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Development Of Islanding Detection Technique For Utility Interactive Distributed Generation System

V.Veera Nagireddy
Assistant professor

Dr. D.V. Ashok Kumar
Professor
EEE Department
SDIT, Nadyal

ABSTRACT

Distributed generation (DG) on the distribution system provides many potential benefits like peak shaving, fuel switching, improved power quality and reliability, increased efficiency, and improved environmental performance. Impacts are steady state voltage rise, increase the fault level, power quality, islanding. One of the problem is an islanding.

So many islanding detection techniques are available, each one having their own advantages and drawbacks. A fuzzy rule-based passive islanding detection technique is implemented in this project. The initial classification model is developed using decision tree (DT) which is a crisp algorithm. This algorithm is transformed into a fuzzy rule base by developing fuzzy membership functions (MFs) from the DT classification boundaries.

Introduction

Distributed generation (DG) generally refers to small-scale (typically 1 kW – 50 MW) electric power generators that produce electricity at a site close to customers or that are tied to an electric distribution system. There are many reasons a customer may choose to install a distributed generator. DG can be used to generate a customer's entire electricity supply; for peak shaving (generating a portion of a customer's electricity onsite to reduce the amount of electricity purchased during peak price periods); for standby or emergency generation (as a backup to wires owner's power supply); as a green power source (using renewable technology); or for increased reliability.

some remote locations, DG can be less costly as it eliminates the need for expensive construction of distribution and/or transmission lines .

The distributed generation systems are operated in parallel with utility power systems, especially with reverse power flow, the power quality problems become significant. Power quality problems include frequency deviation, voltage fluctuation, harmonics and reliability of the power system. In addition, one of important problem is an islanding protection. A fault occurring in the power distribution system is generally cleared by the protective relay that is located closest to the faulty spot. As a result, a distributed generation tries to supply its power to part of the distribution system that has been separated from the utility's power system. In most cases, this distributed generation assumes an overloaded condition, where its voltage and frequency are lowered and it is finally led to stoppage. However, though this is a rare case, a generator (or a group of generators) connected to this islanded system is provided with a capacity that is large enough to feed power to all the loads accommodated in the islanded system. When the loads are fed power only from the distributed generations even after the power supply is suspended from the power company, such a situation is called an "islanded operation" or "islanding" [2]. They can be broadly classified into two types locally built-in and communication based detection schemes. Local detection methods detect islanding situations based on the information (such as voltage, frequency, harmonic. Local Detection methods further divided into passive, active and hybrid techniques.

Technical challenges

Distributed generation (DG) is not without problems. DG faces a series of integration challenges, but one of the more significant overall problems is that the electrical distribution and transmission infrastructure has been designed in a configuration where few high power generation stations that are often distant from their consumers, "push" electrical power onto the many smaller consumers.

A). Islanding Control

Depending on the amount of DG connected and the strength of the utility power system, the issues listed above can become substantial problems. Of the challenges with DG, the problem of protection against unplanned islanding is a significant one.

A single line diagram of a power distribution system is shown in Fig(a) . The substation is the sending end for several feeders where transmission voltage is stepped-down into distribution voltage level. One of the feeders is shown in detail with many customer connection points. An islanding situation can occur in distribution system due to operation of an upstream breaker, fuse or an automatic sectionalizing switch in response to fault or due to manual switching. The islanding of the portion of network due to opening of re-closer switch ‘C’ is shown in Fig. 1.1. The DG1 will feed the power into the resultant island in this case. The most common cause for a re-closer to open is a fault in the downstream of the re-closer. An islanding situation could also happen when fuse at the point ‘F’ melts. In this case the inverter based DG3 will feed the local loads, forming a small islanded power system. Formation of islanding can be intentional or unintentional.

B). Intentional islanding

The use of DG with proper control to supply the islanded portion of the network, during utility outage conditions is called intentional islanding operation. This improves the reliability of supply and also brings many other benefits. Once the disturbance is over the islanded portion of the network should be connected back to the grid. The transition between grid connected and islanding operation modes must be seamless without any down time, in order to provide uninterruptible power supply to critical and sensitive loads.

