Islanding Detection Scheme of Distributed Generation Systems using Hybrid FAT-SGO Approach

Sathish K R, T Ananthapadmanabha

Abstract: In this paper an effective hybrid FAT-SGO approach is proposed for islanding detection of distributed generation (DG) system. The proposed approach is the joint implementation of Feedback Artificial Tree (FAT) and Shell Game Optimization (SGO) named as FAT-SGO technique. Reducing the non-detection zone (NDZ) as near as possible and keep the output power quality unmovable is main contribution of this paper. Furthermore, this method solves the issue of establishing detection thresholds inherent in existing methods. The proposed strategy uses the rate of change of frequency (ROCOF) in DG destination location is utilized as input sets of FAT system for intelligent islanding detection. Here, FAT is trained by SGO, which extracts the different intrinsic characteristics among islanding and grid disturbance. With the extracted characteristics, the FAT method is used for classifying the disturbances in islanding and grid. For authenticating the feasibility of this strategy is authorized through various conditions and different conditions of load, switching operation, and network. The simulation of the proposal is done in MATLAB / SIMULINK and the performance in islanding and non-islanding events was studied. Statistic analysis of proposed and existing methods of mean, median and standard deviation is analyzed. DG performance is assessed by comparative analysis with current techniques.

Keywords: Distributed generation, Islanding detection, Feedback Artificial Tree algorithm, Shell Game Optimization, Non-detection zone.

I. INTRODUCTION

Wind farms and solar cells are the major source of the DG system due to their energy generation systems have an expanded ubiquity. This DG system, a specific load is provided using Distributed Energy Resources (DER), interrelated by high-scale electric grid to enhance the distribution of the large amount of power, create the uses as a means to promote energy use sustainable source assets and improvement of the common consistency and proficiency of the power grid [1-3]. The segment of the phase is the constant issue in distributed power creations, while involuntarily separated from the remainder stage; DER has been hindered to employees as well as gear in which the required wellspring of inception exists [4-6].

When the section is disengaged then the DER can keep on controlling the detached portion in this condition; "island" is shaped [7]. At DG system the islanding is described as one of the severe problem to be deduced and while the electric power system part is disengaged from the principle power grids then it will occurs [8]. At least one DGs consisted from the detached electric power system is known as islanded DGs [9]. Additionally, in this islanded portion the electric hardware connected through the section is injured using voltage or frequency deviations [10].

Based on the islanding condition, anomalous activity, negative results on warranty, operation and management are introduced into the power system. Normally, in the DG system the islanding location is the most important condition [11]. Thus, by the industry standards unwanted island arrangement are described, such as IEEE 1547 has been created and more ever suitable restorative move can be made in a convenient manner. The specialists used as a great number of islanding detection and classification techniques to find the islanding condition [12, 13]. However, these detection techniques are inclined via the extensive NDZ [14] and run time among great part of one second and 2 s [15], and therefore cannot be used for the independent uninterrupted operation of island. Two types of island detection techniques are remote and local systems. Two types of local systems are active and passive procedures. At the point the remote procedures may have better dependability when contrasted and the local method, yet they are costly to execute and thus uneconomical [16].

Passive procedures are presented based on the rate of change of frequency (ROCOF), phase angle shift, monitoring voltage magnitude, rate of change of generator power output, total harmonic distortion method, impedance monitoring and wavelet transform function [17].

Moreover, if the power inequality in the system is low, the earlier mentioned techniques have some disadvantages that they do not detect the islanding condition [18]. In few conditions, the real method has won the claim. [19]. In this way, based on the few new procedures, the presentation of passive and active strategies are improved for example, intelligent techniques and signal processing techniques, Machine learning based techniques, decision tree, fuzzy logic, adaptive neuro-fuzzy inference system, support vector machine and Artificial Neural Network (ANN) [20].

In this paper an effective hybrid FAT-SGO approach is proposed for island-wide distributed generation (DG) system detection.

