ISLANDING DETECTION IN DISTRIBUTED GENERATION BY USING THREE PARAMETERS CHANGING METHOD

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ABSTRACT

The proposed method develops a fuzzy rule based approach loss of mains detection for distributed generation. The advancement in new technology like fuel cell, wind turbine, photo voltaic customer demands for better power quality and reliability are forcing the power industry to shift for distributed generations. One of the technical issues created by DG interconnection is inadvertent islanding. Islanding occurs when a portion of the distributed system becomes electrically isolated from the remainder of the power system, yet continues to be energized by DG connected to the isolated subsystem. The proposed algorithm utilizes multi-criteria approach with fuzzy logic decision- making.

INTRODUCTION

The increased expanding of distributed (dispersed) generation (DG) in utility systems has been mainly caused by the liberalization of the electricity markets, recent advances in energy conversion systems and the environmental drive to promote green energy. These recent advances in energy conversion include the emergence of cheaper and more efficient power generation systems using renewable and hybrid power schemes. The attractions of 'green energy' have been and will continue to be a powerful force in the expansion of distributed generation.

The increasing presence of dispersed generators in utility networks creates problems with regards to the operation and control of the distribution system. If DG is feeding the power to the networks without the utility supply, then it produces several negative impacts on utility power system and the DG itself, such as the safety hazards to utility personnel and the public, the quality problems of electric service to the utility customers, and serious damages to the DG if utility power is wrongly restored [2], [3]. Therefore, during the interruptions of utility power, the connected DG must detect the loss of utility power and disconnect itself from the power grid as soon as possible. Islanding operations of DG usually occur when power supply from the main utility is interrupted due to several reasons but the DG keeps supplying power into the distribution networks. These kinds of islanding conditions cause negative impacts on protection, operation, and management of distribution systems; therefore, it is necessary to effectively detect the islanding conditions and swiftly disconnect DG from distribution network. Moreover, the islanded operation should be avoided because of safety reasons for maintenance man and power quality reasons of distributed lines.

DISTRIBUTED GENERATION

Small localized power sources, commonly known as “Distributed Generation” (DG), have become a popular alternative to bulk electric power generation [6]. There are many reasons for the growing popularity of DG; however, on top of DG tending to be more renewable, DG can serve as a cost effective alternative to major system upgrades for peak shaving or enhancing load capacity margins. Additionally, if the needed generation facilities could be constructed to meet the growing demand, the entire distribution and transmission system would also require upgrading to handle the additionally limited to North America

Islanding

Islanding is the situation in which a distribution system becomes electrically isolated from the remainder of the power system, yet continues to be energized by DG connected to it. As shown in the figure1.4. Traditionally, a distribution system doesn't have any active power generating source in it and it doesn't get power in case of a fault in transmission line upstream but with DG, this presumption is no longer valid. Current practice is that almost all utilities require DG to be disconnected from the grid as soon as possible in case of islanding. IEEE 929-1988 standard [24] requires the disconnection of DG once it is islanded .Islanding can be intentional or Non intentional. During maintenance service on the utility grid, the shutdown of the utility grid may cause islanding of generators. As the loss of the grid is voluntary the islanding is known. Non-intentional islanding, caused by accidental shut down of the grid is of more interest. As there are various issues with unintentional islanding. IEEE 1547-2003 standard stipulates a maximum delay of 2 seconds for detection of an unintentional island and all DGs ceasing to energize the distribution system,

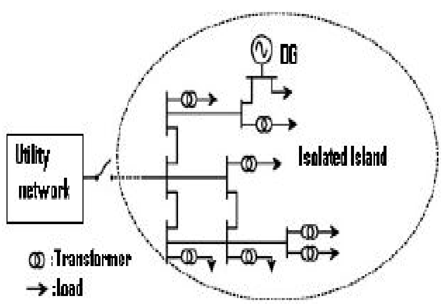


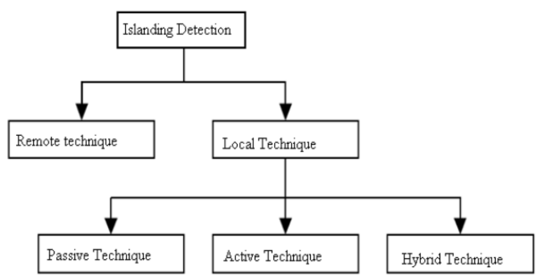
Figure 1 Scenario of Islanding operation