C). Benefits of intentional islanding operation

The intentional islanding operation potentially brings many benefits to the DG owner, distribution network operators (DNO) and customers. Due to the increasing competition amongst energy suppliers to attract more and more customers, intentional islanding of DG units are a valuable option. Intentional Islanding can improve the quality of supply indices and reliability. The additional revenue to DG owners can be achieved by the increased power supplied during network outage. It helps in increasing the customer’s satisfaction due to the reduction in frequency and duration of interruptions from outages in the distribution network. The intentional islanding operation can help the society in general, by preventing civil disobedience, assault, looting and disruption in essential services during utility power outage conditions

D). Issues

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 [3] 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 [4].
- Various risks resulting from this include the degradation of the electric components as a consequence of voltage& frequency drifts.

E). Contributions

- Implementing power distribution network with DG in MATLAB.
- Development of passive islanding detection technique using fuzzy logic rule base.
- An extensive simulation studies on islanding detection based on above techniques using MATLAB.

Another problem for power line communication is the complexity of the network and the affected networks. A perfectly radial network with one connecting breaker is a simple example of island signaling; however, more complex systems with multiple utility feeders may find that differentiation between upstream breakers difficult.

F).Fuzzy logic controller

A fuzzy logic controller is a control algorithm based on several linguistic control rules connected along them through a fuzzy implication and a compositional rule of interference, together with a defuzzification mechanism, that is to say, a mechanism that changes the action of fuzzy control in to one which is not fuzzy. Fuzzy logic controllers, as a focus for analysis nd design of control strategies, are obtaining good results, increasing considerably their application in the last years. Fig 4.1 shows the configuration of fuzzy logic controller.

G).DESCRIPTION OF SIMULATION MODEL

Power distribution network with DG

In order to investigate the performance of the proposed Technique during various contingencies a simulation model

was implemented. It is important that the model reflects a real system in all vital parts. The behavior of the simulated system must be similar to what happens in a real situation. How this has been achieved is described in the following. In the preliminary study we have considered a system as shown in the fig.a [11].

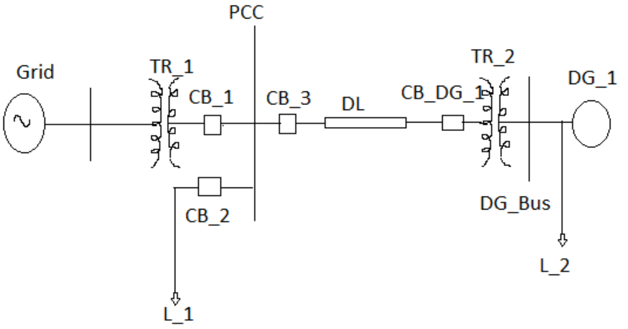


Fig. a : Block diagram of power distribution network with DG

Transformers

Transformer T1

Rated MVA =25 *f=60Hz* Rated kV=69/13.8 Dy_n1
X_1=0.1pu R_1=0.00375pu X_m=500pu R_m=500pu

Transformer T2

Rated MVA =10 *f=60Hz* Rated kV=13.8/13.8 Y_nd1
X_1=0.1pu R_1=0.00375pu X_m=500pu R_m=500pu

Load data

Load (L-1) = 10MW 3.5MVAR, load (L-2) = 5MW 2.0MVAR

Transmission lines data

Rated MVA =20 *f=60Hz* Rated kV=13.8 X_{0L}=0.0534ohms /Km R_{0L}=0.0414ohms /Km X_{1L}=0.0178ohms /Km R_{1L}=0.01384ohms /Km X_{0CL}=5.1nF /Km X_{1CL}=17nF /Km line length =20Km

Rated MVA =10 *f=60Hz* 54poles Y_n Rated kV=13.8 Inertia constant H =3.0sec.

H).Decision tree

Decision tree learning is a method commonly used in data mining. The goal is to create a model that predicts the value of a target variable based on several input variables. The basic idea involved in any multistage approach is to break up a complex decision into a union of several simpler decisions, hoping the final solution obtained this way would resemble the intended desired solution [17].

Decision tree chart

Simulated Fig(b) Block diagram using MATLAB/Simulink from that extract **Δ***f*/**Δ**t, **Δ**p/**Δ**t, *f* these terms and verified with below flow-chart .This flow-chart explain given network is islanding/non-islanding.

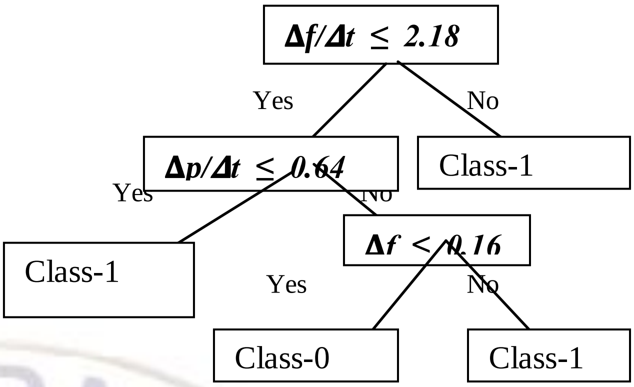


Fig. b: Decision tree chart [10].

