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E-Mail :
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OPTIMALPLACEMENT OF DGS IN DISTRIBUTION SYSTEM USING AN IMPROVED HARRIS HAWKS OPTIMIZER BASED ON SINGLE OBJECTIVE APPROACHE

T. Sreenivasa Murthy[1], M. Swathi[2], N. Sai Sowmya[3,] S Maruthi Prasad[4], M. Venkata Raghavulu [5,] , T. Shivaji[6.] .
[1] [2][3][4][5][6] Department of Electrical and Electronics Engineering,
Qis College Of Engineering and Technology, Vengamukkapalem, Ongole -523272,
Andhra Pradesh, India.

ABSTRACT: Distributed Generation (DG) issues, including voltage regulation, power loss, etc., have a viable solution in distributing the power. The section among the electrical framework connects. The low-voltage Consumer service point for high-voltage transmission. network. Improved energy efficiency and reliable Distributed generators offer several benefits, including increased energy efficiency, secure power systems, and improved power quality. These advantages can be attained by allocating distributed generation resources as efficiently as possible while considering restrictions, the objective function, and an appropriate optimization algorithm. This study thoroughly examines the best way to allocate DGs for various goals, restrictions, and algorithms, all of which are vital for enhancing the precision and effectiveness of the outcomes. In light of this, Single Improved goal to determine the ideal position as well dimension of distribution networks with dispersed generating units. While taking various When loading models into account, the Optimization of Harris Hawks (IHHO) algorithm is suggested and utilized. This algorithm aids in determining the ideal placement of circulated generation (DG) within radial distribution systems. It is observed that the ideal placement and size of distributed generation resources in distribution networks can be considerably impacted by load models. By using the rabbit location rather than the random location in the case of IHHO, the performance of the traditional HHO algorithm is enhanced. The efficacy of the suggested methods is evaluated using radial distribution systems with IEEE 33-bus and IEEE 69-bus architectures. This analysis demonstrates the effectiveness of the suggested algorithms in terms of the best results found for the scenarios with a single purpose.

Key Words: IHHO, Single Objective, 33 - bus System, 69- bus System based on IEEE, Distributed Generators (DGS), Improved Harris Hawks optimizer.

INTRODUCTION:

In contrast to typical centralized generation, distributed generation uses a decentralized approach, where electric power is created and delivered to customers through small generation units located close to the end users. A primary focus of the research study on distributed generation (DG) is Strategically deploying DG at optimal locations in power systems to minimize losses and enhance voltage. profile, improve the Substation Power factor, increase reliability, maximize DG capacity, minimize costs, etc. The following are the primary technical and financial benefits of using distributed generation (DG) units in a power system:[1]

- Enhanced system security,

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- Decreased losses,
- Improved voltage profile,
- Improved frequency,
- Enhanced power quality,
- Enhanced substation power factor,
- Decreased pollutant emissions,
- Increased overall energy efficiency,
- Enhanced system reliability and security,
- Decreased reserve supplies and related costs, etc.

The fundamental elements consolidated with advancement issue are speculation cost, activity cost, network arrangement, dynamic and receptive power expenses, intensity and power necessities, and voltage profile and framework misfortunes. Both positive and unfortunate results happen if there should be an occurrence of enormous scope entrance of inexhaustible DGs type. Turn around power streams, power misfortunes, unfortunate voltage levels, and so on goes under the adverse results. In this manner, to conquer this unfortunate results choice of the best sizes and areas of these DGs is conceivable by utilizing a suitable improvement strategy which can give the best answer for a given conveyance organization. In this proposition, IEEE 33-transport and IEEE 69-transport spiral appropriation frameworks are utilized to check the adequacy of the proposed calculations, and the acquired outcomes are contrasted and those got by other advancement procedures. [2]

Literature Review:

Situated near the load centre, the distribution system DG unit should be at the same level as the electrical grid. Before the DG unit is installed, this should be confirmed. is related to the distribution system, effects on power system dependability, harmonic distortions, voltage profile, and short-circuit current are frequently investigated separately. The distribution system's advantages are ascertained by the distributed generation units' ideal placement. [3]

The ideal placements and sizes for the DGs have been determined using a variety of optimization techniques [4], [5]. The problem of assigning distributed generation (DG) has been handled utilizing optimization techniques, both single- and multi-objective. In single-objective optimization situations, only one objective function is implemented and needs to be optimized; in this case, power losses have been selected as the main objective function. A multi-objective optimization issue, on the other hand, calls for the simultaneous optimization of several objective functions. Evolutionary algorithms are often used in meta-heuristic optimization approaches to distribute distributed generation (DG) in single-objective settings.

Algorithms based on artificial intelligence (AI) have been used to determine the optimal placements for multiple distributed generators (DGs) in a distribution system [6], [7]. DG allocation problems are commonly expressed as fuzzy, stochastic, or nonlinear functions that can be used as constraint or objective functions. Dominance is the only goal in single-objective optimization; hence it is not an issue. Particle Swarm Optimization (PSO) has been developed in [8] and [9] to allocate DG and minimize the active power loss in single goal situations by using various load models. In the event of a power outage, the Radial Distribution System (RDS) is assigned the DG in the most efficient manner by using the Genetic Algorithm (GA) to minimize the overall [10].

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A fuzzy and clonal selection method was created in [11] to assign DG. Enhancing convergence characteristics and reducing computation time are two benefits of using the clonal technique to find the optimal locations for DGs in distribution networks. Recently, several nature-inspired optimization techniques have been used to address the DG allocation problem times, such as the Backtracking Search Optimization Algorithm (BSOA) [12], the Chaotic Sine Cosine (CSCA) [13], the Bacterial Foraging Optimization Algorithm (BFOA) [14], and the Whale Optimization Algorithms, such as the Whale Optimization Algorithm (WOA) [15].

On the other hand, in a multi-objective assessment, many goal capabilities may conflict or complement one another; so, a case of dominance occurs. The DGs assignment has been managed using the multi-objective enhancement issue in light of several methodologies. among which is the Weighted Total Strategy, which makes use of a weighting aggregate for each goal's capabilities. We might use Mixture Calculation in MOOP to obtain the perfect configuration. In light of this weighted aggregate philosophy, numerous examination works have been presented to improve multi-objective capabilities to be specific Voltage Deviation (VD), Power Misfortune (Ploss), and Voltage Dependability Record (VSI), such as GA [16], PSO [16], GA/PSO (Hybrid Calculation) [16], Educating Learning Based Streamlining (TLBO), Semi Oppositional Pig Flu Model-Based Advancement with Isolation (SIMBO-Q), rendition (QOTLBO) [17], and so forth.

