

Anti-Islanding Protection of Distributed Generation Based on Social Spider Optimization Technique

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Abstract— Anti-islanding protection is one of the most important requirements for the connection of Distributed Generators in power systems. This paper proposes a Social Spider Optimization (SSO) algorithm to detect unintentional islanding in power systems with distributed generation. The SSO algorithm is employed to differentiate frequency oscillations in synchronous generator those caused by non-islanding events. The SSO algorithm is based on the foraging strategy of social spiders, which generated vibrations spread over the spider web to determine the positions of preys or any other disturbances. The vibrations from the spider are used to detect the occurrence of islanding in the synchronous generator. The SSO algorithm has superior performance when tested with IEEE 34 bus distribution system. The taken test system is evaluated for different scenarios and load distribution. The proposed SSO algorithm detects the islanding and prevents the system from undue tripping and outages. Furthermore, this technique may apply to prevent the system from islanding and maintains the future Indian Distributed Generation (DG) system reliability.

Keywords—Anti-islanding Protection, IEEE 34 Bus Distribution System, Distributed Generation, Social Spider Optimization algorithm, Synchronous Generator Oscillations.

I. INTRODUCTION

The growing power demand and increasing concern for the use of fossil fuels in conventional power plants are increasing nowadays. The new paradigm of distributed generation is gaining greater commercial and technical importance. Distributed Generation (DG) involves the interconnection of small-scale, on-site Distributed Energy Resources (DER) with the main power utility at distribution voltage level [1].

Distributed Energy Resources mainly constitute non-conventional and renewable energy sources like solar PV, wind turbines, fuel cells, small-scale hydro, tidal and wave generators, micro-turbines etc. These generation technologies are being preferred for their high-energy

efficiency and low environmental impact. Their applicability as uninterruptible power supplies to power quality sensitive loads. Electric energy market reforms and developments in electronics and use of anti-islanding protection are justified by the operational requirements of the utilities [2]. Anti-islanding systems are used to ensure personnel safety at the grid end and to prevent the generator out of synchronism.

The islanding condition is a situation in which a part of an electric power system is solely energized and separated from the rest of the system. Failure to islanding detection [3] have several negative impacts for generators and connected loads. Imported one is the islanded grid because it cannot effectively control its frequency and voltage. This results in damage of equipment. Due to these damages, it causes safety hazards to utility workers and customers.

To avoid these problems, many power utilities using reclosers with transferred trip in the DG connection point. Other utilities request dedicated feeders with transfer trip. The detection methods are local techniques and Communication based techniques. These communication-based methods are more effective than local techniques. The local methods are proposed as alternatives to methods based on communication and it is divided into three categories. The methods are active and passive methods.

The active methods [4] inject small signals in the distribution system or force the DG to an abnormal situation, while the connection to the system keeps it under normal conditions. The disturbances inserted in the distribution system may cause power quality deterioration. The passive method uses wavelet [5]. The wavelets extract voltage and current features and use a decision tree to identify the islanding. The method uses a very large data set for training.

The group living phenomenon has been studied intensively in animal behavior ecology. One of the reasons that an animal gather and live together is to increase the possibility of successful foraging and reduce the energy cost in this process. In order to facilitate the

analysis of social foraging behavior [6], researchers proposed two foraging models: Information Sharing (IS) model [7] and Producer-Scrounger (PS) model [8]. The individuals under the IS model perform individual searching and seek for opportunity to join other individuals simultaneously. In the PS model, the individuals are divided into leaders and followers. Since there is no leader in social spiders, it seems the IS model is more suitable. The Bacterial Swarm Optimization (BSO) [9]-[10] is proposed for scheduling generating system. Even though it solves the problem, a step involved in solving this algorithm is large. Inspired by geographical elements, Biogeography-Based Optimization (BBO) [11]-[12] introduced to solve numerous problems in DG formulated micro grid. Sometimes the BBO struck in local optima leads towards worst optimal solution. The Ant Colony Optimization (ACO) [13] is introduced to solve the optimal power flow problem, the Ant's path takes more time to find the optimal path. The Bat Motivated Optimization (BMO) [14] involves the inspiration from social facts leads to poor solution.