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The combined implementation of Feedback Artificial Tree (FAT) and Shell Game Optimization (SGO) named as FAT-SGO technique.

Reducing the non-detection zone as near as possible and keep the quality of output power unmovable is main contribution of this paper.

II. PROPOSED FAT-SGO BASED ISLAND DETECTION OF DISTRIBUTED GENERATION SYSTEM

FAT-SGO method consists of three process information generation, feature extraction and detection, classifications. The block diagram of the proposed plan is displays at Figure 1. The negative sequence component of PCC voltage is removed in generation process. Therefore non-stationary information is given to the analyzer. Then the analyzed information is given to the feature extraction. The frequency, voltage power are extracted and that is processed using the optimization [31]. The major purpose of the proposed approach is for designing a skilled way to handle with islanding detection by taking on attached FAT-SGO system.
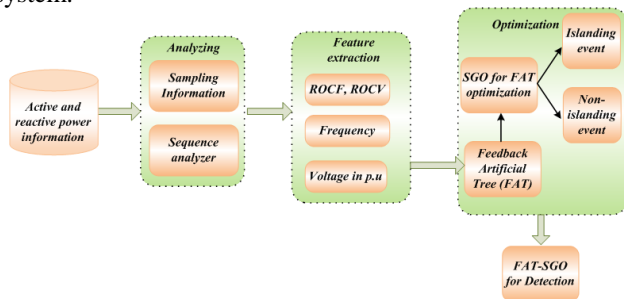

Figure 1: Block Diagram of FAT-SGO Method

The islanding event is mainly depends on the active and reactive power mismatch. Load switching, capacitance bank switching, motor switching, DER trip, single-phase ground fault, two-phase ground fault, three-phase ground fault, as well as phase-to-phase fault on every bus are the non-islanding occasions. For the identification of limits of DG the features are extracted. Frequency, rate of frequency change, voltage, and rate of voltage change are most of the feature extraction parameters.

III. FAT-SGO BASED CLASSIFICATION TECHNIQUE FOR ISLANDING DETECTION

In this section, based on the selected features the FAT-SGO approach is employed for detecting and classifies the islanding and non-islanding actions. The proposed technique is the combined execution of both the Feedback Artificial Tree (FAT) and Shell Gamer Optimization (SGO) named as FAT-SGO. Improved version of artificial tree algorithm is named as Feedback Artificial tree algorithm. Shell Game Optimization is the game based optimization inspired by the determination of the ball hidden less than one of the three shells, which is presumption by players. The main objective of FAT-SGO method is diminishing the non-detection zone (NDZ) as near as to be permitted and to stay the output power quality unaffected. At this point, the features are extracted using the analyzer and the islande3d and non-islanded disturbances are classified using the FAT and then that best value is modified using the SGO algorithm.
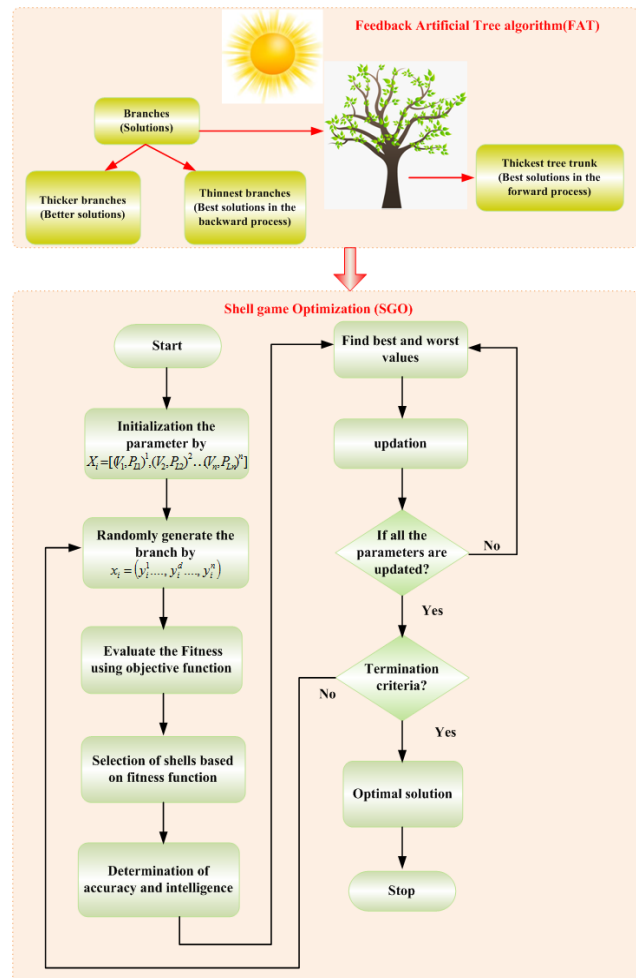