Therefore, in situations where the arrangements are not truly prevailing, we employ another multi-objective strategy that employs a compromise among the target capabilities based on the Pareto predominance theory. The obtained arrangements are divided into ruled and non-overwhelmed configurations using the Pareto strength approach. The Maxima-Minima or Fluffy Strategy then selects the optimal arrangement from the non-overwhelming arrangements. A few more accurate calculations, such as Multi Objective Molecule Multitude Enhancement (MOPSO) and Non-Overwhelmed Arranging Hereditary Calculation (NSGA-II), have been developed in light of procedure [18]. In order to minimize power loss and address the VD for the DG designation issue in [19], MOPSO has been utilized with fluffy decision-making. It has been suggested that Multi Objective Whale Streamlining (MOWOA) improve the VSI and reduce dynamic power misfortune and VD [20]. WOA is presented given the unique way that humpback whales hunt. These are some methods for optimally coordinating the DG unit in circulation frameworks.

Further refined Harris Birds of Prey Streamlining (IHHO), a nature-driven enhancement calculation, is suggested for this postulation to determine the optimal size and area of DGs in appropriation frameworks based on the talks mentioned above. The Harris Falcons Enhancer (HHO) is a meta-heuristic enhancement technique based mostly on the intelligence and hunting behaviour of Harris Falcons. The main advantages of HHO are its ease of use and the fact that it requires less manipulation and exploratory tools than other systems. HHO has been used in many improvement difficulties, such as the photovoltaic cell module [22] and energy component module [21] boundary distinguishing proof. However, in this investigation study, IHHO is suggested for the DG distribution through both single-objective improvement. Consequently, the essential promises made for this work are listed below:

- Considering the bunny area instead of the arbitrary region when performing a Better Harris Falcons Enhancement computation (IHHO),

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- Putting the suggested IHHO into practice to determine the optimal amount of DGs in the dispersion framework to reduce all bad luck, voltage deviation, and increase VSI while simultaneously advancing the sub-station effect factor.
- The effectiveness of the suggested approach is compared using the standard IEEE 33-transport and 69-transport dissemination frameworks with the standard HHO and other documented streamlining techniques.

Methodologies:

Nature-enlivened meta-heuristic calculations HHO and IHHO are chosen for improving the proposed single-targets as well as multi-objective capabilities. It has been seen from the writing that HHO and IHHO have very much demonstrated streamlining calculations to tackle design improvement issues in view of their benefits, for example, simplicity of understanding and execution, that drove the writers to choose this calculation. A similar investigation has been made in light of the most recent improvement calculation with the assistance of MATLAB and MATPOWER programming to check whether the IHHO had given an improved arrangement. IHHO calculation is a recently evolved enhancement calculation where to work on the HHO; it is suggested that assuming the falcons outperform the cutoff points, they ought to get once again to the hare position in its place of irregular position.

HARRIS HAWKS OPTIMIZER (HHO):

HHO is utilized here for a single objective improvement issue. Harris Falcon is one of the most wise and notable hunter birds in nature that shows particular aggregate preying capacities in following, flushing out, and catching the possible bunny in a gathering for its food. Here, the underlying populace is expected to be a gathering of falcons that attempt to prey from various headings by a few killing systems. Be that as it may, the pioneer falcons neglect to get a handle on the creature due to its powerful nature and get away from the conduct of prey. Then, at that point, exchanging strategies is followed, so different falcons in the gathering will raise a ruckus around town prey until seized. HHO is a population-based meta-heuristic process that has been applied, with stages of deception and research.

Exploration Phase:

The principal saying of the Harris falcons is to pursue the prey, which is, for the most part, a bunny. Accordingly, at first, falcons investigate for the hare. This stage can be verbalized utilizing two techniques, where the initial one recommends that the falcons' areas ought to be close to the relatives and the prey. Then again, the second procedure expects that the birds of prey are situated aimlessly in trees.

Two systems of investigation stage are communicated numerically as underneath:

$$X(t+1) = \begin{cases} X_{rand}(t) - r_1|X_{rand}(t) - 2 * r_2 X(t)| & \text{if } q \geq 0.5 \\ X_{rab}(t) - X_m(t) - r_3(LB + r_4(UB - LB)) & \text{if } q < 0.5 \end{cases} \text{......... (1)}$$

Where, Mean position of the Hawks $= X_m(t) = \frac{1}{n}\sum_{i=1}^{n} X_i(t)$ .... (2)

Here, n =Total number of birds of prey,

t=current cycle,

Xi (t) addresses the bird of prey position I,

X (t+1) = Position of birds of prey at emphasis (t+1),

X (t) = Bird of prey's situation at current emphasis (t),

Xrab (t) =Position of the hare and

Xrand (t) =randomly chose birds of prey's situation.

Irregular boundaries r1, r2, r3, and r4 are utilized as inside the breaking point [0, 1], while LB and UB are utilized to signify the lower and upper limits of the pursuit space. The over-two investigation methodologies can be exchanged utilizing an irregular variable q between [0, 1].

Escaping Energy:

Falcons attempt to find and raise a ruckus around town during the investigation stage. Because of this, there is a significant change in the energy (E) of the prey. This energy of the bunny during the pursuit has been utilized to change among investigation and double-dealing in HHO, which is communicated as underneath:

$$E = 2E_0(1 - \frac{t}{T}) \text{....... (3)}$$

Where, T = most extreme emphasis numbers,

E0 =random starting energy of the bunny between [-1, 1].

Here, the hawks should continue their examination if E≥1, as this indicates that the rabbit can fly.

If E is less than 1, it indicates that the rabbit has a vulnerability, hence the hawks should start their hunting near the rabbit's location.

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Exploitation Phase:

During this stage, the prey is attacked by employing alternating techniques. Depending on the If the energy is escaping, the attack could be either minor or severe. forceful besiege. At this point, the rabbit can escape successfully when r < 0.5 and unsuccessfully when r > 0.5. Nonetheless, depending on the fleeing energy, hawks can execute a harsh besiege when |E|<0.5 and a mild besiege when |E|≥0.5.

Thus, four chasing strategies—explained below—can be used to quantitatively simulate the HHO's exploitation process.

i. Soft Besiege

The hare energy and attempt to escape by bouncing and the birds of prey encompass it delicately. At the point when r ≥0.5 and |E| ≥ 0.5, a delicate blockade is performed.