Class-1 means islanding and class-0 means non-islanding.

I).Rule based fuzzy logic controller

The most significant features **Δ***f*/**Δ**t, **Δ**p/**Δ**t, **Δ***f* are considered as X_1, X_2 and X_3, respectively. The fuzzy MFs developed for variable X_1 are A_1 and A_2, for X_2 are B_1, B_2, and for X_1 are C_1, C_2.

Per the above formulations, the rectangular MFs are derived as

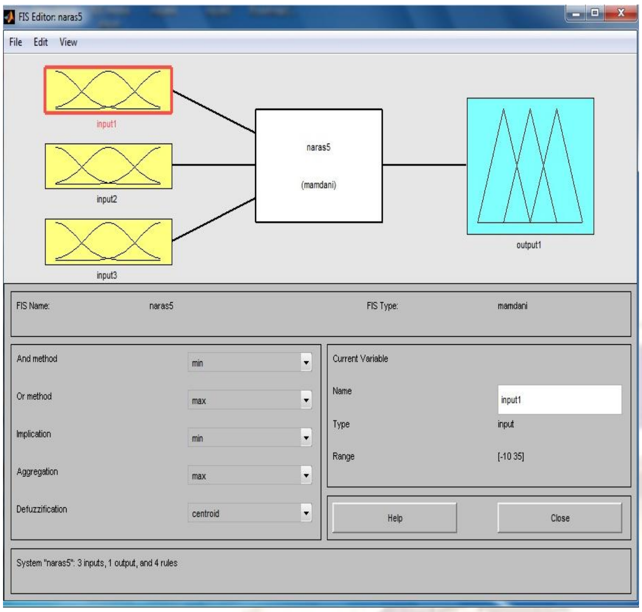
$A_1=\mu\{X_1, [2.18, 2.18, 34.0, 34.0]\}$
$A_2=\mu\{X_1, [-9.5, -9.5, 2.18, 2.18]\}$
$B_1=\mu\{X_2, [0.64, 0.64, 19.0, 19.0]\}$
$B_2=\mu\{X_2, [-0.5, -0.5, 0.64, 0.64]\}$
$C_1=\mu\{X_3, [0.16, 0.16, 0.6, 0.6]\}$
$C_2=\mu\{X_3, [-0.05, -0.05, 0.16, 0.16]\}$.

The fuzzy MFs generated from the DT classification boundaries are rectangular in nature. But to further add fuzziness to the membership functions, the rectangular boundaries are skewed to a certain extent by heuristic tuning. The coordinates of the trapezoidal fuzzy MFs are decided after testing on several values around the initial values resulting from DT [10]. Thus, the final fuzzy MFs are

Rule base

R1: If X_1 is A_1 and X_2 is B_1 then Class-1
R2: If X_1 is A_2 and X_2 is B_2 then Class-1
R3: If X_1 is A_2 and X_2 is B_1 and X_3 is C_1 then Class-1
R4: If X_1 is A_2 and X_2 is B_1 and X_3 is C_2 then Class-0

Class-1 means islanding and class-0 means non-islanding.



FIS Name: naras5
FIS Type: mamdani
And method: min
Or method: max
Implication: min
Aggregation: max
Defuzzification: centroid
Current Variable
Name: input1
Type: input
Range: [-10 35]
System "naras5": 3 inputs, 1 output, and 4 rules

Fig.c: Fuzzy inference system.

J).SimulationResults

Modeling of case study network (figure a) using Mat lab was done. Simulations were carried out considering the following critical conditions at different PCC bus loads:

- Condition-1: Tripping of the circuit breaker CB-1 to simulate the condition of islanding of the DG with the PCC bus loads.
- Condition-2: Tripping of the circuit breaker CB-2 (isolating the PCC bus loads) to simulate disturbances on the DG.
- Condition-3: Tripping of the circuit breaker CB-3 to simulate the islanding of the DG without the PCC- bus loads.
- Condition-4: Three-phase fault on the GEN_BUS with instantaneous (1 cycle) fault-clearing time by the CB-1 which, in turn, causes islanding of the DG.