Issues with Islanding:

Although there are some benefits of islanding operation there are some drawbacks as well. Some of them are as follows:

- Line worker safety can be threatened by DG sources feeding a system after primary sources have been opened and tagged out.
- The voltage and frequency may not be maintained within a standard permissible level. Islanded system may be inadequately grounded by the DG interconnection.
- Instantaneous reclosing could result in out of phase reclosing of DG. As a result of which large mechanical torques and currents are created that can damage the generators or prime movers Also, transients are created, which are potentially damaging to utility and other customer equipment. Out of phase reclosing, if occurs at a voltage peak, will generate a very severe capacitive switching transient and in a lightly damped system, the crest over-voltage can approach three times rated voltage.
- Various risks resulting from this include the degradation of the electric components as a consequence of voltage& frequency drifts. Due to these reasons, it is very important to detect the islanding quickly and accurately.

Islanding detection technique:



2.1 Remote islanding detection techniques:

Remote islanding detection techniques are based on communication between utilities and DGs. Although these techniques may have better reliability than local techniques, they are expensive to implement and hence uneconomical .Some of the remote islanding detection techniques are as follows:

2.1.1Power line signaling scheme:

These methods use the power line as a carrier of signals to transmit islanded or non-islanded information on the power lines. The apparatus includes a signal generator at the substation (25kV) that is coupled into the network where it continually broadcasts a signal as shown in figure (2.2). Due to the low-pass filter nature of a power system, the signals need to be transmitted near or below the fundamental frequency and not interfere with other carrier technologies such as automatic meter reading. Each DG is then equipped with a signal detector to receive this transmitted signal. Under normal operating conditions, the signal is received by the DG and the system remains connected. However, if an island state occurs, the transmitted signal is cut off because of the substation breaker opening and the signal cannot be received by the DG, hence indicating an island condition.

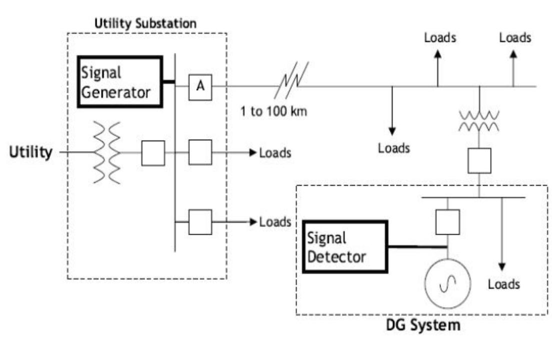


Figure 2.2: Distributed Generation power line Signaling Islanding Detection

This method has the advantages of its simplicity of control and its reliability. In a radial system there is only one transmitting generator needed that can continuously relay a message to many DGs in the network.

2.1.2 Transfer trip scheme: The basic idea of transfer trip scheme is to monitor the status of all the circuit breakers and reclosers that could island a distribution system. Supervisory Control and Data Acquisition (SCADA) systems can be used for that. When a disconnection is detected at the substation, the transfer trip system determines which areas are islanded and sends the appropriate signal to the DGs, to either remain in operation, or to discontinue operation. Transfer tip has the distinct advantage similar to Power Line Carrier Signal that it is a very simple concept. With a radial topology that has few DG sources and a limited number of breakers, the system state can be sent to the DG directly from each monitoring point. This is one of the most common schemes used for islanding detection .This can be seen in figure 2.4