The numerical demonstration of Delicate blockade is as below:

$$X(t+1) = \Delta X(t) - E|JX_{rab}(t) - X(t)| \ldots\ldots (4)$$

$$J = 2(1 - r_5) \qquad \ldots. (5)$$

$$\Delta X(t) = X_{rab}(t) - X(t) \ldots\ldots (6)$$

Where , ΔX(t)=distance between the bunny area and the birds of prey's situation,

J =random bounce of the hare for getting away,

r5 =random number between 0 and 1.

ii**. Hard Besiege**

At this stage, the prey is completely depleted and the falcons encompass it scarcely and play out the unexpected jump. Hard assault could happen when r ≥0.5 and |E| <0.5. The positions are refreshed using underneath conditions:

$$X(t+1) = X_{rab}(t) - E|\Delta X(t)| \ldots\ldots (7)$$

iii. Soft Besiege with Progressive Rapid Dives

The hare actually owns the energy and attempts to get away, and this happens when |E|≥0.5 and r < 0.5, facilitating a delicate attack that is expected before the unexpected jump by the birds of prey. This step is savvier than in the past. Due to its smart way of behaving, HHO is thought of as better than the other multitude of strategies. Here, Duty flight (LF) idea is utilized for

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moderately quick plunges of falcons to perform delicate assault and the following move of prey is processed by falcons utilizing underneath conditions.

$$Y = X_{rab}(t) - E|JX_{rab}(t) - X(t)| \ldots (8)$$

Where, Y=Soft Attack Position

Birds of prey jump in light of LF-based designs utilizing the standard;

$$Z = Y + S * LF(D)$$

Here, D: Aspect of issue,

S is a random vector of size 1×D

LF capability is numerically displayed as:

$$LF(x) = 0.01 * \frac{\mu * \sigma}{|v|^{\frac{1}{\beta}}}$$

Where ,

$$\sigma = \left(\frac{\tau(1+\beta) * \sin(\frac{\pi\beta}{2})}{\tau\left(\frac{1+\beta}{2}\right) * \beta * 2^{\left(\frac{\beta-1}{2}\right)}}\right)^{\frac{1}{\beta}} \ldots\ldots(9)$$

Where, B= consistent worth set to 1.5,

μ Also, v are irregular qualities between [0, 1].

In this manner, bird's situation at the following cycle is acquired as given below:

$$X(t+1) = \begin{cases} Y, & F(Y) < F(X(t)) \\ Z, & F(Z) < F(X(t)) \end{cases} \ldots\ldots (10)$$

iv. Hard Besiege with Progressive Rapid Dives

In the event that |E| <0.5 and r < 0.5, this assault happens. The prey creature misfortunes its energy and become depleted. A hard blockade is trailed by falcons and it diminishes the distance of its area with the prey for killing the prey and it has been circled scarcely by the falcons. Similarly, Duty flight (LF) idea is executed to express this attack as past case;

$$Y = X_{rab}(t) - E|JX_{rab}(t) - X_m(t)| \ldots\ldots (11)$$

IMPROVED HARRIS HAWKS OPTIMIZER (IHHO):

Further developed HHO is additionally executed here for the single Improvement issue. In HHO calculation, in the event that the falcons go past as far as possible, Birds of prey used to get once again to least and most extreme situation as beneath condition;

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$$X(t+1) = \begin{cases} X(t+1), & X_{min} \le X(t+1) \le X_{max} \\ X_{min}, & X(t+1) < X_{min} \\ X_{max}, & X(t+1) > X_{max} \end{cases} \quad \ldots\ldots (11)$$

To further develop the HHO, for example, IHHO, it is suggested that assuming the falcons go past the cutoff points, birds of prey ought to get once again to the hare position rather than the irregular positions, which can be demonstrated like this:

$$X(t+1) = \begin{cases} X(t+1), & X_{min} \le X(t+1) \le X_{max} \\ X_{rab}(t), & X(t+1) < X_{min} \\ X_{rab}(t), & X(t+1) > X_{max} \end{cases} \quad \ldots\ldots (12)$$

To further develop the HHO, for example, IHHO, it is suggested that assuming the falcons go past the cutoff points, birds of prey ought to get once again to the hare position rather than the irregular positions, which can be demonstrated.

ALGORITHM OF IHHO:

i. After reading the Load and align data from the system and defines the objective function.

ii. Subsequently, at random, begin an array of hawks' searches inside the HHO parameters' upper and lower bounds, the DGs' positions and sizes, and (k max).

iii. Then, in order to minimize power loss, execute the power flow and identify each search hawk's objective function.

iv. Keep the optimal solution of Xrab solution.

v. Modify the HHO parameters, which are E, E0, and J.

vi. Based on the tactics used in the exploration and during the exploitation phases, update the sizes and locations of the best solutions.

vii. Next, make sure the borders of the sizes locations are correct by updating the Position.

viii. Verify that (k < k max), and if so, repeat step 3.

ix. Give back the last, best option that was saved for the dimensions and positions of the DGs.

x. Run the power flow one last time to get the system's voltage profile.

PSEUDO CODE FOR HHO & IHHO:

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For the MATLAB/MATPOWER software to be used, the installation of Pseudo Code is required to achieve the previously stated objectives.

i. inputs: The total number of emphasis T and the population size N.
ii. Randomly produce N Harris Falcons in search space
iii. Calculate the wellness values.
iv. While (end condition isn't met t<=T) do
v. Pick the best pursuit specialist as a hare
vi. Compute E1=(1-t/T)
vii. for (each Bird of prey (Xi), i=1: N) do
viii. Arbitrarily create beginning energy(E0) of the bunny
ix. Update the E by condition (E=2E0*E1)
x. Arbitrarily create bounce strength (j) of the bunny
xi. on the off chance that (|E|>=1)//Investigation Stage
xii. Update area utilizing eqn. (13)
xiii. on the off chance that (|E|<1)//Double-dealing Stage
xiv. Update hop strength utilizing eqn. (17)
xv. Randomly produce an irregular number r
xvi. on the off chance that Delicate Blockade (r>=0.5 and |E|>=0.5)
xvii. Update area utilizing eqn. (16)
xviii. else on the off chance that (r>=0.5 and |E|<0.5)//Heavy Attack
xix. Update area utilizing eqn. (19)
xx. else on the off chance that (r<0.5 and |E|>=0.5)//Delicate Attack with moderate quick plunges
xxi. Update area eqn. (24)
xxii. else in the unlikely event that (r<0.5 and |E|<0.5)//Hard Blockade with moderately rapid downsizing
xxiii. update area utilizing eqn. (25)
xxiv. End if
xxv. Check the limit conditions and update wellness esteem.
xxvi. Close if

xxxvii. That concludes for

xxviii. Conclude While

xxix. Give back the finest solution globally (rabbit).

