Islanding Detection Technique based on Simulation of IEEE16 Bus System

[1]Mahesh M, [2]Kusuma Devi G.H.
[1]PG Scholar, [2]Research Scholar Jain University Bengaluru.
Dept. of Electrical and Electronics Engineering.
Acharya Institute of Technology, Bengaluru, India.

***Abstract*— The aim of this paper is to identify the islanding condition in the power system which is well equipped with particular DG's such as synchronous based or inverter based DG system. This is achieved by developing a well-defined algorithm for islanding detection which facilitates us the most optimized and efficient results. The primary step that has to be carried out is to extract the suitable simulation results which are essentially required for islanding detection. In order to avoid the DG tripping during the non-detection zone, the predefined technique which is usually termed as Random Forest (RF) technique is proposed for detection of islanding and non-islanding conditions. The standard IEEE 16 bus system is developed for both islanding and non-islanding cases. The developed model is simulated with the help of MATLAB/Simulink.**

***Index Terms*— Power System, Random Forest, Islanding, Synchronous based DG, Invertor Based DG, IEEE16 Bus.**

I. INTRODUCTION

Distribution generation (DG) is the small power generating unit, which is located very near to the load centers. Most of the DG's are run with renewable energy resources. Conventional energy generating stations like gas, coal fire powered plants, hydro plants and solar power plants are used to generate power. The power thus generated are transmitted over long distance with the aid of transmission lines. By the use distribution energy resources (DER), a number of losses involved in long transmission systems can be easily avoided thereby improving overall system efficiency which are near to the load centers. Hybrid system can be employed in order to produce clean and green energy.

'Frequency shift techniques' it is applicable to grid connected inverter based DG system. Earlier the traditional frequency shift methods such as slip mode frequency and active frequency drift methods. These methods are less effective when considered parallel RLC loads, so to overcome this problem the author developed automatic phase shift algorithm [1]. Anti-islanding method based on different current distortion injection waveform output. When compared classic AFD method, the total harmonic distortion is 30% less in this method which results in reducing non-detection zone and also improves the speed of islanding detection. [2].

Communication Based Detection method is further classified into transfer trip and power line signaling and these methods not convenient to use in today's power system islanding detection because of their high cost and reduced efficiency. Active Based Detection method is activated when small noise signals are introduced into the system. Under normal condition these noise signals are not harmful to the system and during islanding these signals are amplified which will lead to islanding detection. Passive Based Detection method is based on the measurements of system parameters such as voltage, frequency etc. to detect islanding at the point of common coupling (PCC) [5].

- **ISLANDING- POWER QUALITY PROBLEM**

Islanding exists, when fault or open circuit condition occurs in power system, the main utility or feeding substation are disconnected from the system, but power supplied through internally connecting distribution generating systems. The islanding issue is one of the major problem we are facing nowadays in the DG system. Whenever the fault occurs in the healthy power system, the faulty section is disconnected from the operation to avoid the further destruction of the power system and the main grid and hence at this point of time the local IPP's or conventional DG's are used to excite the system which is effected due to faulty condition and this series of process is known as islanding. Due to islanding condition, the main utilities or sources which are supplying the required demand are disconnected, under this condition DG's will not be able to supply the excess load and hence this condition has to be detected within fraction of seconds in order to avoid the utter destruction of distribution generation system. The main attributes which are harmful to DG system under islanding condition are tabulated as follows:

Table 1*-The Islanding attributes and its problems.*

Sl.no	Attributes	Problems
1	Supply	Distributed generator is a weak supply that does not have the stability and momentum of the typically strong utility system to effectively control transients.
2	Behavior	The Distributed generators behavior may be unpredictable if loads are mismatched to the supply characteristics.
3	Synchronization	On reclosure from a fault, DG"s will not be synchronized with the utility system. The results would be potential damage to DG's, utilities & also for the customers.
4	Threats	Un-controlled islands may pose a threat for unaware utility workers.
5	Quality	By mismatch in utility Vs IPPS's objectives, the consumer's electricity quality cannot be effectively managed.