Figure 2: Flowchart of FAT-SGO algorithm

IV. RESULT AND DISCUSSION

In this section described the performance of FAT-SGO strategy of islanding detection for distribution generation. In this technique first the voltage and frequency of the system is extracted based on the feature extraction and using that the islanding and non-islanding actions of DG is determined. Here, at different load condition the islanded detection is checked and analyzed the performance of the system. The simulation results are carried out based on four test cases they are 24 hours period, load 0.5, load 1.5 and load 2.

Bus voltage and power loss are investigated in the simulation result. FAT-SGO method is implemented by MATLAB/Simulink working platform.

FAT-SGO technique outcome is compared with existing techniques like loading condition, normal condition, particle swarm optimization (PSO), bear smell search algorithm (BSA) and black widow optimization (BWO), hybrid black widow optimization algorithm and bear smell search algorithm (IBWBSA). Brief descriptions of the test cases are described as follows.

Case 1: 24-hour period

Figure 3 shows the voltage profile of the system before and after islanding is shown in figure. The voltage of before islanding the voltage is start at 0.99p.u then it gradually decreased to reach the value of 0.91p.u at bus number 18.

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At bus number 18 the voltage is increased to reach the voltage of 0.998 then it gradually decreased to reach the value of 0.965 at bus number 33. After islanding the proposed method increase the voltage profile value. After islanding, at bus number 1 the voltage is start at 1p.u and it gradually decreased and reaches the value of 0.941p.u. then it gradually increased to reach 0.995 at bus number 19 then it decreased to reach the value 0.968p.u at bus number 33.
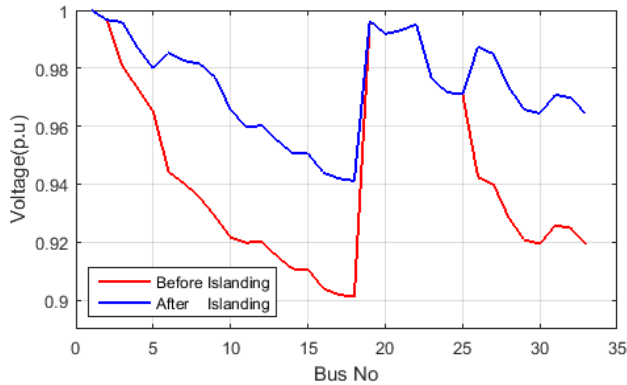

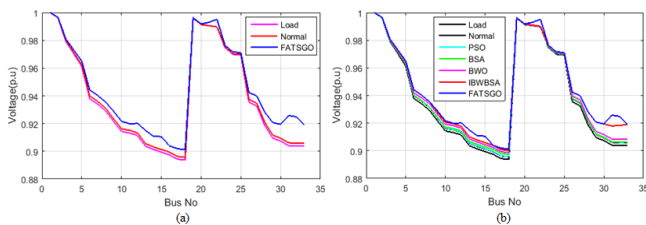**Figure 3: Voltage profile before and after islanding**