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FLOW CHART OF IHHO:

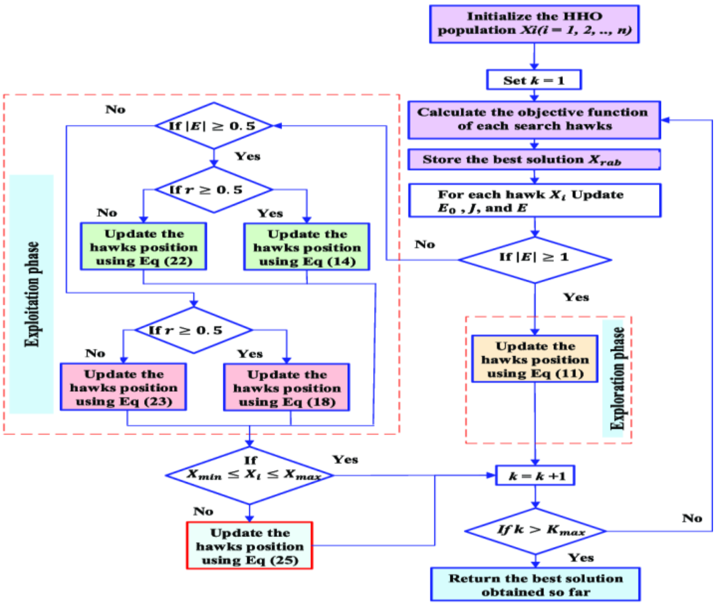

FIGURE :1. Flow Chart of IHHO.

This flowchart addresses the essential iterative course of the Better Harris Bird of Prey's Enhancer. Every cycle includes assessing the wellness of arrangements, refreshing the best arrangements found, and changing the places of the falcons to investigate the pursuit space. The interaction goes on until end measures are met, like arriving at the most extreme number of cycles or accomplishing a combination.

RESULT:

From the issue plan, numerical display, and techniques examined in the prior part, those calculations and pseudocodes have been utilized utilizing MATLAB/MATPOWER programming for examination purposes in this segment. The better procedures of Harris Birds of Prey Improvement concerning single-objective cases (IHHO) are used with two common IEEE outspread circulation frameworks, the 33-transport and the 69-transport. The ideal measuring and siting of numerous DG units is not entirely set in stone to limit all-out power misfortune as a single objective streamlining issue. To confirm the plausibility and proficiency of the better strategies, an extensive correlation is completed in this part. The accompanying four cases are considered for both a single objective examination of the IEEE standard 33-transport and 69-transport frameworks:

i. Example 1 (no DG),
ii. Example 2 (integrating 3 DGs with unity power factor),
iii. Example 3 (integrating 3 DGs with 0.95 pf),
iv. Example 4 (integrating 3 DGs with ideal pf).

The BUS system, IEEE 33:

The principal outspread circulation network is a 33-transport framework, as displayed in Figure, and its framework information is accessible, having 100 MVA and 12.66 kV as base qualities.

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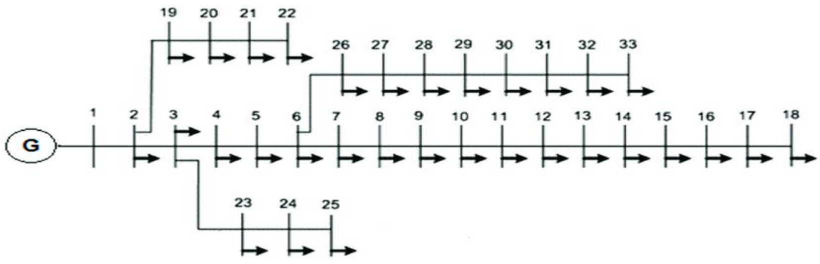

Figure: 2, Single line Diagram of IEEE 33 – Bus System.

Three sidelong feeders, an invalid sub-parallel feeder, and one fundamental feeder are visible on the IEEE 33-Transport Framework single-line chart. where five tie switches and thirty-two sectionalized switches are available. The most extreme responsive power load connected to the framework is 2.3 MVARs, whereas the largest dynamic power load is 3.715 MW.

The Bus System (IEEE 69):
With 100 MVA and 12.66 kV as basic qualities, the second widespread conveyance network is a 69-transport framework, as shown in Figure, and its framework information is available.

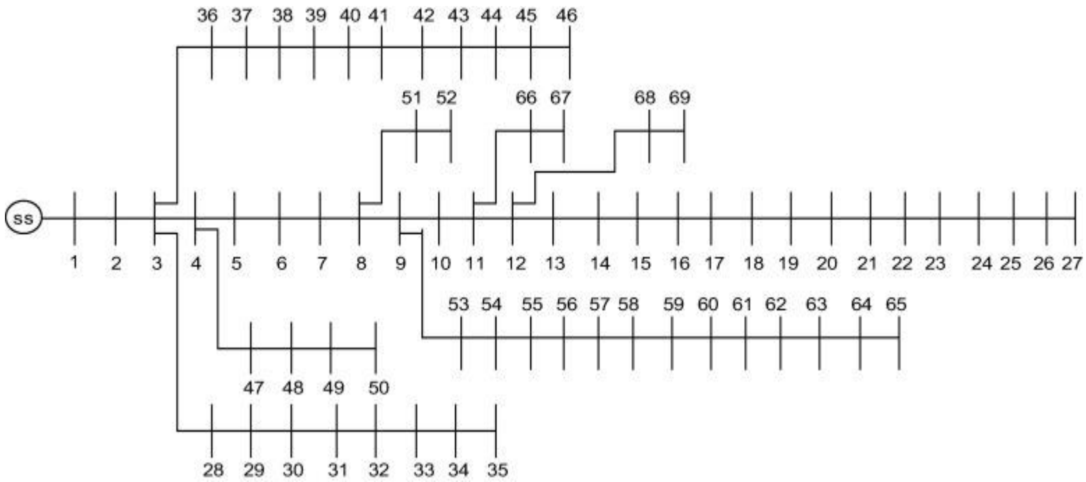

Figure 3. Single line diagram of the IEEE 69 Bus system.

The IEEE 69-Transport framework's single-line chart shows that there is one basic feeder, seven sidelong feeders, and one invalid sub-parallel feeder. This provides access to five tie switches and 68 sectionalized switches. The highest dynamic power load and highest receptive power load connected to the framework, respectively, are 3.802 MW and 2.694 MVARs.

Table:1. When no DGs are connected to the base scenario.