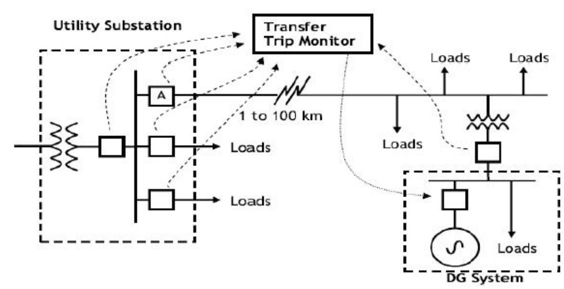


fig: Transfer Distributed Generation Trip Islanding detection

2.2.1 Passive detection techniques

Passive methods work on measuring system parameters such as variations in voltage, frequency, harmonic distortion, etc. These parameters vary greatly when the system is islanded. Differentiation between an islanding and grid connected condition is based upon the thresholds set for these parameters. Special care should be taken while setting the threshold value so as to differentiate islanding from other disturbances in the system. Passive techniques are fast and they don't introduce disturbance in the system but they have a large non detectable zone (NDZ) where they fail to detect the islanding condition. There are various passive islanding detection techniques and some of them are as follows:

(a) Rate of change of output power: The rate of change of output power, dp/dt , at the DG side, once it is islanded, will be much greater than that of the rate of change of output power before the DG is islanded for the same rate of load change. It has been found that this method is much more effective when 19 the distribution system with DG has unbalanced load rather than balanced load.

(b) Rate of change of frequency: The rate of change of frequency, df/dt , will be very high when the DG is islanded. The rate of change of frequency (ROCOF) can be given by ROCOF,

$$\text{ROCOF}, \frac{df}{dt} = \frac{\Delta p}{2HG} \times f$$

Where, P is power mismatch at the DG side
H is the moment of inertia for DG/system
G is the rated generation capacity of the DG/system

Large systems have large H and G where as small systems have small H and G giving larger value for df/dt ROCOF relay monitors the voltage waveform and will operate if ROCOF is higher than setting for certain duration of time.

Rate of change of frequency over power: df/ dp in a small generation system is larger than that of the power system with larger capacity. Rate of change of frequency over power utilize this concept to determine islanding condition.

Voltage unbalance: Once the islanding occurs, DG has to take change of the loads in the island.

Harmonic distortion: Change in the amount and configuration of load might result in different harmonic currents in the network, especially when the system has inverter based DGs.

2.2.2. Active detection techniques With active methods, islanding can be detected even under the perfect match of generation and load, which is not possible in case of the passive detection schemes. Active methods directly interact with the power system operation by introducing perturbations. The idea of an active detection method is that this small perturbation will result in a significant change in system parameters when the DG is islanded, whereas the change will be negligible when the DG is connected to the grid.

(b) Phase (or frequency) shift methods: Measurement of the relative phase shift can give a good idea of when the inverter based DG is islanded. A small perturbation is introduced in form of phase shift.

2.2.3 Hybrid detection schemes Hybrid methods employ both the active and passive detection techniques. The active technique is implemented only when the islanding is suspected by the passive technique. Some of the hybrid techniques are discussed as follows: (a) Technique based on positive feedback (PF) and voltage imbalance (VU): This islanding detection technique uses the PF (active technique) and VU (passive technique). The main idea is to monitor the three-phase voltages continuously to determinate VU which is given as

$$VU = \frac{V + sq}{V - sq}$$

V Sq and V-Sq are the positive and negative sequence voltages, respectively. Voltage spikes will be observed for load change, islanding, switching action, etc. Whenever a VU spike is above the set value, frequency set point of the DG is changed. The system frequency will change if the system is islanded.

(b) Technique based on voltage and reactive power shift: In this technique voltage variation over a time is measured to get a covariance value (passive) which is used to initiate an active islanding detection technique, adaptive reactive power shift (ARPS) algorithm

$$\text{Co-variance}\,(T_{av'}, T_v) = E\ T_{av'}^{(n)} - U_{av}\quad T_v^{(n)} - U_v$$

$T_{av'}$ is the average of the previous four voltage periods.