Figure 4: Voltage profile of (a) proposed with load and normal condition (b) comparison of proposed with existing techniques

Figure 4 (a) depicts the bus voltage graph of proposed as well as existing approaches at 24 hour period. The bus voltage profile is analyzed under load condition, the method of normal as well as proposed. When the islanding is applied then the voltage of the FAT-SGO technique is increased compared to normal and load condition. The proposed method at bus1, voltage is 1 p.u. From bus number 1 to 18 the voltage is decreased. At bus number 18 onwards the voltage value is remains increased to reach the voltage value of 0.99p.u. Then the voltage is decreased from bus number 19 to 33. At bus number 33, voltage value is 0.92p.u. The normal and load voltage of the system is less compared to the proposed method. Figure 4 (b) portrays the comparison of bus voltage graph of FAT-SGO as well as existing approaches at 24 hour period. The bus voltage profile is analyzed under load condition, the method of normal as well as proposed. When the islanding is applied then the voltage of the FAT-SGO technique is increased compared to normal and load condition. The proposed method at bus1, voltage is 1 p.u. From bus number 1 to 18 the voltage is decreased. At bus number 18 onwards the voltage value is remains increased to reach the voltage value of 0.99p.u. Then the voltage is decreased from bus number 19 to 33. At bus number 33, voltage value is 0.92p.u. The normal and load voltage of the system is less compared to the proposed method.

Case 2: At Load 0.5

Figure 5 (a) shows the voltage profile of proposed with load and normal condition. At load 0.5, when the islanding is applied then the voltage of the FAT-SGO technique is increased compared to normal and load condition. The proposed method at bus1, voltage is 1 p.u. From bus number 1 to 18 the voltage is decreased. At bus number 18 onwards the voltage value is remains increased to reach the voltage value of 0.99p.u. Then the voltage is decreased from bus number 19 to 33. At bus number 33, voltage value is 0.941p.u. The normal and load voltage of the system is less compared to the proposed method. Figure 5 (b) shows the bus voltage comparison of FAT-SGO and existing technique. FAT-SGO technique gives the good voltage profile compared to the existing method. At load condition the voltage of system is very less compared to the other methods. All the voltages are start around 1 p.u after the voltages are decreased to reach the bus number 18 then it is raised from 18 to 19 after that the voltage is decreased and reaches bus number 33.From figure it is clearly depicted the FAT-SGO method improve the voltage profile than existing technique.
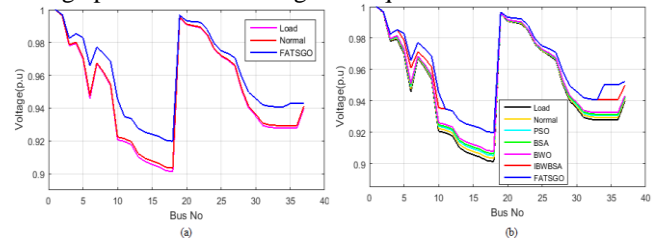

Figure 5: Voltage profile of (a) proposed with load and normal condition (b) comparison of proposed with existing techniques
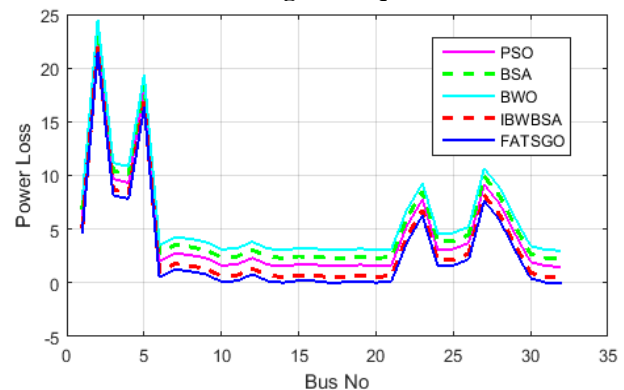

Figure 6: Power loss comparison at load 0.5

Power loss comparison at load 0.5 is depicts in figure 6. The proposed method the power loss is minimized from voltage profile analysis which is obtained after the islanded profile. The proposed method, at bus 1 the power loss become 5kW then it gradually increased to reach 22kW. Then the loss becomes decreased to reach 7.5kW at bus number 3. At bus number 5 the loss becomes 17kW. From bus number 6 to 21 the power loss of the system is around 0.5kW. At bus number 33 the loss is 0kW. Compared to existing method proposed method has low power loss.