II. Literature Survey

The exhaustion of conventional energy resources like coal and diesel had given rise to make the best use of non-conventional inexhaustible energy sources such as solar, wind, geothermal etc. The last two decades have seen an upsurge in the number of research activities with respect to the integration of non-conventional energy sources into the existing grid system. The concept of distribution generation, their adverse effects like islanding have been studied along with development of number of algorithms to detect and secure the power system against these adverse effects. The survey of literature in this regard have been detailed in this chapter.

H.H.Zeineldien, M.M.A.Salama [3] these two authors developed a method based on frequency shift method which is called 'Sandia frequency shift (SFS) method'. These method purely based on multi inverter grid connected system to reduce non detection zone during islanding conditions in power system. Among all the frequency shift methods, SFS method is most effective way to detect islanding condition in inverter based DG system. Non-islanding zones and islanding condition are mainly depends on great extent on SFS parameters. A mathematical formula had been developed for multiple inverter based DG system. The author Salama proposed the performance of the SFS method is based on impact of load active power frequency.

L.Loops et.al [4] also proposed islanding method based on 'active frequency drifting'. The RLC load space (Δp v/s Δq) developed in frequency drifting IDM'S and its theoretical NDZ performance cannot be described. Parameters of load space depends on resonant frequency and quality factor of the local load.

H.Karimi, M.Ropp et.al [6] [7] proposed the fast islanding detection method based on negative sequence current injection. By the use of 'unified three phase signal processor' at common coupling point (CCP), the negative sequence had been detected and VSC controller is used to inject negative sequence at CCP.

III. Proposed System

The proposed universal islanding detection method can be applied to both synchronous and inverter based DG systems. In this project IEEE 16 bus system are constructed with the help of MATLAB/Simulink model as shown in Fig 1. This system is considered as small distribution network for analyzing and observing the islanding detection results. This system is developed by using library tools of Simulink and Simscape, and also these tools can be used to represent the numerical values in terms of physical model.

- **DATA EXTRACTION AND SELECTION**

Different islanding recognition strategies have been suggested in previous literatures that depend on a determination of a finite set of system components. In this project, a combination of different system parameters have been selected from past islanding discovery techniques concentrating on inverter-based and synchronous based-DG. Twenty one components were measured locally in order to incorporate maximum number of parameters that could influence the effect of islanding in the system. The estimations are considered on the island side