U_{av} is the mean of $T_{av'}$

Tv is the voltage periods

U_V is the mean of T_V

ISLANDING OPERATION: Opening the utility grid breaker causes a potential power island fed from the embedded generator and isolated from the grid supply (Figure 1). If loss of grid remains undetected, the embedded generator may quickly loose synchronism with the utility grid supply. This introduces the possibility of reconnection of the two systems while their generators are out of phase. The consequences of out-of-phase re-closing are severe stresses on the embedded generator and disruption of the utility supply. There are also safety and health issues. It is possible that the remaining load from the utility system in the island would be greater than the capacity of the embedded generator. This would cause the embedded generator to be dragged down, along with the industrial process, leading to a complete outage. When embedded induction or synchronous generators are used in the system, a further consequence of loss of grid can be self-excitation. Loss of grid, or 'islanding' protection involves the automatic detection of a situation when the connection to the grid supply is lost. This allows of a dispersed generator to supply the local, isolated grid.

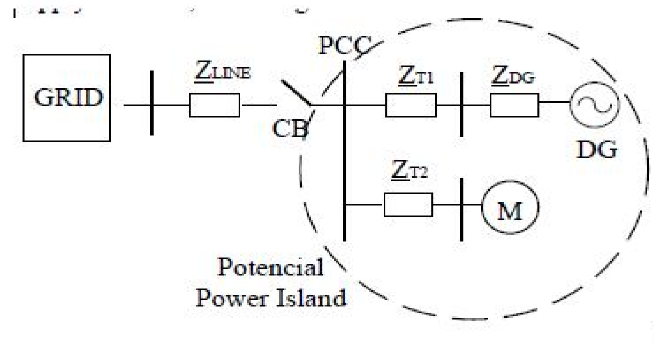


FIG:3 TYPICAL LOSS OF GRID SCENARIO

ANTI ISLANDING DETECTION METHODS In a conventional situation after the connection between a local network and utility network is lost, the DG has to take charge of the remaining network and the connected loads; therefore, the loading condition of the DG is suddenly changed after islanding. For detection such a condition traditionally an under/over-voltage and under/over-frequency criteria are used. These (under/overvoltage and under/over-frequency) relays may, however, fail to detect loss of Mains in situations where the islanded load is reasonably well matched to generator power output. The generator's AVR and speed governor controller may be able to compensate for the smaller load change, causing minimal change in the generators voltage and frequency. Therefore, changes of these parameters are to small in order to detect a loss of grid correctly.

PROPOSED DETECTION ALGORITHM

To detect islanding effectively, it is necessary to have good understanding of all possible islanding conditions nowadays, many classical methods and novel algorithms for the islanding protection have been proposed. These techniques can be divided into two categories: passive and active methods such as classical passive systems include under/over frequency and under/over voltage relays and the most widely recognized methods like the Rate of Change of Frequency (ROCOF), Voltage Vector Shift (VVS) .

The considered methods have been evaluated by using of MATLAB simulations. The 5MW synchronous DG generator and local load is connected to 110 kV utility supply network. Various loss-of-grid scenarios have been simulated by adjusting the size of the site load, and the amount of power flowing from the generator into the site load. Load changes in the modeled DG system are simulated with the use of additional load in series with the site load. Standard IEEE governor models are used together with controller fitted to the AVR.

It is intended that the generator control systems are as similar to those used in the field as possible. Equivalent scheme of the considered system is outlined in Figure 2. Measurements voltage and current are taken from the Point of Common Coupling (PCC). To facilitate comparison, a conventional rate of change of frequency signal was also implemented in the software model using voltage samples taken from the generators terminals

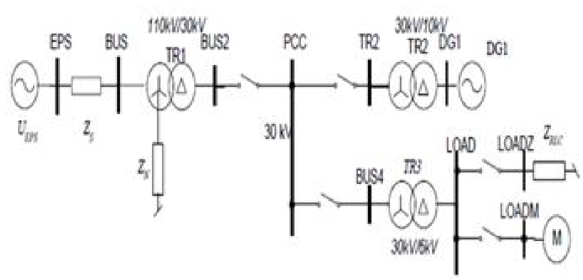


FIG: 4 Equivalent scheme of the considered network

Fuzzy logic based relay (FLR)

Generally, it is difficult to detect islanding operation by monitoring only single system parameter. The proposed fuzzy system is based on processing of three measured parameters, namely: voltage, frequency derivative (ROCOF) and active power derivative (ROCOP) [9]. The choice between these control parameters is based on the desired actions by the protection system of the dispersed generator in response to power system conditions.

