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 forging 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 wavelet extracts voltage and current features and uses 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
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).

\[
\frac{2H}{\omega_0} \frac{d^2 \delta}{dt^2} + D \frac{d\delta}{dt} = P_m - P_e
\]  

(1)

Where \( \delta \) is the relative rotor angle, \( t \) is the time, \( H \) is the generator inertia constant, \( D \) is the damping coefficient, \( \omega_0 \) 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).

\[
P_e = P_{\text{max}} \sin \delta
\]  

(2)

A small perturbation \( \Delta \delta \) in \( \delta \) from the initial operating position \( \delta_0 \) is represented by (3)

\[
\delta = \delta_0 + \Delta \delta
\]  

(3)

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

\[
\frac{2H}{\omega_0} \frac{d^2 \Delta \delta}{dt^2} + D \frac{d\Delta \delta}{dt} + P_e \Delta \delta = 0
\]  

(4)

\( P_e \) is known as the synchronizing power coefficient and is defined by the equation

\[
P_e = P_{\text{max}} \cos \delta_0
\]  

(5)

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

\[
\frac{d\Delta \omega}{dt} = -\frac{\omega_e \Delta \delta(0)}{\sqrt{1 - \zeta^2}} e^{-\zeta^2} \sin \omega_d t
\]  

(6)

Where

\[
\omega_d = \omega_0 \sqrt{1 - \zeta^2}
\]  

(7)

\[
\zeta = \frac{D}{2 \sqrt{2HP_e}}
\]  

(8)

\[
\omega_n = \frac{\omega_0}{\sqrt{2H}} P_e
\]  

(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).

\[
\frac{2H}{\omega_0} \frac{d^2 \Delta \delta}{dt^2} + D \frac{d\Delta \delta}{dt} = \Delta P
\]  

(10)

\( \Delta P \) is the power variation due to the islanding; in other words, the transmitting power in the electrical system split point. In this case, \( \Delta P \) is assumed as constant during the islanding. \( \Delta P \) 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

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for (10) are \( \Delta \delta(0) = 0 \) and \( \frac{\Delta \delta(0)}{dt} = 0 \). Solving (10),
the equation for electrical frequency deviation is obtained.
\[
\Delta \omega = \frac{d\Delta \delta}{dt} = \frac{\Delta P}{D} \left( 1 - e^{\frac{\alpha s}{D}} \right)
\]  
(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 \( \omega_s \). 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 \( S \)
\[
N_f = floor(0.9 - rand(0.25).
N]
\]
and
\[
N_m = N - N_f
\]  
(12)

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

Step 2: Initialize randomly the female
\( (F = \{ f_1, f_2, ..., f_{N_f} \}) \) and male \( (M = \{ m_1, m_2, ..., m_{N_m} \}) \)
members
\[
S = \{ s_1 = f_1, s_2 = f_2, ..., s_{N_f}, s_{N_f+1} = m_1, ..., s_{N_m} = m_{N_m} \}
\]
and calculate the radius.
\[
r = \sum_{j=1}^{n} (P_{j^{\text{high}}} - P_{j^{\text{low}}}) / 2n
\]  
(13)

Step 3: Calculate the weight of every spider of \( S \)
\[
w_i = J(s_i) - \text{worst, } j \text{best, } j \text{worst, } j
\]
\[
\text{best, } j = \max_{k=1,2,...,N} J(s_k)
\]

and
\[
\text{worst, } j = \min_{k=1,2,...,N} J(s_k)
\]  
(14)

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

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
\[
Vib_i = w_i \cdot e^{-d_{ij}^2},
\]
(15)

Where \( d_{ij} \) is the Euclidian distance between the spiders \( i \)
and \( j \), such that
\[
d_{ij} = \| s_i - s_j \|
\]  
(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 \( Vib_{i,j} \) are perceived by the individual \( i(s_i) \)
as a result of the information transmitted by the member
\( c(s_j) \) who is an individual that has two important
characteristics: it is the nearest member to \( i \) and possesses
a higher weight in comparison to \( i(w_i > w_j) \).
\[
Vib_{i,j} = w_i \cdot e^{-d_{ij}^2}
\]  
(17)

2. The vibrations \( Vib_{i,j} \) perceived by the individual \( i \) as a
result of the information transmitted by the member
\( b(s_j) \), with \( b \) being the individual holding the best
weight (best fitness value) of the entire population \( S \), such
that \( w_b = \max_{k=1,2,...,N} (w_k) \).
\[
Vib_{i,j} = w_b \cdot e^{-d_{ij}^2}
\]  
(18)