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Bus	Ploss(MW)	Qloss(MVar)	VD(pu)	VSI(pu)	Substation Power factor
33	0.2110	0.1430	0.1338	0.6672	0.849
69	0.2240	0.1021	0.0993	0.6839	0.8195

BASE CASE: When no DGs are connected to the base scenario, we may obtain the p loss and q loss values for base kV = 12.66 kV and base MVA = 100 MVA by using the MATPOWER device during power stream analysis on the 33 and 69 transport fraTable: 1, Results on Base Case. After breaking down the power stream results for the base case, it is found that the dynamic and responsive influence misfortunes for the IEEE 69-transport framework are 224 kW and 102.1 k VAR, respectively, and the dynamic and receptive power misfortunes for the IEEE 33-transport framework are 211 kW and 143 k VAR, respectively. In this manner, three DG units with different PF are optimally positioned using the IHHO to minimize the absolute power misfortunes.

SINGLE OBJECTIVE OPTIMIZATION PROBLEM (SOOP) ANALYSIS: The ideal measuring and sitting of different DG units are utilized to limit complete power misfortune as a single objective improvement issue, utilizing HHO and IHHO for the two frameworks.

HHO & IHHO ANALYSIS FOR 33 – BUS SYSTEM (AT UNITY P.F)

Table 2: Single-Objective Analysis of the IEEE 33-bus System Using HHO & IHHO at Unity Pf.

Method	Bus	Size(kW)	Power Factor	Ploss(kW)	VD(pu)	VSI(pu)	Loss Reduction (%LR)	SSpf
	14	778.8	1	72.7926	0.0150	0.7396	65.5	0.3411
HHO	24	1088.2	1					
	30	1059.3	1					
	13	801.8	1	72.7837	0.0151	0.8807	65.51	0.3369
IHHO	24	1091.3	1					
	30	1053.6	1					

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With dynamic power limits of 801.8 kW, 1091.3 kW, and 1053.6 kW individually, Table 2 clearly shows that the ideal areas for these three DGs using IHHO are 13, 24, and 30. This will reduce the power misfortunes from 211 kW to 72.7837 kW, where the misfortune decrease (LR) is 65.51%. However, when compared to other improvement procedures and the standard HHO, further evolved IHHO offers the most reduced power misery.

AT 0.95 p. f:

Table 3: Single-Objective Analysis for IEEE 33-bus System Using HHO & IHHO at 0.95 pf.

Method	Bus	Size(kW)	Power Factor	Ploss(kW)	VD(pu)	VSI(pu)	Loss Reduction (%LR)	SSp
	12	953.8	0.95	29.223	0.0023	0.9370	86.15	0.36
HHO	24	1129.2	0.95					
	30	1168.8	0.95					
	13	830.1	0.95	28.532	0.0021	0.9538	86.47	0.39
IHHO	24	1124.8	0.95					
	30	1239.7	0.95					

According to Table 3, the optimal regions for three distributed generators (DGs) using IHHO are 13, 24, and 30, with respective dynamic power limits of 830.1 kW, 1124.8 kW, and 1239.7 kW. This leads to a reduction in power losses from 211 kW to 28.532 kW, resulting in a loss ratio (LR) of 86.47%. However, while considering the other ways of improvement and regular HHO, the improved IHHO provides the least amount of power misfortune.

AT OPTIMAL P.F:

Table 4: Single-Objective Analysis of IEEE 33-bus System Using HHO & IHHO at Optimal pf.

Method	Bus	Size(kW)	Power Factor	Ploss(kW)	VD(pu)	VSI(pu)	Loss Reduction (%LR)	SSpf
	10	925.5	0.87	14.6486	0.0009	0.9501	93.05	0.937
HHO	24	905.7	0.8					
	30	1059.8	0.8					
	13	796.5	0.903	11.763	0.0006	0.9696	94.42	0.9054
IHHO	24	1040.9	0.889					
	30	1045.4	0.723					

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IHHO'S STATISTICAL AND PERFORMANCE ANALYSIS FOR THE 33-BUS SYSTEM:

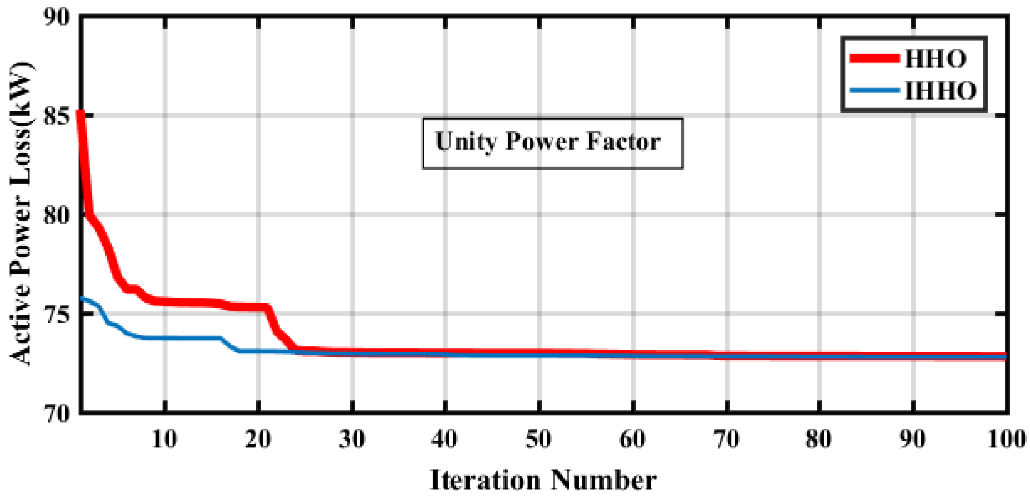

Figure 4 shows the convergence characteristics of the IEEE 33-bus test system's HHO and IHHO at unity pf.

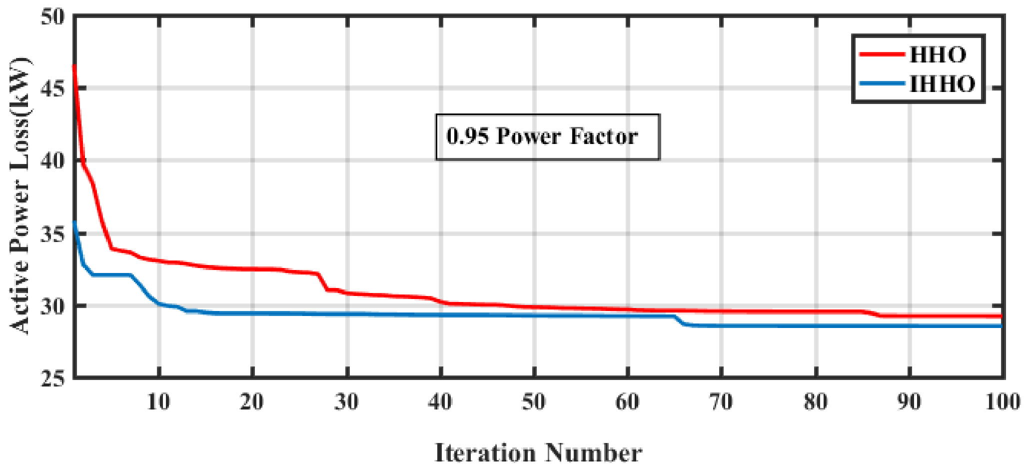

Figure 5. Convergence characteristics of the IEEE 33-bus test system's HHO and IHHO at 0.95pf are shown.