Criterion 1:

Change of voltage. The decision as to whether voltage following is permitted under current power system conditions can only be made if the voltage is normal, otherwise voltage control is always effected. To predict the voltage dynamics it is propose to define the Rate of Change of Voltage parameter

Criterion 2:

ROCOF Rate of Change of Frequency as control parameter is more stable than the voltage under grid connected conditions and therefore gives useful information about the nature of the connected network. In particular, this parameter is used to indicate the stiffness of the network system and to assess the relationship between the system frequency and the active power flow from the dispersed generator [5,7].

Criterion 3

- ROCOP Rate of Change of Active Power is used to assess the impact that active power fluctuations have on the connected network's frequency and voltage. When the inertia of the connected system is high, such as when the dispersed generator is operating in parallel with the grid the impact is negligible. This is, however, not true under isolated operation. The rate of change of active power is used taking into account of the state of the system voltage and frequency. This algorithm remains stable during local load changes and during wide range of power system fault condition

Measurement unit

The simplified block diagram of the considered FLR for power generator is presented in Figure 3. The sampled voltage and currents from PCC sides of the protected unit are measured as well as at the terminal. The measuring unit forms the signals and measurements is based on Finite Impulse Response (FIR) full-cycle orthogonal filters designed using the 1kHz sampling rate.

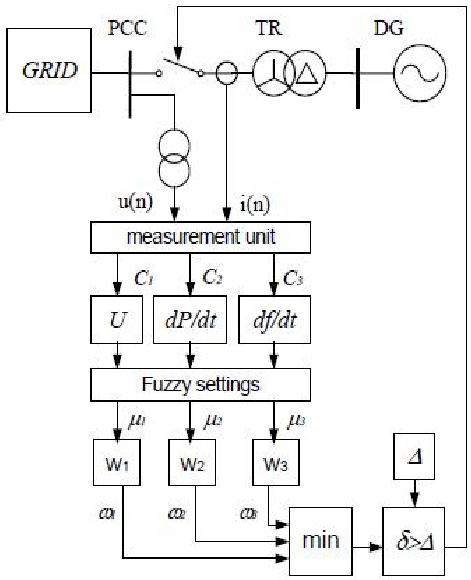


Figure5 . Block diagram of multi-criteria relay of antis landing protection

Fuzzy logic rules

Each of criteria (processed system parameters) can be used alone for loss of grid detection. However, no one separate criterion does not ensure that it would be able to properly detection and not nuisance operation during normal load variation. Authors put forward to fuzzy logic rule approach because of its flexibility for enhancement and update [11]. The fuzzy logic rules for islanding detection are applied only if the situation is not clear or uncertain. Voltage magnitude should consist between limits described below:

$$IF \quad U_{(n)} \geq 1.1 \cdot U_r or U_{(n)} \leq 0.9 \cdot U_r \quad THEN$$

Similarly with frequency derivative, ROCOF:

$$IF \quad \left| \frac{df}{dt}(n) \right| \geq ROCOF \quad THEN \quad B$$

And the Rate of Change of active Power:

$$IF \quad \left| \frac{dP}{dt}(n) \right| \geq ROCOP \quad THEN \quad C$$

where A,B,C are the decision criteria terms of each parameter. The proposed multi-criteria approach is more stable and gives the correct decision for almost all possible situations.