Case 3: **At load 1.5**

Figure 7 (a) depicts the graph of bus voltage profile of proposed as well as existing approaches. At load 1.5, when the islanding is applied then the voltage of the FAT-SGO technique is increased compared to normal and load condition. The proposed method at bus1, voltage is 1 p.u. From bus number 1 to 18 the voltage is decreased.

At bus number 18 onwards the voltage value is remains increased to reach the voltage value of 0.99p.u. Then the voltage is decreased from bus number 19 to 33. At bus number 33, voltage value is 0.941p.u. The normal and load voltage of the system is less compared to the proposed method. Figure 7 (b) shows the bus voltage comparison of FAT-SGO and existing technique. Here, the proposed technique is leading in the bus voltage deviation process. And the other techniques give fewer outcomes to minimize the bus voltage deviation. The proposed method gives the good voltage profile compared to the existing method. At load condition the voltage of system is very less compared to other methods. All the voltages are start around 1 p.u after the voltages are decreased to reach the bus number 18 then it is raised from 18 to 19 after that the voltage is decreased and reaches bus number 33.From figure it is clearly depicted the FAT-SGO method improve the voltage profile than existing technique.
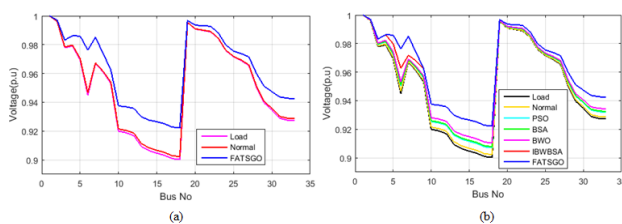

Figure 7: Voltage profile of (a) proposed with load and normal condition (b) comparison of proposed with existing techniques
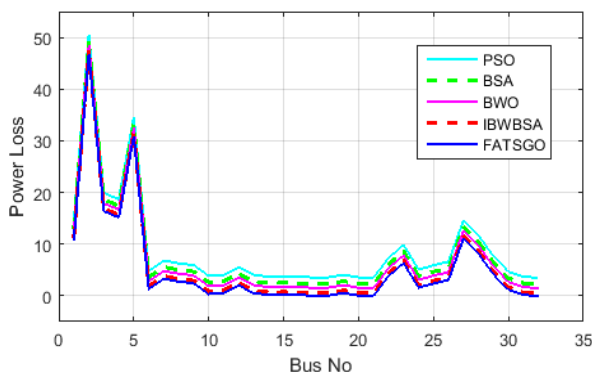

Figure 8: Power loss comparison at load 1.5

Power loss comparison at load 1.5 is depicts in figure 8. The proposed method the power loss is minimized from voltage profile analysis which is obtained after the islanded profile. The proposed method, at bus 1 the power loss become 11kW then it gradually increased to reach 49kW. Then the loss becomes decreased to reach 16kW at bus number 3. At bus number 5 the loss becomes 30kW. From bus number 6 to 21 the power loss of the system is around 0.5 to 0kW. At bus number 33 the loss is 0kW. Compared to existing method proposed method has low power loss.