In this paper, the Social Spider Optimization (SSO) [15] algorithm is introduced to solve Anti-islanding protection of DGs. It is inspired by the social behavior of the social spiders, especially their foraging behavior. The foraging behavior of the social spider is described as the cooperative movement of the spiders towards the food source position. The spiders receive and analyze the vibrations propagated on the web to determine the potential direction of a food source [16]. In this process, the spiders cooperate with each other to move towards the prey. The natural behavior is utilized to perform optimization over the search space in SSO. The proposed algorithm has less iteration and fast ability to find optimal solution when compared with other techniques.

II. PROBLEM FORMULATION

2.1 Formulation of Synchronous machine models

The synchronous machine operating in steady state, the relative position between rotor and resulting magnetic field remain almost constant. When a sudden disturbance occurs, the angle between them oscillates dynamically according to the swing equation given by (1).

$$\frac{2H}{\omega_0} \frac{d^2\delta}{dt^2} + D \frac{d\delta}{dt} = P_m - P_e \quad (1)$$

Where δ is the relative rotor angle, t is the time, H is the generator inertia constant, D is the damping coefficient, ω_0 is the DG synchronous speed, P_m, P_e are mechanical input and electric power output of the DG, respectively.

2.1.1 Frequency variation during non-islanding events

When a small disturbance occurs in the electrical system, the DG oscillates and returns to its original state after some time. The electrical power injected by DG in the distribution system is written as (2).

$$P_e = P_{\max} \sin \delta \quad (2)$$

A small perturbation $\Delta\delta$ in δ from the initial operating position δ_0 is represented by (3)

$$\delta = \delta_0 + \Delta\delta \quad (3)$$

Due to this perturbation, the swing equation (1) is linearized and rewritten as

$$\frac{2H}{\omega_0} \frac{d^2\Delta\delta}{dt^2} + D \frac{d\Delta\delta}{dt} + P_s \Delta\delta = 0 \quad (4)$$

P_s is known as the synchronizing power coefficient and is defined by the equation

$$P_s = P_{\max} \cos \delta_0 \quad (5)$$

Solving the differential equation shown in (4), shows that the frequency deviation from nominal synchronous speed is given by (6).

$$\Delta\omega = \frac{d\Delta\delta}{dt} = -\frac{\omega_n \Delta\delta(0)}{\sqrt{1-\zeta^2}} e^{-\zeta\omega_d t} \sin \omega_d t \quad (6)$$

Where

$$\omega_d = \omega_n \sqrt{1-\zeta^2} \quad (7)$$

$$\zeta = \frac{D}{2} \sqrt{\frac{\omega_0}{2HP_s}} \quad (8)$$

$$\omega_n = \sqrt{\frac{\omega_0}{2H} P_s} \quad (9)$$

From (6), the frequency is given by a damped sinusoidal waveform.

2.1.2 Frequency variation during islanding events

During an islanding event, the DG loses connection with the main system and, therefore, the synchronizing coefficient is 0. In this way, (4) is rewritten as (10).

$$\frac{2H}{\omega_0} \frac{d^2\Delta\delta}{dt^2} + D \frac{d\Delta\delta}{dt} = \Delta P \quad (10)$$

Δp is the power variation due to the islanding; in other words, the transmitting power in the electrical system split point. In this case, Δp is assumed as constant during the islanding. Δp is assumed positive when the electrical power in the split point is flowing from the main system to DG.

Since the rotor angle is synchronized with the stator magnetic field before islanding, the two initial conditions

for (10) are $\Delta\delta(0)=0$ and $\frac{d\Delta\delta(0)}{dt}=0$. Solving (10), the equation for electrical frequency deviation is obtained.

$$\Delta\omega = \frac{d\Delta\delta}{dt} = \frac{\Delta P}{D}(1 - e^{\omega_0 D t / 2H}) \quad (11)$$

Comparing (6) to (11), it is observed that the frequency of the DG behaves differently. During DG parallel operation with the system, the frequency tends to oscillate at the damped natural frequency ω_d . Disregarding the voltage controllers, governors, and the load dynamic during islanding, which may change due to voltage and frequency variation, the frequency does not oscillate during an islanding, but it is given by an exponential response.