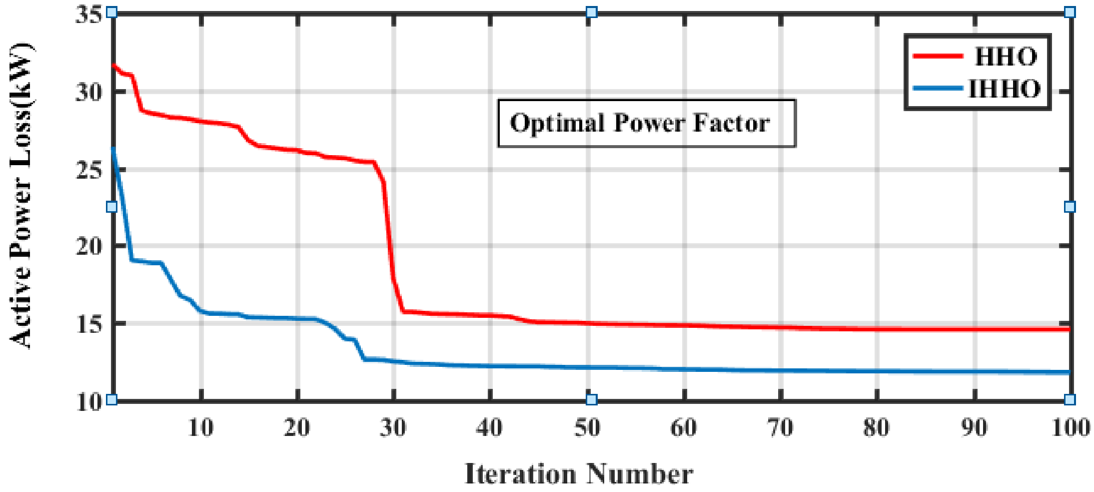

Figure 6 shows the convergence characteristics of the IEEE 33-bus test system's HHO and IHHO at ideal pf.

A factual analysis of the data obtained from the various tables referencing the results of 5-8 MATLAB runs for the normal HHO and IHHO to show the efficacy of the better approach. After analysing the aforementioned tables, it is evident that IHHO possesses the least amount of characteristics in each instance. The combination qualities for HHO and IHHO are shown individually for solidarity pf, 0.95 pf, and ideal pf in Figures 4,5 and 6, however, the figures above show how much more effective the IHHO is than the conventional HHO method.

VOLTAGE PROFILE FOR SOOP IN THE 33-BUS TEST SYSTEM:

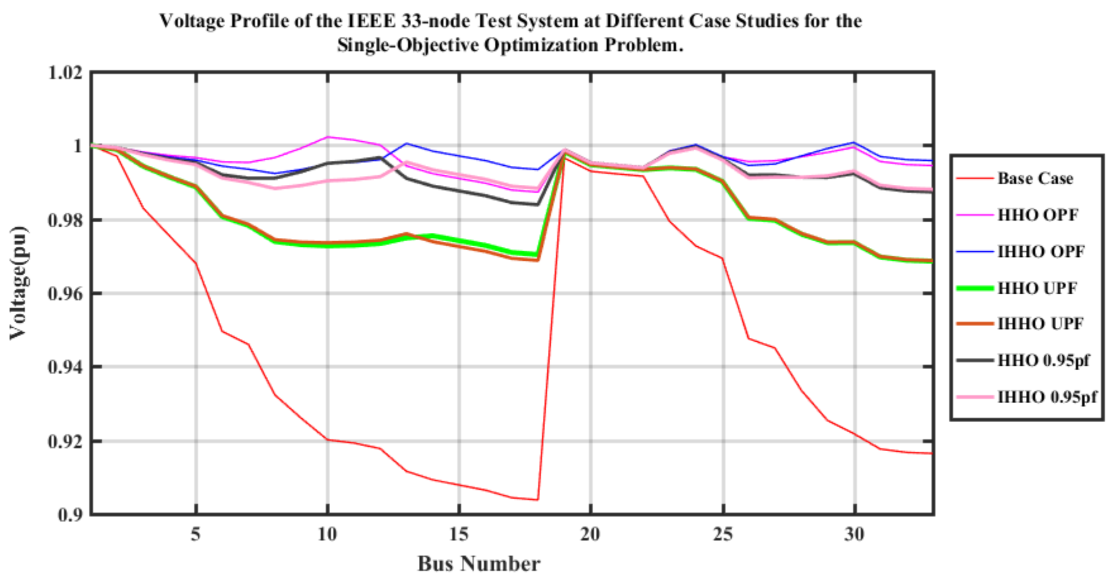

Figure 7. IEEE 33-BUS TEST SYSTEM VOLTAGE PROFILE FOR EXAMPLE SOOP

In order to minimize dynamic power loss, work has been done on the voltage profile of the IEEE 33-transport architecture for SOOP. It is clear from Figure 4.6 that the significant improvement in the voltage profile is considered to be at the optimal pf.

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HHO & IHHO ANALYSIS FOR 69 – BUS SYSTEM:

AT UNITY P.F: Table 6: IEEE 69-bus System: Single-Objective Analysis Using HHO & IHHO at Unity pf.

Method	Bus	Size(kW)	Power Factor	Ploss(kW)	VD(pu)	VSI(pu)	Loss Reduction (%LR)	SSpf
	11	577.6	1	69.4	0.0053	0.9185	69.01	0.4081
HHO		332.2	1					
	61	1713.9	1					
	11	514.9	1	69.3698	0.0053	0.9185	69.03	0.4117
IHHO	18	379.7	1					
	61	1716.4	1					

The DGs in solidarity with the HHO are shown to be adequately represented by the IHHO shown in Table 6. When three DG units—11, 18, and 61—are placed with infused dynamic powers of 514.9 kW, 379.7 kW, and 1716.4 kW each, the IHHO gains the most notable LR, increasing to 69.03 the percentage.

AT.95 P. F: Table: 7. Single-Objective Analysis Using HHO & IHHO at 0.95 pf for IEEE 69-buSystem.