The PCC bus loads are
1. PCC-bus loading P=0.5pu, Q=0.175pu.
2. PCC-bus loading P=0.3pu, Q=0.105pu.
3. PCC-bus loading P=0.625pu, Q=0.22PU.

Table 1 provides the test results for different conditions of inputs X_1, X_2, and $X_3$for islanding detection. In 1 table E11 means, E indicated event, first 1 indicated fault, second 1 indicated PCC bus load condition.

Table1: Different test conditions results

Event no	X_1	X_2	X_3	Actualcondition
E11	5.500	-0.20	0.234	Islanding
E12	5.330	-0.30	0.020	Islanding
E21	0.001	3.00	0.005	Non-islanding
E23	0.001	5.40	0.005	Non-islanding
E31	4.900	-0.01	0.005	Islanding
E33	5.000	-0.10	0.005	Islanding
E41	5.800	5.00	0.01	Islanding

The table1 shows conventional results of our case study system. With fuzzy results are given below. The system study state reaches around 300ms. After 300ms system (fuzzy output results)output value reaches 0.5, it is islanding condition other ways non-islanding condition.

1) Tripping of the circuit breaker CB-1at 1sec to simulate with PCC bus loads is P=0.5pu, Q=0.175pu.

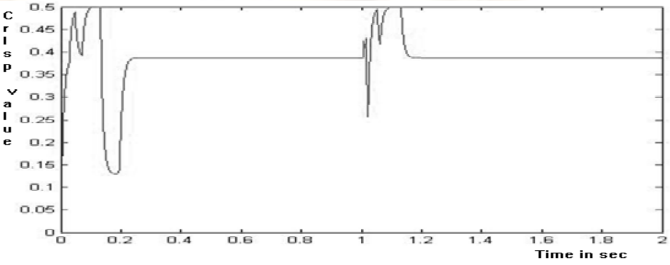


Fig. d: E11 Crisp values plot.

The fig. d shows the crisp value plot, crisp value reaches 0.5 after 300msec, islanding is occurred.

2) Tripping of the circuit breaker CB-1at1sec to simulate with PCC bus loads is P=0.3pu, Q=0.105pu.

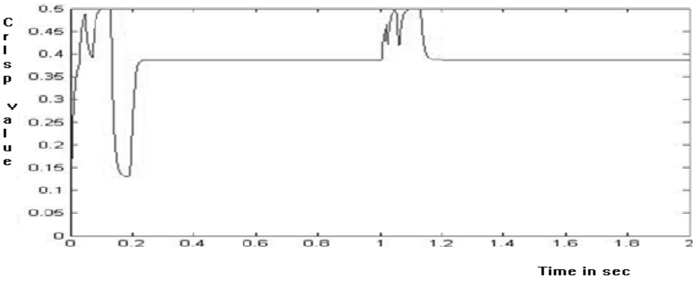


Fig. e: E12 Crisp values plot.

The fig. e shows the crisp value plot, crisp value reaches 0.5 after 300msec, islanding is occurred.

3) Tripping of the circuit breaker CB-2(1sec) to simulate with PCC bus loads is P=0.5pu, Q=0.175pu.

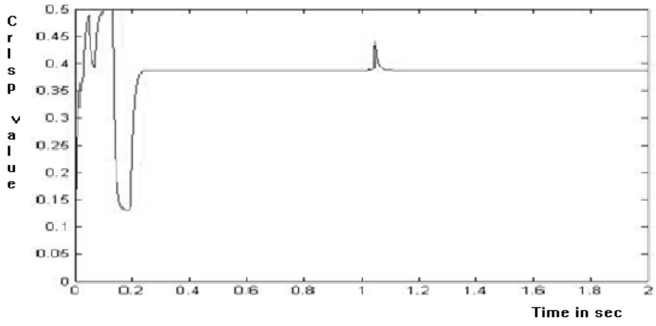


Fig. f: E21 Crisp values plot.

The fig. 5.3 shows the crisp value plot, crisp value not reaches 0.5 after 300msec, islanding is not occurred.

CONCLUSION

This thesis describes and compares different islanding detection techniques. 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. A fuzzy rule-based passive islanding detection is implemented in this project. The initial classification model is developed using decision tree (DT) which is a crisp algorithm. This algorithm is transformed into a fuzzy rule base by developing fuzzy membership functions (MFs) from the DT classification boundaries.

The islanding detecting time obtained from simulation results is 100ms to 150ms, it's followed by IEEE Std. 1547-2003 [10].

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