III. SOCIAL SPIDER OPTIMIZATION TECHNIQUE

The Social Spider Optimization is the one of the nature inspired optimization technique and it is developed from behavior of social spiders. Swarm intelligence is a research field that models the collective behavior in swarms of insects or animals. Several algorithms arising from such models have been proposed to solve a wide range of complex optimization problems. The SSO algorithm is based on the simulation of cooperative behavior of social-spiders. In the proposed algorithm, individuals emulate a group of spiders, which interact to each other based on the biological laws of the cooperative colony.

3.1 Algorithm for SSO

Step 1: Considering N as the total number of n-dimensional colony members, define the number of male N_m and females N_f spiders in the entire population S

$$N_f = \text{floor}[(0.9 - \text{rand}) \cdot 0.25 \cdot N] \quad (12)$$

and

$$N_m = N - N_f$$

Where rand is random number between [0, 1] whereas floor(.) maps real number into integer number.

Step 2: Initialize randomly the female ($F = \{f_1, f_2, \dots, f_{N_f}\}$) and male ($M = \{m_1, m_2, \dots, m_{N_m}\}$) members (where $S = \{s_1 = f_1, s_2 = f_2, \dots, s_{N_f} = f_{N_f}, s_{N_f+1} = m_1, \dots, s_N = m_{N_m}\}$) and calculate the radius.

$$r = \sum_{j=1}^n (P_j^{\text{high}} - P_j^{\text{low}}) / 2 \cdot n \quad (13)$$

Step 3: Calculate the weight of every spider of S

$$w_i = J(s_i) - \text{worst}_s / (\text{best}_s - \text{worst}_s)$$

$$\text{best}_s = \max_{k \in \{1, 2, \dots, N\}} J(s_k)$$

and

$$\text{worst}_s = \min_{k \in \{1, 2, \dots, N\}} J(s_k) \quad (14)$$

Where $J(s_i)$ is fitness value obtained by the evaluation of spider position s_i with regard to the objective function $J(\cdot)$.

Step 4: Move female spiders according to female cooperative operator

The vibrations perceived by the individual i as results of the information transmitted by the member j are modeled according to be following equation

$$\text{Vib}_{i,j} = w_j \cdot e^{-d_{i,j}^2} \quad (15)$$

Where $d_{i,j}$ is the Euclidian distance between the spiders i and j , such that

$$d_{i,j} = \|s_i - s_j\| \quad (16)$$

Although it is virtually possible to compute perceived vibrations by considering any pair of individuals, three special relationships are considered within the SSO approach:

1. Vibrations Vib_{c_i} are perceived by the individual $i(s_i)$ as a result of the information transmitted by the member $c(s_c)$ who is an individual that has two important characteristics: it is the nearest member to i and possesses a higher weight in comparison to i ($w_c > w_i$).

$$\text{Vib}_{c_i} = w_c \cdot e^{-d_{i,c}^2} \quad (17)$$

2. The vibrations Vib_b perceived by the individual i as a result of the information transmitted by the member $b(s_b)$, with b being the individual holding the best weight (best fitness value) of the entire population S, such that $w_b = \max_{k \in \{1, 2, \dots, N\}} (w_k)$.

$$\text{Vib}_b = w_b \cdot e^{-d_{i,b}^2} \quad (18)$$

3. The vibrations Vib_f perceived by the individual $i(s_i)$ as a result of the information transmitted by the member $f(s_f)$, with f being the nearest female individual to i .

$$\text{Vib}_f = w_f \cdot e^{-d_{i,f}^2} \quad (19)$$

$$f_{i,j}^0 = P_j^{\text{low}} + \text{rand}(0,1) \cdot (P_j^{\text{high}} - P_j^{\text{low}}) \quad (20)$$

$i = 1, 2, \dots, N_f; j = 1, 2, \dots, n$

$$m_{k,j}^0 = P_j^{low} + rand(1,0).(P_j^{high} - P_j^{low}) \quad (21)$$

$$k = 1,2,\dots,N_m; j = 1,2,\dots,n$$

Step 5: Move the male spiders according to the male cooperative operator.