Method	Bus	Size(kW)	Power Factor	Ploss(kW)	VD(pu)	VSI(pu)	Loss Reduction (%LR)	Substation Power factor
	11	577.6	1	69.4	0.0053	0.9185	69.01	0.4081
HHO	21	332.2	1					
	61	1713.9	1					
	11	514.9	1	69.3698	0.0053	0.9185	69.03	0.4117
IHHO	18	379.7	1					
	61	1716.4	1					

Table 7 below reveals that IHHO achieves the best results at 0.95 pf, where the power misfortune is 20.7656 kW with LR approaching 90.73 %. This is superior to the traditional HHO, where three DG units are placed at 11, 18, and 61 with infused dynamic powers

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equivalent to 548.9 kW, 415.3 kW, and 1875.7 kW independently. The IHHO achieves the most notable LR at 0.95 pf, rising to 90.73 %.

AT OPTIMAL p.f :

Table 8. Single-Objective Analysis with HHO & IHHO at Optimal pf for IEEE 69-bus System is shown.

Method	Bus	Size(kW)	Power Factor	Ploss(kW)	VD(pu)	VSI(pu)	Loss Reduction (%LR)	SSpf
	12	340.3	0.8151	4.6210	0.0002	0.9772	97.93	0.8114
HHO	22	369.8	0.8144					
	61	1704.8	0.8148					
	11	516.8	0.8417	4.2478	0.0001	0.9772	98.10	0.8044
IHHO	18	360	0.8088					
	61	1667.2	0.8126					

According to Table 8, the IHHO's effectiveness remains constant at 4.24 kW, which is the least power-related misfortune, even with a range of working abilities that are ideal. The power misfortune is reduced by 98.10% from the basic scenario with optimal PF, which is considered a significant and real impact misfortune decrease.

PERFORMANCE AND STATISTICAL ANALYSIS OF IHHO FOR 69 – BUS SYSTEM:

A factual examination in view of the different information accomplished as referenced through various tables after 5-8 runs in MATLAB for the customary HHO and IHHO to demonstrate the power of the IHHO strategy. Subsequent to dissecting the above tables, clearly, IHHO has the least qualities in every one of the cases. While the combination qualities for HHO and IHHO are displayed in Figures 8,9 and 10 for solidarity pf, 0.95 pf, and ideal pf separately. The accomplished outcomes express the capacity of IHHO in acquiring the ideal arrangement beyond what HHO can do, and this can be clear from the underneath combination attributes.

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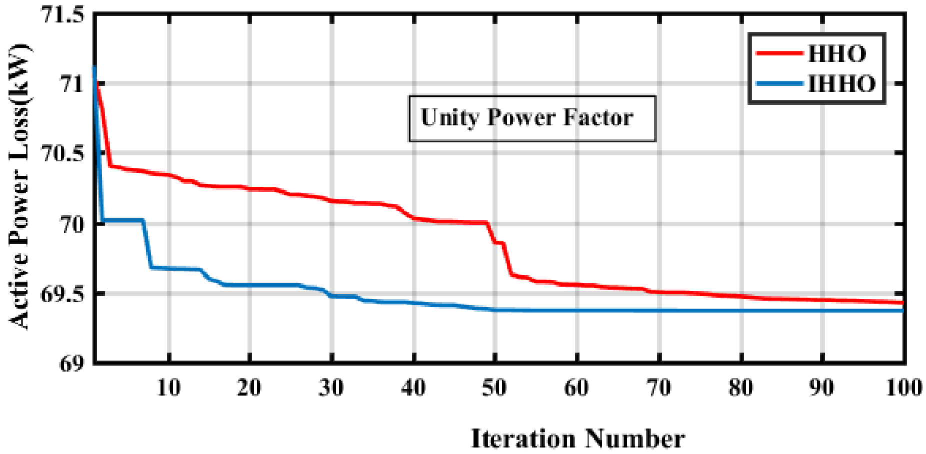

Figure 8 shows the convergence characteristics of the IEEE 69-bus test system's HHO and IHHO at unity pf.

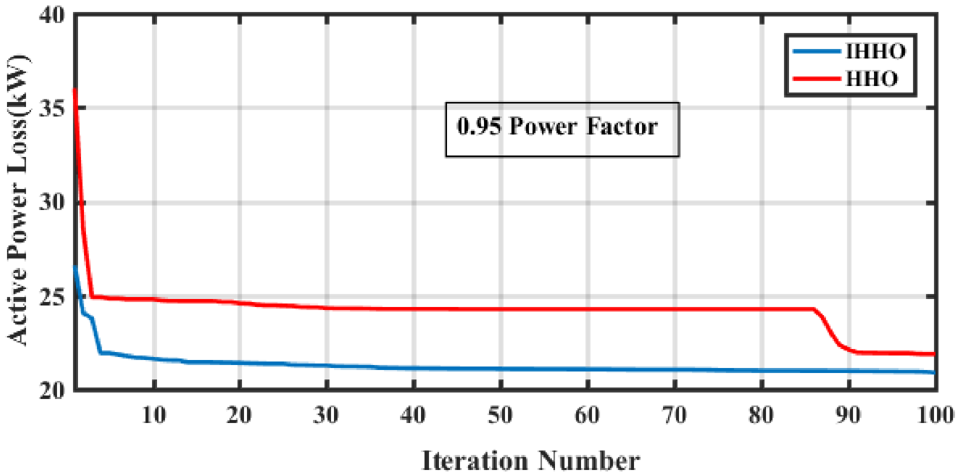

Figure 9 shows the convergence characteristics of the IEEE 69-bus test system's IHHO and HHO at 0.95 pf.

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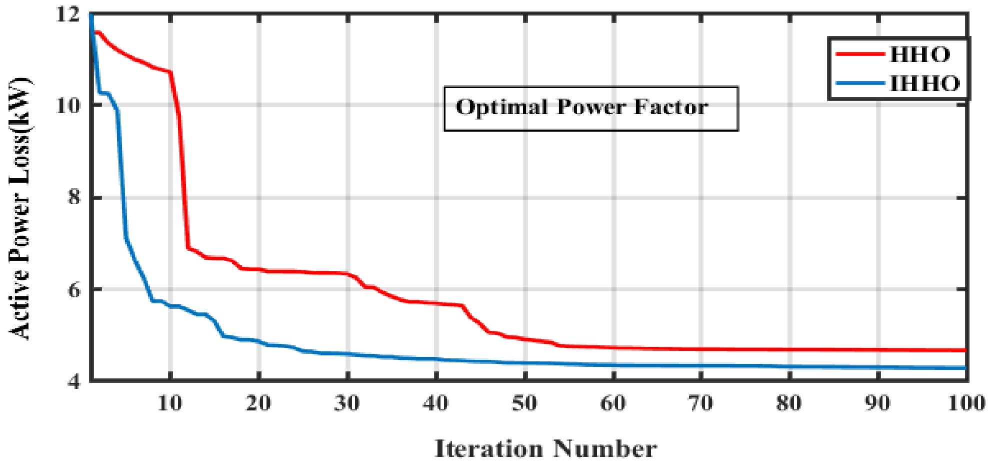

Figure 10. shows the convergence characteristics of the IEEE 69-bus test system's HHO and IHHO at optimal pf.