Multi-criteria decision making If the situation is clear, the signals µ1, µ2, µ3 called the member functions are reduced to Boolean logic variables and equal either 0 or 1. Under uncertain conditions, however, they may take values from the interval 0-1, and thus, partly support certain hypotheses. Moreover, there may be contradictions between the recognition given by the particular criteria. In addition, the criteria in terms of quality of provided recognition are in some cases more, and in another less reliable. In order to resolve this and balance the decisions made by the criteria with the criteria powers, the multi-criteria decision-making methods are recommended [10]. The algorithm should rule-out all the non-islanding conditions, the signals ω l, ω 2, ω 3 are aggregated into the overall tripping support d, by means of a kind of continuous logic AND-operator:

$$\delta = \min(\omega_1, \omega_2, \omega_3) \qquad (4)$$

The tripping is initiated if d overreaches a constant time-varying or tripping threshold Δ:

$$TRIP = (\delta \geq \Delta) \qquad (5)$$

SIMULATION RESULTS

To demonstrate the performance of a loss of mains algorithm, a number of studies are required. The simulation studies were carried out using MATLAB software. Standard MATLAB libraries were used. The test of investigated algorithm was conducted with several network conditions. There was simulated specific kind of islanding conditions - with neglecting changes in the load of DG after islanding operation (Figures 4,5). The islanding was initiating after changing of 2.5% of the nominal DG power (Figure4).

In below circuit consist transformers ,circuit breakers, DG, PCC, Source, Load and Bus.pcc is used to check three phases of phase angle and magnitude. Take different loading conditions observe fault and islanding. If any fault (over voltage or under voltage) occurs in the circuit then circuit breaker opens islanding formed. In figure 7 and 8 loss of grid with small variation in DG loading at time after 5sec fault occurs the power is zero islanding formed.A normal operation condition during load fluctuation causing voltage and frequency dip, during parallel operation of DG with the grid. From fig 9 effect of connecting the additional loads Z_{RLC} fault occurs at time after 0.2sec and from fig 10 the result for increasing network load by starting the induction motor fault occurs at time after 0.1sec. From fig 11 RLC load is connected fault occurs at time after 0.1 sec islanding occurs and Fig 12 and 13 three phase to ground fault condition consider the fault occurs at time after 3sec power is zero islanding formed.

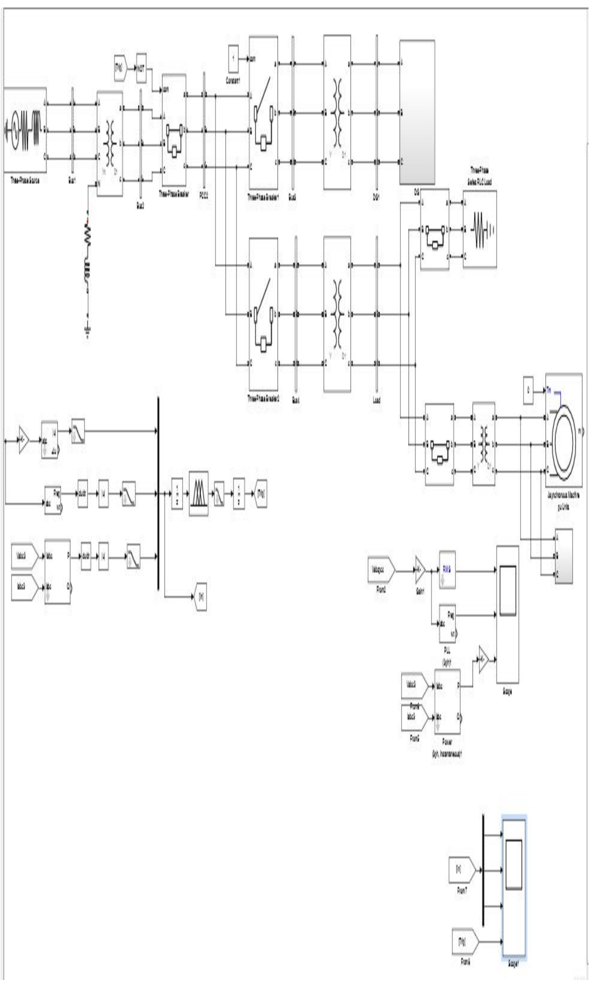
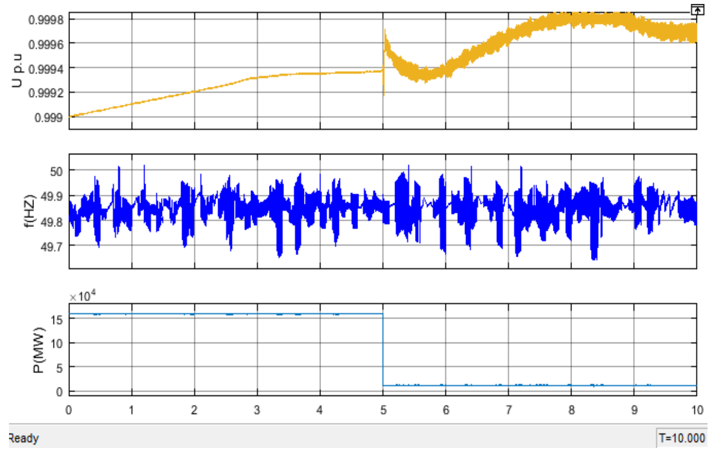