According to this, change of positions for the male spider is modeled as follows:

$$m_i^{k+1} = \begin{cases} m_i^k + \alpha \cdot vib f_i \cdot (s_f - m_i^k) + \delta \cdot (rand - 1/2) & \text{if } w_{N_i+i} > w_{N_i+m} \\ m_i^k + \alpha \cdot \left(\frac{\sum_{h=1}^{N_m} m_h^k \cdot w_{N_i+h}}{\sum_{h=1}^{N_m} w_{N_i+h}} - m_i^k \right) & \text{if } w_{N_i+i} \leq w_{N_i+m} \end{cases} \quad (22)$$

Where the individual s_f represents the nearest female individual to the male I whereas $\left(\frac{\sum_{h=1}^{N_m} m_h^k \cdot w_{N_i+h}}{\sum_{h=1}^{N_m} w_{N_i+h}} \right)$ correspond to the weighted mean of the male population M .

Step 6: If the stop criteria is met, the process is finished; otherwise, go back to Step 3.

IV. IMPLEMENTATION OF SOCIAL SPIDER OPTIMIZATION ALGORITHM TO ANTI-ISLANDING PROTECTION PROBLEM

- (1) Initialize the parameters such as Mechanical input, Electrical output, DG Synchronous speed, Time, Number of Male spider, Number of Female spider, Weight of the spider, Vibration of the spider. Here the Distributed Generator represents the spider, the majority of population is male which represents the synchronous generator.
- (2) The vibration that made by spider indicates the frequency oscillation in the online synchronous generator. The weight of the spider correlates the DG synchronous speed.
- (3) Randomly place the DG unit in distribution system and calculate frequency deviation (i.e., the vibration of the external agents) of synchronous generator (eqn. 6 and eqn. 11) of DG units.
- (4) Calculate the Weight of the spider (DG), in this step the best and worst position of the spider is calculated. The weight in the spider correlates the capacity of the DG unit.
- (5) Evaluate the spider that senses huge vibrations, the corresponding spider are considered as the best ones. Here the vibration specifies the synchronous generators frequency oscillations that causes due to the sudden inclusion of unexpected load.
- (6) If that huge vibration is identified, then the spider separates the Zone of DG units (Islanding). i.e., it prevents the system from islanding (Anti-islanding). If step 3 is not satisfied, then randomly place the DG unit (Spider). The following steps are repeated until

the optimal solution (less vibration) is found.

V. TEST RESULTS AND DISCUSSIONS

To evaluate the performance of the proposed method, it has been used on the IEEE 34 node distribution test system (Online Available) presented in Figure 1.

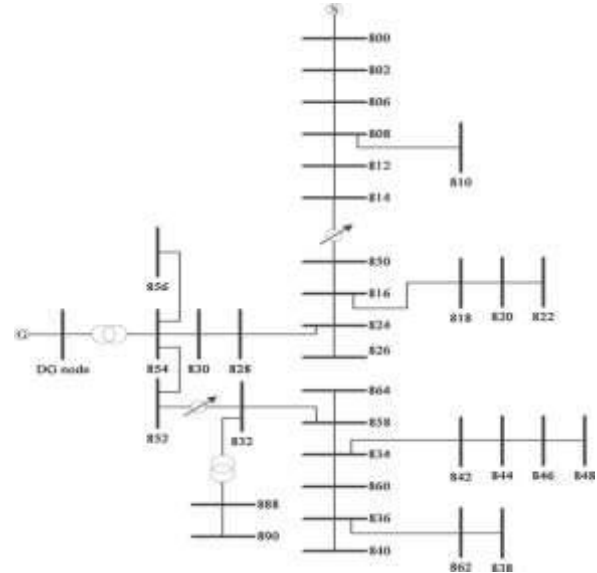


Fig.1: IEEE 34 Node Test Feeder

The transformer data are given in Table 1.