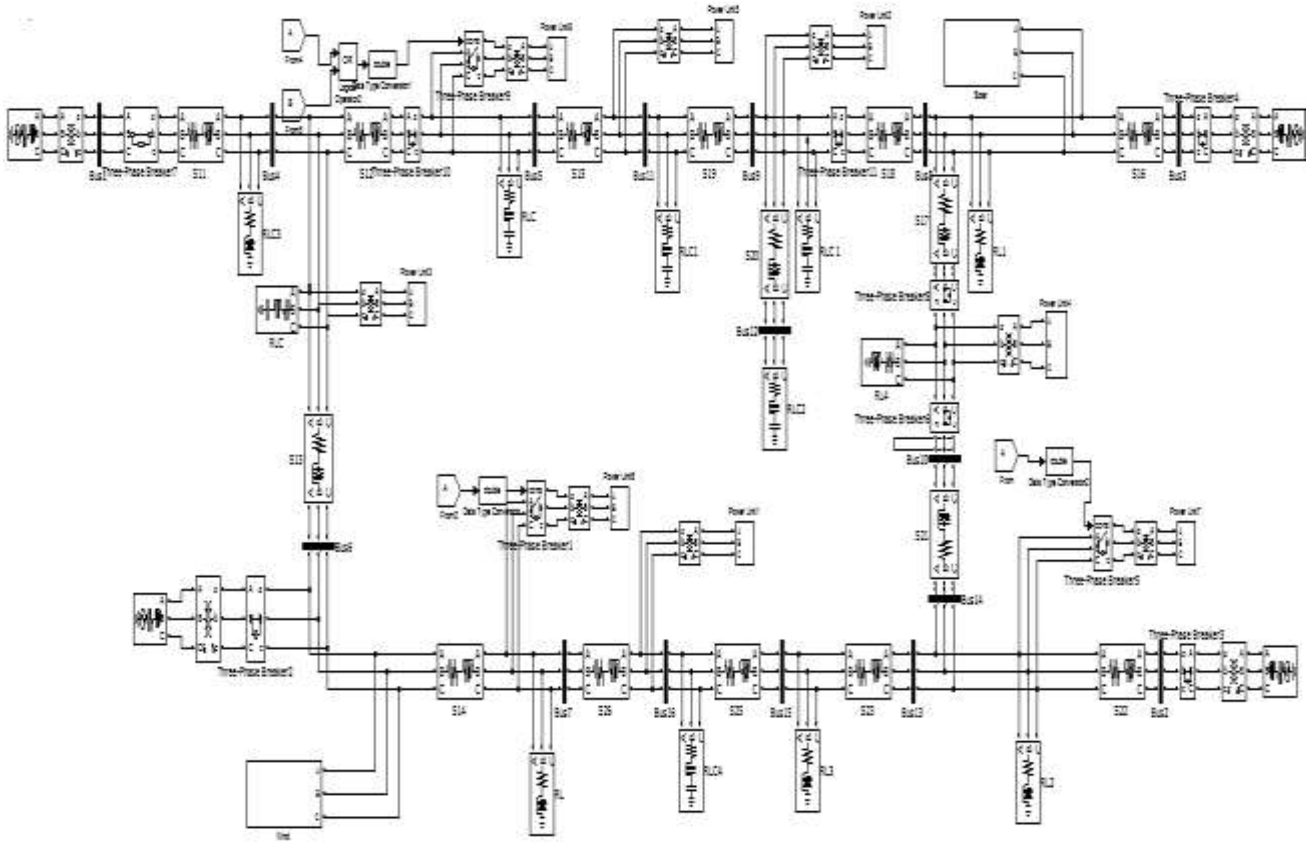

***Fig 1.** IEEE 16 bus system*

In the proposed islanding detection method, among twenty one parameters we choose three major parameters like Rate of change of voltage (ΔV/Δt), current and power (active and reactive) and these parameters are selected based on the basic electric open and short circuit concepts

- **ISLANDING DETECTION PROCESS**

In the developed model, the DG systems are tested in three different cases. These three cases are created forcefully in standard 16 bus distribution system with the help of circuit breakers (CB) so as to analyze the three different islanding condition and these cases are elaborated as follows:

Case 1: Creating a small island where one island and one DG are considered.

Case 2: Creating a medium island where it incorporates multiple DG's and multiple loads.

Case 3: Creating a large island which includes all the loads and the all DG's or all the utilities /substations are disconnected.

- **FORWARD AND BACKWARD METHOD**

This method is used to select bus parameters simultaneously from buses 1 to 8 and 16 to 9 respectively. Using this methods it is possible to reduce the calculation time of bus parameters. Initially, i=1 and j=16 (where i & j are buses) and storage allocation memory (m) is set to zero at beginning. After completion of every cycle the storage memory (m) increments by 1 and this is added up to forward buses i and gets subtracted to backward bus j and this cycle is terminated when bus i=8 and bus j=9. These methods are modeled by using Simulink as shown in Fig 2.

***Table 2**-Parameters mismatches*

Cases	Description	Condition
1,2,3	P mismatches up to ±20% Q mismatches up to ±1.5% I mismatches up to ±20%	Islanding Islanding Islanding