FIG:6 SIMULINK MODEL OF PROPOSED SYSTEM

Figure 7. Loss of grid with small variation in DG loading



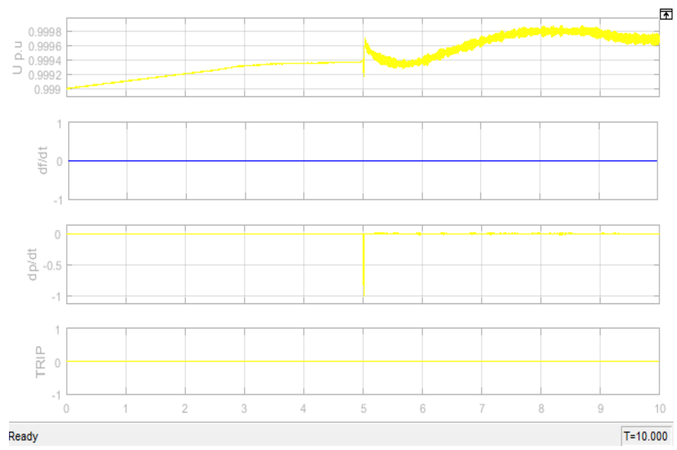


Figure 8 The response of algorithm during loss of grid with small variation in DG loading

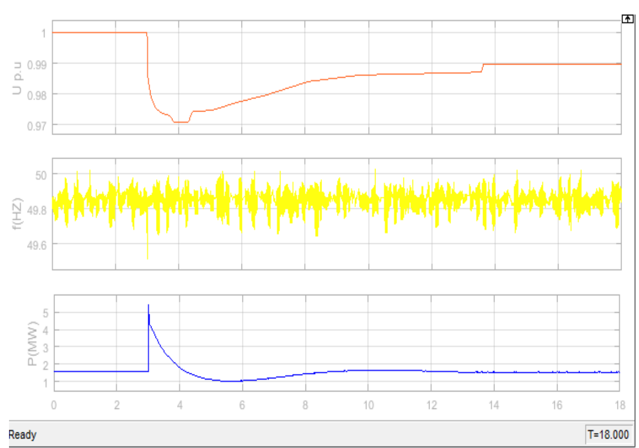


Figure 9. Effect of connecting the additional loads ZRLC

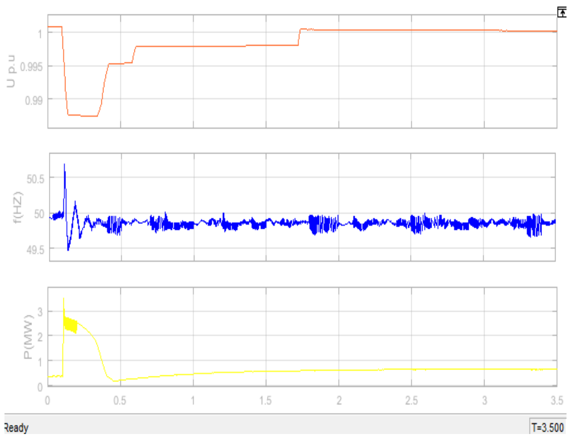


Figure 10. The result for increasing network load by starting the induction motor