Table 1: 854-Point of common coupling three phase transformer data

Parameter	Value
Rated power	3.0 MVA
Nominal frequency	60 Hz
Rated voltage	24.9/2.4 kV
Connection	D/Y _n
Vector group	Phase shift 1 × 30°
Positive sequence reactance (X1)	0.059371 p.u.
Positive sequence resistance (R1)	0.008667 p.u.
Zero sequence short circuit impedance	0.06 p.u.
Zero sequence short circuit resistance	0.0087 p.u.

The diesel generator controls the power factor to 0.98 inductive its data are presented in Table 2, and DG voltage and frequency regulators are given in [18]. The excitation system model used in a static excitation equivalent and the governor is the same used in [19]. The Rate of Change of Frequency (ROCOF) is calculated at each frequency sample by

$$\frac{df}{dt} = (f_r - f_{r-1}) f_{sampling} \quad (23)$$

$f_{sampling}$ is the sampling frequency. When ROCOF exceeds the threshold, a time counter starts.

Table 2: Generator parameters

Parameter	Value	Parameter	Value
Reference machine	Not flag	Direct axis reactance X_d	1.56 p.u.
Mode of local voltage controller	Voltage	Direct axis reactance X_q	NA
Dispatch voltage	1.0 p.u.	Direct axis transient reactance X'_d	0.26 p.u.
Nominal apparent power	3.125 MVA	Direct axis sub transient reactance X''_d	0.15 p.u.
Nominal voltage	2.4 kV	Quadrature axis sub transient reactance X''_q	0.15 p.u.
Power factor	0.8	Direct axis short-circuit transient time-constant T'_d	3.7 s
Connection	Y_n	Direct axis short-circuit Sub transient time-constant T''_d	0.05 s
Inertia time constant (H)	1.071 s	Quadrature axis short-circuit sub transient time-constant T''_q	0.05 s
Leakage reactance	8.8%	Main flux saturation – Sg10	0.17 p.u.
Rotor type	Salient pole	Main flux saturation – Sg12	0.60 p.u.

Table 3 ROCOF 3 operates if voltage and reactive remains greater than 0.8p.u. ROCOF 1 and 2 do not use any voltage restriction. This temporization is important because of the high sensitivity of ROCOF protection, and helps to avoid unwanted Trips for short time transients in the distribution system, especially short circuits.

Table 3: Rate of change of frequency methods configuration

Parameter	ROCOF 1	ROCOF 2	ROCOF 3
$\frac{df}{dt}$ (Hz/s)	0.500	2.500	0.500
Delay(s)	0.150	0.050	0.150
Voltage constraint (p.u)	-	-	0.8

Several islanding conditions are tested and are shown in Table 4, which presents the line switched, the load condition, the DG generated power, the active switching interrupted power, and the protections tripping time. It is possible to see that the proposed method did not fail in any of the simulated cases.

Table 5 shows the methods performance during a single-phase to ground short circuit sustained in the system for 350ms. After this time, the fault line is disconnected, thus

causing the DG islanding. Table 5 shows the short-circuited bus and the fault resistance.

The islanding detection time is the difference between the protection trip times and 350ms; in this way, negative times represent protection trips before DG islanding, i.e., they represent failed trips. The proposed method did not fail in any simulated case presented Table 5.

ROCOF 1 failed once and had some detection times greater than 500ms. ROCOF 2 failed in almost all cases, presenting negative islanding detection times. It detected the islanding during the short circuit in four times and did not trip during real islanding in three cases.