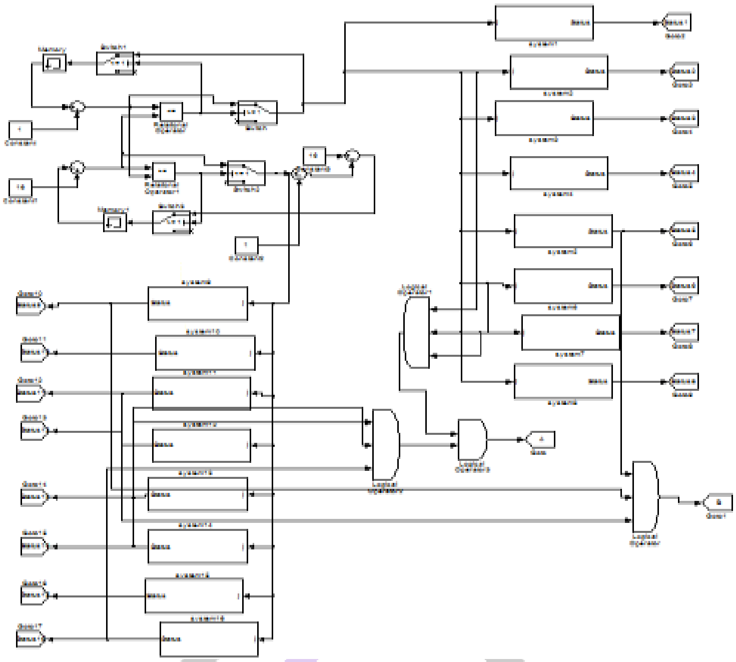

Fig 2. *Forward and backward modeling*

- **RANDOM FOREST CLASSIFIER (RF)**

This method is used to differentiate in between the islanding and non-islanding condition in this project. RF classifier will consider bus parameters in pu such as Δv/Δt, current and power. The below model shows the modeling of RF classifier which consists of three comparators in order to compare the bus parameters such as Δv/Δt, current and power respectively and these parameters are set for preset values in the comparator which are given as Δv/Δt=1.015, current and power equals to 0.8 and these values are in pu status. The output of comparator is given to logical operator which will give the status of the bus. The entire process is applied to all the 16 bus system which is modeled in Simulink. The active power (P), reactive power (Q) and current (I) are considered to detect the islanding. The Q controls the rate of change of voltage (Δv/Δt) and hence it is better to consider Q mismatches and these mismatching condition to cause islanding are tabulated as shown in table 2.

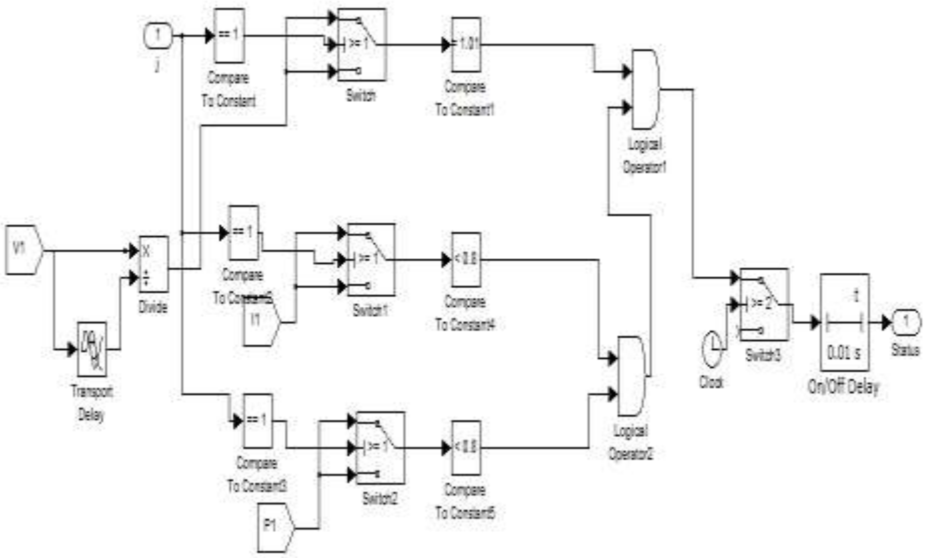

Fig 3. *Comparator modelling of three bus parameters*

IV. RESULTS AND DISCUSSIONS

The IEEE bus system are modeled with different components such as transmission line, RLC loads, DG's, utilities and circuit breakers. The three islanding cases are executed with the help of RF classifier. The RF classifier is based on voting criterion, the majority vote of buses will give either islanding or non-islanding condition. The buses which are included in the islanding condition will give the islanding detection time. When these bus parameters like $\Delta v/\Delta t$, I and P exceed the predefined value will give rise to islanding condition. The bus parameters will vary continuously during islanding across each bus and these results are studied by using the graphs obtained by the simulation results.

The test cases for three different islanding conditions are carried out successfully for IEEE 16 bus system.
Case 1: In this case, the island includes single load and single DG which is as shown in the below Fig 4. The islanding condition is created in the existing system by disconnecting the CB-6 and CB-8 whose transition time is 2.2 to 2.25 seconds. In between this transition time the islanding condition is created and with the help of RF classifier the resulted islanding condition is detected.