VOLTATURE PROFILE OF THE 69-BUS SOOP TEST SYSTEM:

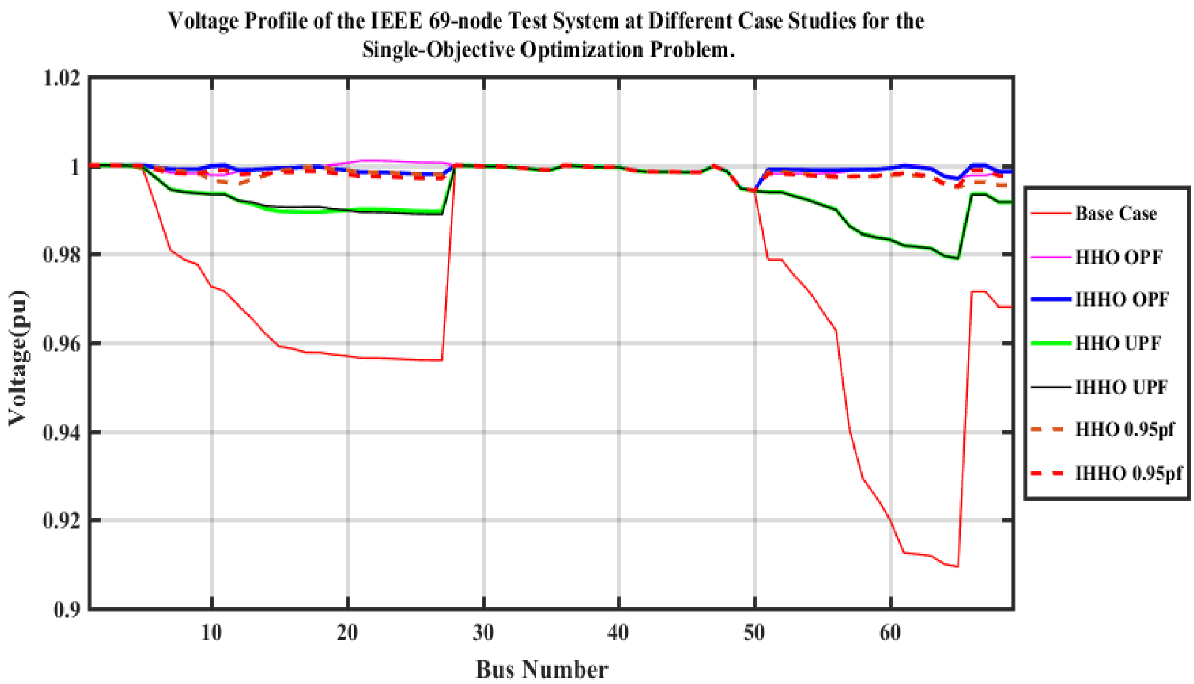

Figure 11. VOLTAGE PROFILE OF THE IEEE 69 - BUS TEST SYSTEM FOE SOOP.

As the dynamic power loss is minimized, Figure 11 illustrates how the voltage profile of the IEEE 69-transport framework is seen as improved. Because of the infused dynamic and responsive power, the voltage profile significantly improves at the optimum pf and generally rises to the one provided by the 0.95 pf.

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DISCUSSION:

It is crucial to stress that we shall take the technique and its ramifications into account when talking about where distributed generators (DGs) should be placed in distribution systems. Using an Improved Harris Hawks Optimizer (IHHO) based on single-objective methods will be required for this. (IHHO) using methods with only one purpose.

To improve When optimizing a distribution system's overall performance, the single-objective method focuses on minimizing a specific criterion, such as active power losses or voltage deviations. Inspired by nature, the Improved A meta-heuristic algorithm is the Harris Hawks Optimizer. That finds near-optimal Remember the Finding solutions by effectively navigating the search. space. The positioning of DGs can be optimized to meet System needs and various constraints should be considered when making decisions. The intended goal into account by utilizing the IHHO.

It is critical to stress that the approach and its consequences must be taken into account when talking about where distributed generators (DGs) should be placed in distribution networks. An Improved Harris Hawks Optimizer (IHHO) based on single-objective methods is used in this investigation.

The IHHO's capacity to effectively address challenging optimization issues, such as those encountered in distribution system design, offers significant benefits. of using it for single-objective optimization. Furthermore, despite the presence of uncertainties, the algorithm's stochastic nature enables robustness discovering solutions.

It's crucial to recognize the restrictions and factors that come with this strategy, though. For example, stricter limitations and larger distribution networks could significantly increase the computational complexity of the optimization process. as well as the optimization problem's formulation.

Its effectiveness in improving the operational efficiency and reliability of distribution systems is discussed to find out where distributed generation (DG) should be located using the IHHO based on a single objective approach. Although the results are encouraging, more investigation is necessary to resolve scaling problems and improve the algorithm's effectiveness in addressing distribution system constraints in the actual world.

Conclusion:

Distribution generators (DGs) have been integrated into radial distribution systems (RDS), transforming them from a passive structure to an active one with multidirectional Power flows. The distribution system has been analysed using the method based on the suggested IHHO. The reduction of active power loss is the main aim of the SOOP for the DG allocation. Another goal function that has been improved is the Substation power factor (SSpf), which decreases. The optimized HHO method has been verified with parameters like unity, 0.95, and optimum power factor (pf) using standard IEEE 33-bus and 69-bus at different operating pf.

The IHHO Well-known optimization methods, such as traditional HHO, focus on statistical and performance analysis. The findings demonstrate that better algorithms are more effective in reaching the ideal Distribution system DG allocation, which minimizes. All-out power and voltage deviation while further developing the framework's general voltage profile. Moreover, by forcing specific cutoff points on the framework, SSF is additionally elevated to the next level. As indicated by the created calculations, the standard IEEE 33-transport and 69-transport frameworks achieve the highest misfortune decrease at the ideal influence factor. of 94.42% and 98.10%, respectively. The most extreme VSI was 0.9768 p u and 0.9912 p u, respectively, yet the base VD was 0.0002 p u. These outcomes show the productivity of the IHHO strategy.

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