Table 4: Performance of islanding detection methods during islanding events

Operating characteristic of the system						Islanding detection time (s)		
Opened line	Load (%)	PG (MW)	POP (MW)	QOP (MVar)	Proposed SSO	ROCOF 1	ROCOF 2	ROCOF 3
800-802	100	2.5	-0.38	-0.11	0.221	0.150	0.050	0.150
830-854	100	2.5	-0.75	-0.18	0.221	0.150	0.050	0.150
800-802	50	2.5	-1.32	-0.67	0.221	0.150	0.050	0.150
830-854	50	2.5	-1.61	-0.71	0.221	0.150	0.050	0.150
800-802	100	1.0	1.12	0.13	0.220	0.150	0.050	0.150
830-854	100	1.0	0.72	0.04	0.218	0.150	0.050	0.150
800-802	50	1.0	0.05	-0.31	0.248	Not det.	Not det.	Not det.
830-854	50	1.0	-0.13	-0.49	0.396	Not det.	Not det.	Not det.

Table 6 shows the algorithms performance for temporary phase to ground short circuit. The fault remains during 350ms and disappears spontaneously without any switching.

The proposed algorithm as well as ROCOF 1 and ROCOF 3 worked well in all simulated cases. ROCOF 2 failed in 12 and 3 cases, respectively.

Due to frequency pattern recognition, the proposed method avoids the nuisance tripping that would happen in

other frequency-based relays such as ROCOF and Under/Over frequency. This is an advantage since, for instance, in case of a big generation trip in a large DG penetration scenario, the DG may help the system in the recovering process.

However, a large perturbation on the generation or transmission system may cause frequency variations similar to those present in case of islanding, producing an undesirable tripping.

Table 5: Performance of island detection methods during phase to ground short circuit, sustained for 350ms, and followed by islanding

Operating characteristic of the system						Islanding detection time (s)		
Short circuit bus	Opened line	Z fault (Ω)	Load (%)	PG (MW)	Proposed SSO	ROCOF 1	ROCOF 2	ROCOF 3
802	802-806	0	100	2.5	0.350	0.150	-0.223	Not det.
802	802-806	60	100	2.5	0.350	0.150	-0.230	Not det.
816	816-824	0	100	2.5	0.327	0.189	0.323	Not det.
816	816-824	60	100	2.5	0.213	0.150	-0.230	Not det.
830	830-854	0	100	2.5	0.389	0.208	0.440	Not det.
830	830-854	60	100	2.5	0.232	0.150	-0.230	Not det.
802	802-806	0	50	2.5	0.194	0.401	-0.223	Not det.
802	802-806	60	50	2.5	0.202	Not det.	-0.220	Not det.
816	816-824	0	50	2.5	0.220	0.490	0.050	Not det.
816	816-824	60	50	2.5	0.219	0.540	-0.230	Not det.
830	830-854	0	50	2.5	0.220	0.490	0.050	Not det.
830	830-854	60	50	2.5	0.219	0.527	-0.230	Not det.
802	802-806	0	100	1.0	0.219	0.128	-0.227	Not det.
Operating characteristic of the system						Islanding detection time (s)		

Short circuit bus	Opened line	Z fault (Ω)	Load (%)	PG (MW)	Proposed SSO	ROCOF 1	ROCOF 2	ROCOF 3
802	802–806	60	100	1.0	0.220	0.150	-0.229	Not det.
816	816–824	0	100	1.0	0.219	0.150	0.050	Not det.
816	816–824	60	100	1.0	0.220	0.150	-0.230	Not det.
830	830–854	0	100	1.0	0.219	0.150	0.050	Not det.
830	830–854	60	100	1.0	0.220	0.150	-0.230	Not det.
802	802–806	0	50	1.0	0.192	0.123	-0.300	Not det.
802	802–806	60	50	1.0	0.197	0.150	-0.230	Not det.
816	816–824	0	50	1.0	0.211	0.150	-0.223	Not det.
816	816-824	60	50	1.0	0.194	0.150	-0.231	Not det.
830	830-854	0	50	1.0	0.217	0.150	0.050	Not det.
830	830–854	60	50	1.0	0.194	0.150	-0.231	Not det.