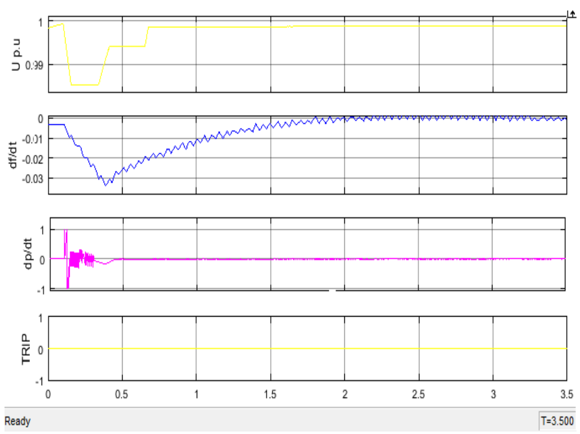


Figure 11. The response of algorithm during RLC load connection

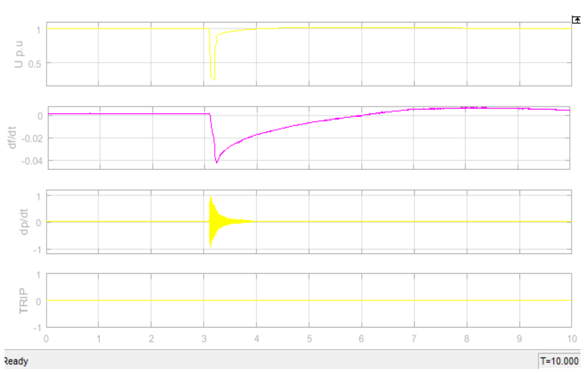


Figure12. Parameter changes during remote 3 phase-to ground fault

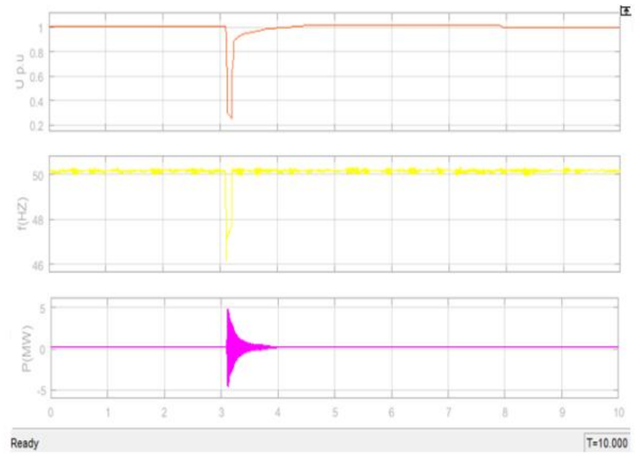


Figure 13. Parameter changes during remote 3 phase-to ground fault

CONCLUSIONS

In the project, the novel islanding detection method was presented. Fast and accurate detection of islanding is one of the major challenges in today's power system with many distribution systems already having significant penetration of DG as there are few issues yet to be resolved with islanding. Islanding detection is also important as islanding operation of distributed system is seen a viable option in the future to improve the reliability and quality of the supply. The algorithm monitors changes of the proposed three parameters and detects the islanding operations by fuzzy logic rules. The loss of grid decision is based on multi-criteria algorithm for distributed resources that are interconnected with distribution network. The proposed method using the radial distribution network with rotating type distributed generations, and different kind of loads was verified and evaluated. The test results show that the proposed criteria and algorithm is capable to detect correctly and with good selectivity the islanding and non-islanding conditions .They intend to adopt the self adjusting of the fuzzy setting and the weight factors and tripping threshold in order to improve FLR operation.

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