Case 4: At load 2

Figure 9 (a) depicts the graph of bus voltage profile of proposed as well as existing approaches. At load 2, when the islanding is applied then the voltage of the FAT-SGO technique is increased compared to normal and load condition. The proposed method at bus1, voltage is 1 p.u. From bus number 1 to 18 the voltage is decreased. At bus number 18 onwards the voltage value is remains increased to reach the voltage value of 0.998p.u. Then the voltage is decreased from bus number 19 to 33. At bus number 33,

voltage value is 0.968p.u. The normal and load voltage of the system is less compared to the proposed method. Figure 9(b) shows the bus voltage comparison of FAT-SGO and existing technique. Here, the proposed technique is leading in the bus voltage deviation process. And the other techniques give fewer outcomes to minimize the bus voltage deviation. The proposed method gives the good voltage profile compared to the existing method. At load condition the voltage of system is very less compared to other methods. All the voltages are start around 1 p.u after the voltages are decreased to reach the bus number 18 then it is raised from 18 to 19 after that the voltage is decreased and reaches bus number 33.From figure it is clearly depicted the FAT-SGO method improve the voltage profile than existing technique.

Figure 9: Voltage profile of (a) proposed with load and normal condition (b) comparison of proposed with existing techniques
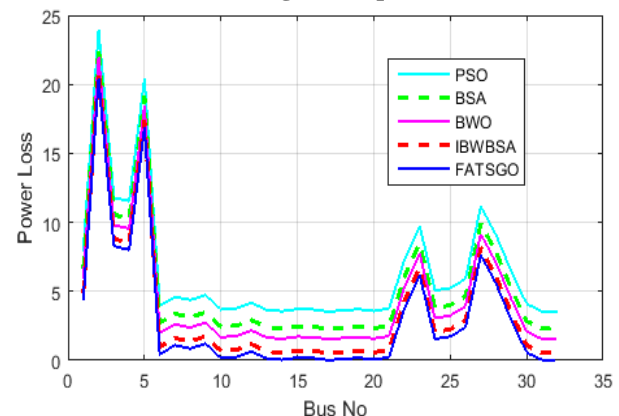

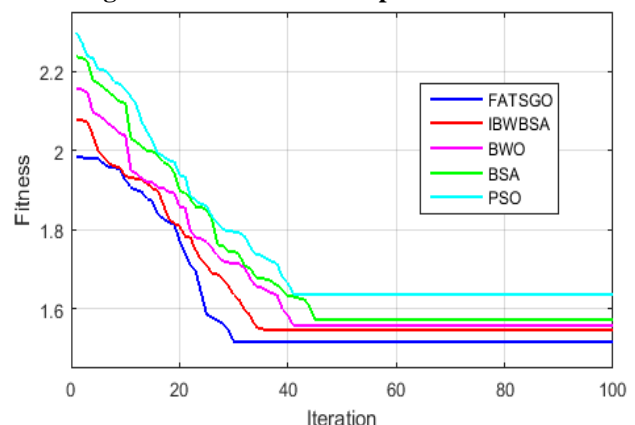**Figure 10: Power loss comparison at load 2**

Figure 11: Fitness comparison of proposed and existing technique

Power loss comparison at load condition 2 is depicts in figure 13. The proposed method the power loss is minimized from voltage profile analysis which is obtained after the islanded profile.

