) voltage of load (c) compensated voltage (d) PCC voltage



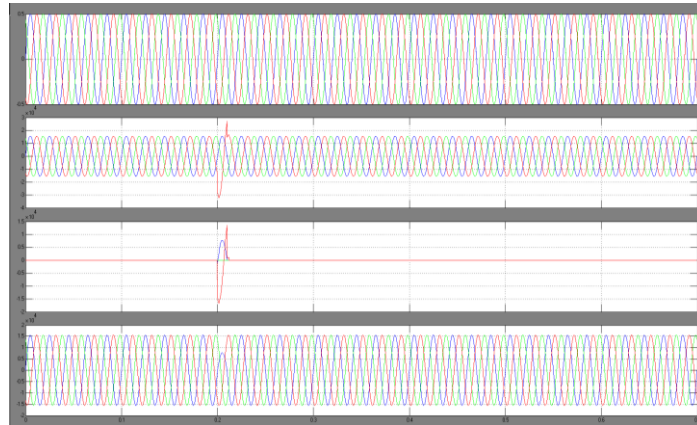


Figure7: Voltage sag (LLG Fault) (a) voltage of grid (b) voltage of load (c) compensated voltage (d) PCC voltage

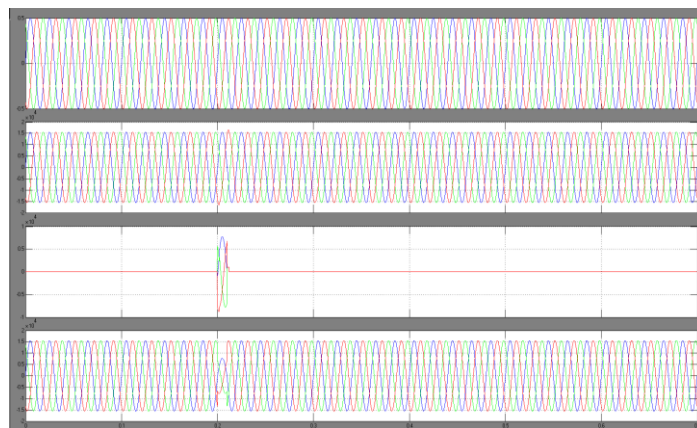


Figure 8: Voltage sag (LLLG Fault) (a) voltage of grid (b) voltage of load (c) compensated voltage (d) PCC voltage