Table 6: Performance of island detection methods during temporary phase to ground short circuit, 350ms

Operating characteristic of the system					Islanding detection time (s)			
Short circuit bus	Opened line	Z fault (Ω)	Load (%)	PG (MW)	Proposed SSO	ROCOF 1	ROCOF 2	ROCOF 3
830	0	100	2.5	Not det.	Not det.	Not det.	Not det.	Not det.
830	60	100	2.5	Not det.	Not det.	0.120	Not det.	Not det.
852	0	100	2.5	Not det.	Not det.	Not det.	Not det.	Not det.
852	60	100	2.5	Not det.	Not det.	0.124	Not det.	Not det.
842	0	100	2.5	Not det.	Not det.	Not det.	Not det.	Not det.
842	60	100	2.5	Not det.	Not det.	0.125	Not det.	Not det.
830	0	50	1.0	Not det.	Not det.	Not det.	Not det.	Not det.
830	60	50	1.0	Not det.	Not det.	0.120	Not det.	Not det.
852	0	50	1.0	Not det.	Not det.	Not det.	Not det.	Not det.
852	60	50	1.0	Not det.	Not det.	0.123	Not det.	Not det.
842	0	50	1.0	Not det.	Not det.	Not det.	Not det.	Not det.
842	60	50	1.0	Not det.	Not det.	0.124	Not det.	Not det.
830	0	100	2.5	Not det.	Not det.	Not det.	Not det.	Not det.
830	60	100	2.5	Not det.	Not det.	0.120	Not det.	Not det.
852	0	100	2.5	Not det.	Not det.	Not det.	Not det.	Not det.
852	60	100	2.5	Not det.	Not det.	0.124	Not det.	Not det.
842	0	100	2.5	Not det.	Not det.	Not det.	Not det.	Not det.
842	60	100	2.5	Not det.	Not det.	0.125	Not det.	Not det.
830	0	50	1.0	Not det.	Not det.	Not det.	Not det.	Not det.
830	60	50	1.0	Not det.	Not det.	0.119	Not det.	Not det.
852	0	50	1.0	Not det.	Not det.	Not det.	Not det.	Not det.
852	60	50	1.0	Not det.	Not det.	0.122	Not det.	Not det.
842	0	50	1.0	Not det.	Not det.	Not det.	Not det.	Not det.
842	60	50	1.0	Not det.	Not det.	0.123	Not det.	Not det.

Table 7 presents the tests of load switching, caused by the opening lines. The ROCOF 2 failed in case 5 identifying an islanding erroneously. The proposed method and ROCOF methods worked well in all tests.

Table 7: Load switching tests

Case	Opened line	Load (%)	PG (MW)	P _{op} (MW)	Q _{op} (MW)
1	854-852	100	2.5	1.511	0.107
2	834-842	100	2.5	0.565	-0.376
3	854-852	50	2.5	0.754	-0.381
4	834-842	50	2.5	0.285	-0.593
5	854-852	100	1.0	1.507	0.112
6	834-842	100	1.0	0.563	-0.374
7	854-852	50	1.0	0.75	-0.375
8	834-842	50	1.0	0.284	-0.558

Therefore, the Standard IEEE 1547 allows the system operator to specify the frequency setting and time delay for under frequency trips down to 57 Hz. In these cases, the settings of the proposed method should take this recommendation into account.

VI. CONCLUSION

This paper proposes the Social Spider Optimization Algorithm technique for islanding detection. During islanding, the synchronous generator oscillates at very slow frequency due to governor's actions or the frequency growth exponentially when the governors are unable to correct it. However, while connected to the main grid, the DG oscillates at a higher frequency. The method uses the communal web vibrations methodology that detects the frequency oscillation during islanding and sends a trip signal to the synchronous generator-operating switch. The suggested algorithm takes less convergence that seek to estimate the frequency of oscillation and damping coefficient, providing faster tripping compared to other optimization techniques. The main advantage of the proposed algorithm is conceptually simple and relatively easy to implement, which is clear from the presented result.

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