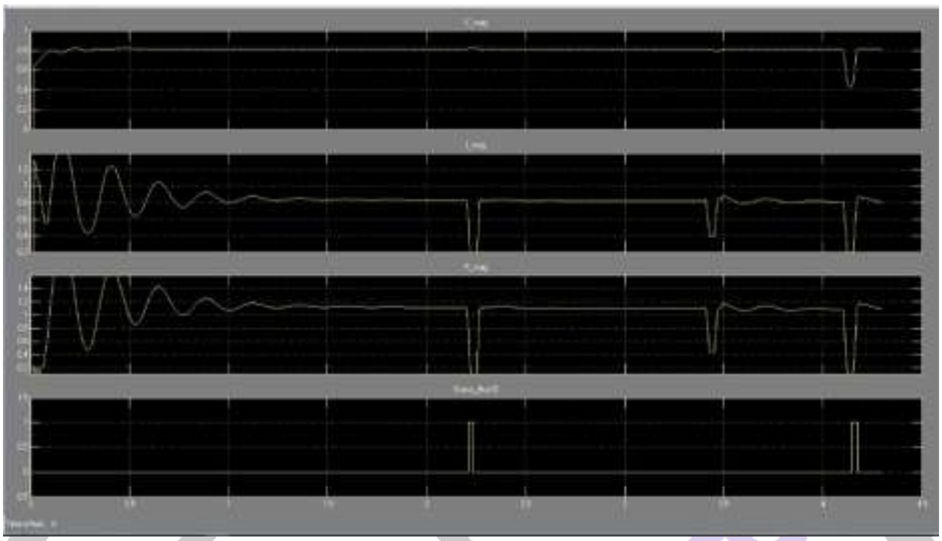

Fig 4. *Status of 10th Bus*

The characteristics of the islanding condition of 10th bus is as shown in above graph. This bus is near to islanding and hence parameters of this bus is considered for analyzing the islanding condition. Under normal condition, the system will generate certain harmonics and as soon as the islanding occurs the system parameters are effected which results in reduction in values of P and I. The pulse is generated during islanding and the time for the pulse generation is noted and this time is known as islanding detection time. In this case, the islanding starting time 2.2105 seconds is subtracted with the preset value of CB 2.20 seconds which gives the islanding detection time as 10.5 milliseconds.

Case 2: In this case, the island includes four loads and three DG's which is as shown in the below Fig 5. The islanding condition is created in the existing system by disconnecting the CB-10 and CB-11 whose transition time is 3.4 to 3.45 seconds. In between this transition time the islanding condition is created and with the help of RF classifier the resulted islanding condition is detected.

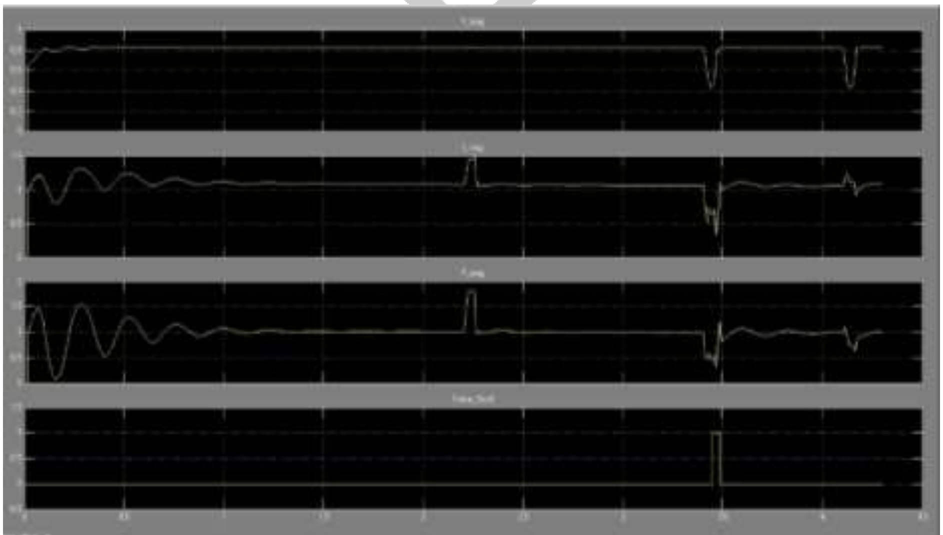

Fig 5. *Status of 9th Bus*

Here in this case, the bus 5, bus 9, bus 11 and bus 12 will come under the vicinity of this islanding area. The characteristics of the islanding condition of 9th bus is as shown in above graph. This bus is near to islanding and hence parameters of this bus is considered for analyzing the islanding condition. In this case, the islanding starting time 3.447 seconds is subtracted with the preset value of CB 3.4 seconds which gives the islanding detection time as 47 milliseconds.