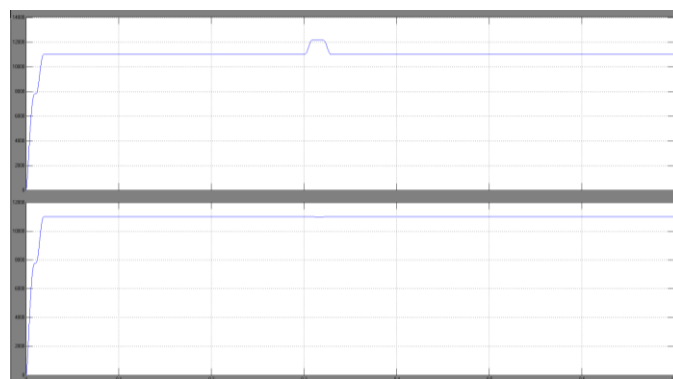


Figure 9: RMS voltage  $V_{rms}$  (a) sell voltage (b) compensated voltage

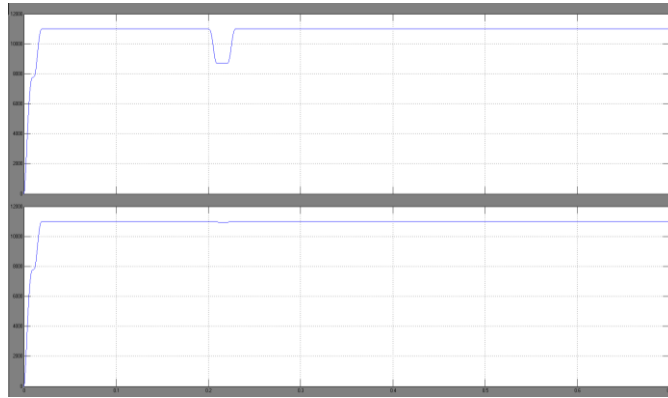


Figure 10: RMS voltage  $V_{rms}$  (a) sag voltage (b) compensated voltage

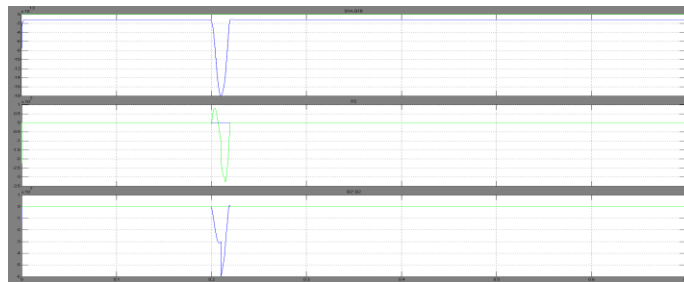


Figure 11: Active & reactive power analysis of  
MOGWO Proposed grid system

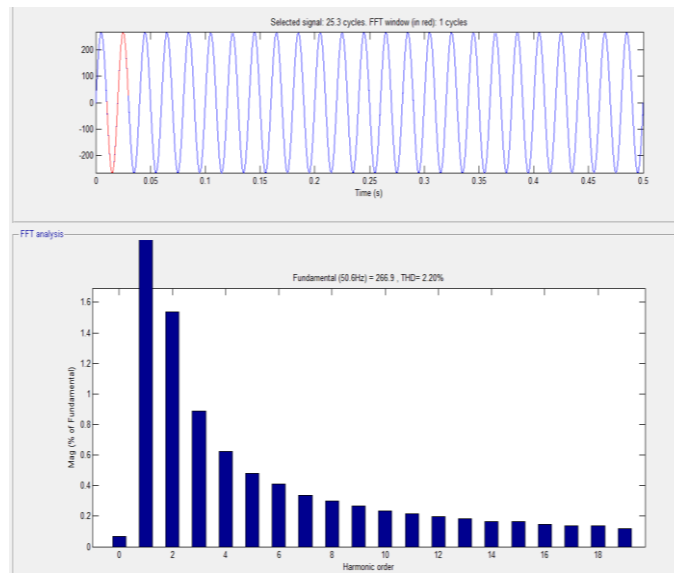


Figure 12: T.H.D analysis of proposed grid system i.e, 2.20% voltage swell condition

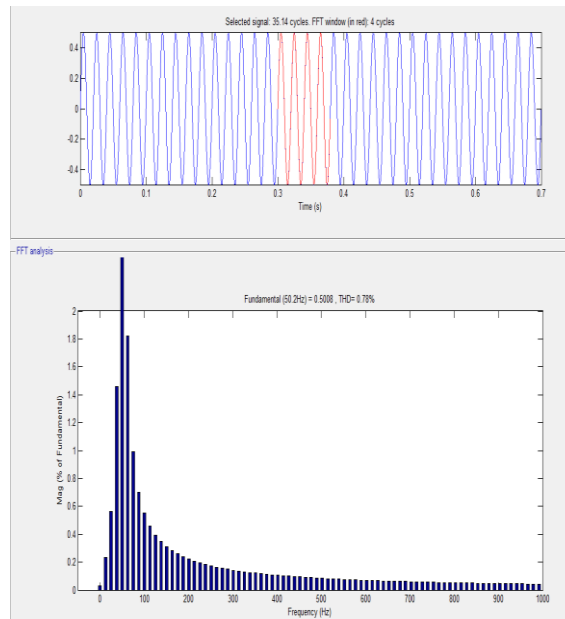


Figure 12: T.H.D analysis of proposed grid system i.e, 0.78% voltage sag condition

Table I: Comparative Analysis of Adaptive Control Strategies

Parameters	Description	GA&PSO [10-12]	ABC Algorithm [13-21]	Proposed MOGWO [25-29]
Voltage	Voltage sag & swell	Actual :415v Swell : 430v Sag: 340v	Actual :415v Swell : 450v Sag: 390v	Actual :415v Swell : 450v Sag: 390v
Time	Settling time of voltage sag & swell	0.3 -0.4 (0.1 sec)sag 0.3-0.5 (0.2 sec)swell	0.2-0.25 (0.05 sec) sag 0.3-0.4 (0.1 sec) swell	0.2-0.21 (0.01 sec)sag 0.3-0.31 (0.01 sec)swell
THD	Total Harmonic Distortion	6.64% to 6.85 %	3.51% to 3.58%	2.20% to 0.78%
Power factor	Power factor	0.7	0.9	1 (unity)
Current	Current distortions	Max: 600A Min:200A	Max: 500A Min:100A	Max: 400A Min:80A
Faults	Faults identified	LG, LLG	LG, LLG, LLLG	LG, LLG, LLLG, LL, LLL

## Conclusion

In this manuscript, a numerical method for grids operation has been introduced considering boundaries like voltage deviation, losses of power, and harmonics in objective function. Also, few operational limitations, and boundaries have been considered into account. Also, the new method of MOGWO has been presented and

utilized for optimization. The outcomes acquired by simulation demonstrate that combination of renewable energy framework based smart grids are directed to financial and environmental benefits moreover to power factor correction, voltage deviation improvement, harmonic elimination, and power loss reduction. This goal is occurred if precise operation method for these sources in executed. The existence of storage units and renewable energy sources near the loads centers decays the voltage deviation, power misfortunes. The total harmonics distortions of grid interface system are 2.20% & 0.78%.

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