3. The vibrations \( Vib_{i,j} \) perceived by the individual \( i(s_i) \)
as a result of the information transmitted by the member
\( f(s_j) \), with \( f \) being the nearest female individual to \( i \).
\[
Vib_{i,j} = w_j \cdot e^{-d_{ij}^2}
\]  
(19)

\[
J_i = P_{i^{\text{high}}} + \text{rand}(0,1) \cdot (P_{i^{\text{high}}} - P_{i^{\text{low}}})
\]
\[
i = 1,2, ..., N_f; j = 1,2, ..., N
\]  
(20)
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:

\[
m^{k}_{j} = m^{k}_{j} + \alpha \text{vibf}(s_{j} - m^{k}_{j}) + \delta \text{rand} - 1/2 \quad \text{if} \quad w_{N_{j},s_{j}} > w_{N_{j},m_{j}}
\]

\[
m^{k+1}_{j} = m^{k}_{j} + \alpha \left( \frac{\sum_{k=1}^{N_{f}} m^{k}_{j} w_{N_{j},f_{k}}}{\sum_{k=1}^{N_{f}} w_{N_{j},f_{k}}} - m^{k}_{j} \right) \quad \text{if} \quad w_{N_{j},s_{j}} \leq w_{N_{j},m_{j}}
\]

(22)

Where the individual \( s_{j} \) represents the nearest female individual to the male \( I \) whereas \( \sum_{k=1}^{N_{f}} m^{k}_{j} w_{N_{j},f_{k}} / \sum_{k=1}^{N_{f}} w_{N_{j},f_{k}} \) 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.

The transformer data are given in Table 1.

| 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 x 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

\[
\frac{df}{dt} = (f_{r} - f_{r-1}) f_{\text{sampling}}
\]

(23)

\( f_{\text{sampling}} \) 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 0.8 p.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) |
|----------------------------------------|-------------------------------|
| **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) |
|----------------------------------------|-------------------------------|
| **Proposed SSO** | ROCOF 1 | ROCOF 2 | ROCOF 3 |
|------------------|---------|---------|---------|
| 802 | 802–806 | 0 | 100 | 2.5 | 0.350 | 0.150 | -0.233 | 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. |
ROCOF methods worked well in all tests.

The proposed method and 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 6: Performance of island detection methods during temporary phase to ground short circuit, 350ms

| 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     | 60          | 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     | 60          | 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     | 60          | 50       | 1.0     | 0.192        | 0.123   | -0.300  | Not det.|
| 816              | 816–824     | 60          | 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     | 60          | 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 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: 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. | Not det. | 0.120 | Not det. | Not det. |
| 852 | 0 | 100 | 2.5 | Not det. | Not det. | Not det. | Not det. | Not det. | Not det. |
| 852 | 60 | 100 | 2.5 | Not det. | 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. | Not det. |
| 830 | 60 | 100 | 2.5 | Not det. | Not det. | Not det. | 0.125 | Not det. | Not det. |
| 830 | 0 | 50 | 1.0 | Not det. | Not det. | Not det. | 0.120 | Not det. | Not det. |
| 852 | 60 | 50 | 1.0 | Not det. | Not det. | Not det. | 0.123 | Not det. | Not det. |
| 852 | 0 | 50 | 1.0 | Not det. | Not det. | Not det. | Not det. | Not det. | Not det. |
| 842 | 60 | 50 | 1.0 | Not det. | Not det. | Not det. | Not det. | Not det. | Not det. |
| 842 | 0 | 50 | 1.0 | Not det. | Not det. | Not det. | Not det. | Not det. | Not det. |
| 830 | 0 | 100 | 1.0 | Not det. | Not det. | Not det. | 0.124 | Not det. | Not det. |
| 830 | 60 | 100 | 2.5 | Not det. | Not det. | Not det. | 0.120 | Not det. | Not det. |
| 852 | 0 | 100 | 2.5 | Not det. | Not det. | Not det. | 0.124 | Not det. | Not det. |
| 852 | 60 | 100 | 2.5 | Not det. | Not det. | Not det. | 0.125 | Not det. | Not det. |
| 842 | 0 | 100 | 2.5 | Not det. | Not det. | Not det. | Not det. | Not det. | Not det. |
| 842 | 60 | 100 | 2.5 | Not det. | Not det. | Not det. | 0.123 | Not det. | Not det. |
| 830 | 0 | 50 | 1.0 | Not det. | Not det. | Not det. | Not det. | Not det. | Not det. |
| 830 | 60 | 50 | 1.0 | Not det. | Not det. | Not det. | 0.119 | Not det. | Not det. |
| 852 | 0 | 50 | 1.0 | Not det. | Not det. | Not det. | 0.122 | Not det. | Not det. |
| 852 | 60 | 50 | 1.0 | Not det. | Not det. | Not det. | 0.123 | Not det. | Not det. |
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 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.

ACKNOWLEDGEMENTS

Authors would like to thank Project Supervisor Dr. R. Vijay, Department of EEE & Authorities of Anna University Regional Campus for the Facilities made for completing this paper in a Successful Manner.

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