Case 3: In this case, the island includes all the inverter and synchronous based DG's which is as shown in IEEE 16 bus system. The islanding condition is created in the existing system by disconnecting the CB-2, CB-3, CB-4 and CB-7 whose transition time is in between 4.1 to 4.15 seconds. In between this transition time the islanding condition is created and with the help of RF classifier the resulted islanding condition is detected and obtained graph is shown in below Fig 6. The obtained results for three islanding cases are tabulated as follows:

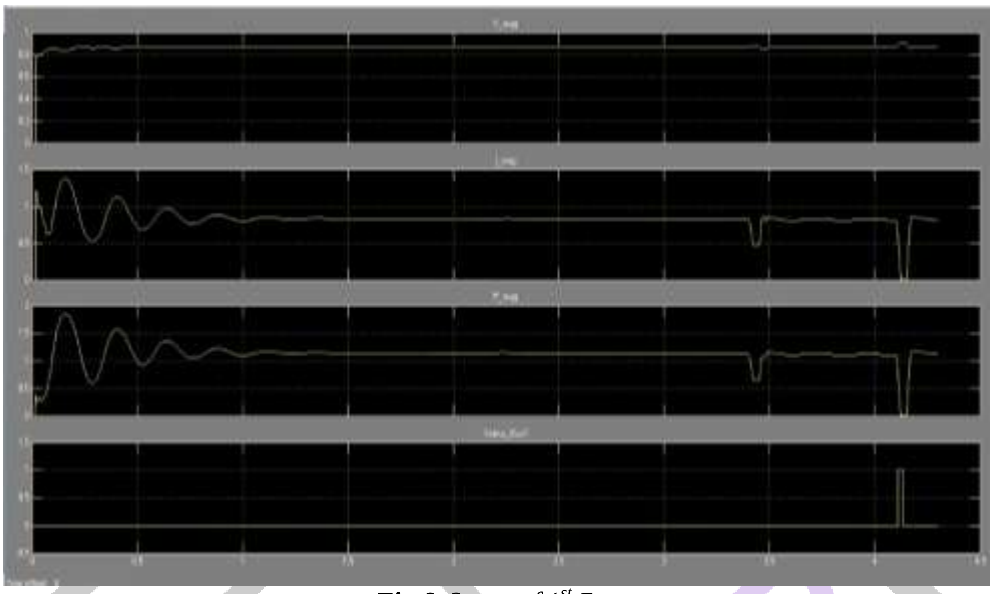

Fig 6. *Status of 1st Bus*

Here in this case, all the buses will come under the vicinity of this islanding area. To get the optimized results the characteristics of the islanding condition of 1st bus is considered. Hence parameters of this bus is considered for analyzing the islanding condition. In this case, the islanding starting time 4.110 seconds is subtracted with the preset value of CB 4.1 seconds which gives the islanding detection time as 10 milliseconds. The islanding detection time for particular selected buses are as tabulated below;

Table.3*-Selected detection time for three Islanding cases.*

Bus no.	**Case1 Detection time in msec.**	**Case2 Detection time in msec.**	**Case1 Detection time in msec.**
10	10	0	47
9	0	47	47
1	0	0	10

V. CONCLUSION

The islanding is one of the major power quality problem in distributed power generating system. The islanding issue must be identified by the system operators for quick remedial action which prevents the system from further destruction. In this project, a new universal islanding detection technique is developed for both inverter and synchronous based DG system. These DG's are modeled in IEEE 16 bus system by using the MATLAB tools effectively. The forward and backward method is used to extract the bus parameters from the required bus which in turn helps in reduction of the bus selection time. The small, medium and large islanding cases are studied by using selected bus parameters to train RF classifier. The RF classifier which is most likely to be suitable for both types of DG's because of its accuracy and detection time in milliseconds. The unnecessary tripping and reduction in NDZ is achieved with the help of proposed technique by investigating the complete system.

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