The proposed method, at bus 1 the power loss become 4.9kW then it gradually increased to reach 20kW. Then the loss becomes decreased to reach 7.5kW at bus number 3. At bus number 5 the loss becomes 16kW. From bus number 6 to 21 the power loss of the system is around 0.1 or 0 kW. At bus number 33 the loss is 0kW. Compared to existing the FAT-SGO technique is leading in the power loss minimization process. Figure 14 displays the fitness comparison of FAT-SGO and existing methods. The fitness value of proposed method is 1.995 then it gradually decreased to reach the iteration of 30. From 30 the iteration to 100 iterations the fitness value is constant to 1.5. Compared to existing methods the FAT-SGO technique fitness is low. So the proposed method provides best performance compared to existing techniques. Table 1 tabulated the islanding and non-islanding events at diverse voltages and frequencies [21]. At frequency 49.977 Hz and the voltage is 0.911 p.u then islanding is occur, as well as the rate of change of frequency is 0.748 Hz/Sec, and the power changes become 44.039 MW/Sec. At frequency 50.279 Hz and the voltage is 0.989 p.u then islanding is occur, as well as the rate of change of frequency is 7.309 Hz/Sec, and the power changes become 508.538 MW/Sec. At frequency 49.986 Hz and the voltage is 0.935 p.u then the rate of change of frequency is 0, and the power changes become 1.981 MW/Sec, then the non-islanding is occur. At frequency 49.979 Hz and the voltage is 1.05 p.u then the rate of change of frequency is 0.175Hz/Sec, and the power changes become 16.706 MW/Sec, then islanding is occur. At frequency 49.986 Hz and the voltage is 0.969 p.u then the rate of change of frequency is 0, and the power changes become 1.15 MW/Sec, then the non-islanding is occur. At frequency 49.986 Hz and the voltage is 0.953 p.u then the rate of change of frequency is 0, and the power changes become 1.127 MW/Sec, then the non-islanding is occur. At frequency 50.043 Hz and the voltage is 0.95 p.u then the rate of change of frequency is 2.364, and the power changes becomes 43.767 MW/Sec, then islanding event is occurred.

Table 1: Islanding and non-islanding events at dissimilar frequency and voltage

Frequency (Hz)	Voltage (pu)	df/dt (Hz/Sec)	dP/dt (MW/Sec)	Islanding States
49.977	0.911	0.748	44.039	1
50.279	0.989	7.309	508.538	1
49.986	0.935	0	1.981	0
49.979	1.05	0.175	16.706	1
49.986	0.969	0	1.15	0
49.986	0.953	0	1.127	0
50.043	0.95	2.364	43.767	1

Table 2: Statistical analysis of the FAT-SGO and existing method

Methods	Mean	Median	S.D
FAT-SGO	1.6060	1.5179	0.1598
IBWBSA	1.6452	1.5481	0.1625
BWO	1.6765	1.5577	0.1817
BSA	1.7112	1.5734	0.1968
PSO	1.7644	1.6377	0.2049

Table 2 tabulated the statistic analysis of FAT_SGO and existing technique. The proposed technique mean value is 1.6060, median value is 1.5179 and the standard deviation value is 0.1598. The IBWBSA technique, mean value is 1.6452, median value is 1.5481 and the standard deviation value is 0.1625. The BWO technique, mean value is 1.6765, median value is 1.5577 and the standard deviation value is 0.1817. The BSA technique, mean value is 1.7112, median value is 1.5734 and the standard deviation value is 0.1968. The PSO technique, mean value is 1.7644, median value is 1.6377 and the standard deviation value is 0.2049. From statistical analysis it is clearly known that the proposed approach mean, standard deviation is less compared to existing technique. Hence, FAT-SGO technique produce better islanded detection result compared to existing method.

V. CONCLUSION

In this Paper, hybrid FAT-SGO based islanding detection method is proposed. In the proposed method the data's is analyzed and the features are extracted initially. The islanding and non-islanding of DG are classified using FAT-SGO. The proposed approach is assure the load requirements, easy to upgrade and with low impact on power quality. The proposed technique actively minimized the power losses, voltage deviation, which is used to reduce NDZ and increase the capacity. Additionally, the FAT-SGO approach provides the reduction of the NDZ to zero. Furthermore, this system overcomes the problems of setting intrinsic location thresholds on current methods. FAT-SGO method is simulated at the work site of MATLAB/Simulink as well as performance is examined with different existing techniques such as loading condition, normal condition, particle swarm optimization (PSO), bear smell search algorithm (BSA) and black widow optimization (BWO), hybrid black widow-bear smell search algorithm (IBWBSA). The comparison results are taken for the power loss and voltage of the distribution system in various conditions.

The simulation outcomes determine that the performance of the FAT-SGO technique is high compared to existing methods for detecting island events in which the innate power output is proportionate to the local load consumption

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