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A Review on Determining the Optimal Location and Impedance of Fault Current Limiter in Distribution Systems Connected with Multiple Distributed Generations by Particle Swarm Optimization (PSO) Algorithm

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Abstract

In order to reduce power losses, and to determine the optimal location and the impedance of fault current limiter in distribution systems connected with multiple Distributed Generations two parameters are used for detecting islanding conditions voltage unbalance and total harmonic distortion of current. Based on this parameters islanding conditions are detected. A fault current limiter is designed in order to minimize the impact of multiple DGs on the protection system in a distribution system during a fault occurrence. Finally, determining the optimal location and impedance of fault current limiter it is modelled as optimization problem with power loss and economical use as objective function. In this paper, Particle Swarm Optimization (PSO) algorithm illustrates for determining the optimal location and impedance of fault current limiter.

Keywords: *Voltage Unbalance, fault current limiter, PSO Algorithm, loss reduction*

INTRODUCTION

The number of DG systems is quickly expanding, and the majority of them are associated with a distribution system by supplying power into the system, and in addition neighborhood loads. An islanding operation happens at the point when the DG keeps supplying power into the system after power from the principle utility is intruded. In the event that the islanding operation happens, the distribution system gets to be out of the utility's control. It can in this way cause various negative effects on the system and DG itself, for example, the security risks to utility faculty and general society, the power quality issues, and genuine harm to the system and DG unless the fundamental utility power is restored accurately and rapidly. Moreover, the DG system must be detached from the system for its protection by the successful location strategy before the recloser begins to work taking after by the islanding operation

Two types of islanding detection methods, which are the passive and active methods developed. active methods , for example, the system fault level checking system and the reactive export error detection technique. In spite of their viability in identifying island operation of DG, these active strategies need to ceaselessly fluctuate the DG output and may adversely influence the operations of the DG and the utility system. Other detection routines can be called passive methods since they recognize islanding operation of DG by observing the system parameters: voltage magnitude, phase displacement, the rate of change in frequency, and impedance checking. Despite the fact that they are unrealistic to impact the working systems and administration of utility power system, if there are little changes in the DG loadings in the wake of islanding, these techniques experience issues in figuring out the islanding operation since the observing parameters don't change enough to recognize these islanding conditions .

Numerous DGs make utilization of power electronic inverters for energy conversion to match the grid voltage and recurrence. Nonetheless, such DGs are known to have an incredible effect on the security and protection of distribution system . The inverter-based DGs (IBDGs) can influence system security when an electrical fault happens because of fault current detection issues . This is on account of they don't create large amounts of fault current when a short circuit happens. Besides, small rated DGs additionally have lacking inactivity to persistently sustain the fault current dissimilar to the conventional expansive rotating machine generators. The IBDGs have their own particular internal protection to guarantee wellbeing of semiconductor devices against substantial over currents coursing through them. Generally, this current is in the range of two to three times of the rated current. The impact of such an internal protection needs to be considered in the general system protection plan subsequent to the inverter inward protection can't identify fault streams with levels lower than its settings. There are essentially two sorts of control plans that govern IBDGs, viz., voltage control and current control..

Based on the above synthesis determination of optimal location and design of fault current limiter in system with multiple DGs is a challenging in the evolving administrative and monetary situations .

In this paper two parameters are used for detecting islanding conditions voltage unbalance and total harmonic distortion of current. Based on this parameters islanding conditions are detected. A fault current limiter is designed in order to minimize the impact of multiple DGs on the protection system in a distribution system during a fault occurrence. Finally, determining the optimal location and impedance of fault current limiter it is modelled as optimization problem with power loss and economical use as objective function. In this paper, Particle Swarm Optimization (PSO) algorithm is used for determining the optimal location and impedance of fault current limiter

Particle swarm optimization is a stochastic optimization paradigm, which mimics animal social behaviors such as flocking of birds and the methods by which they find roosting places or food sources. PSO starts with the initialization of a population of individuals in the search space and works on the social behavior of the particles in the swarm. Each particle is assigned a position in the problem space, which represents a candidate solution to the problem under consideration. Each of these particle positions is scored to obtain a scalar cost, named fitness, based on how well it solves the problem. These particles then fly through the problem space subject to both deterministic and stochastic update rules to new positions, which are subsequently scored. Each particle adaptively updates its velocity and position according to its own flying experience and its companions' flying experience, aiming at a better position for itself. As the particles traverse the search space, each particle remember its own personal best position that it has ever visited, and it also knows the best position found by any particle in the swarm.

On successive iterations, each particle takes the path of a damped oscillatory movement towards its personal best and the global best positions. With the oscillation and stochastic adjustment, particles explore regions throughout the problem space and eventually settle down near a good solution.

Pseudo-code of main body of ABC algorithm:

1: Initiation
2: Evaluate
3: set the particle " pbest"
4: add velocity to initial particle
5: Evaluate the fitness value to initial particle
6: Compare each individual particle's fitness value
7: find "pbest" between particles
8: find minimum fitness value "gbest" between particles
9: update the position and velocity
10: repeat the iteration of PSO until convergence is obtained

ISLANDING DETECTION METHOD

Islanding detection is a one among the most essential issues for the distributed generation (DG) associated with an electric power grid. Islanding condition cause negative effects on protection, operation, and administration of distribution systems; consequently, it is important to effectively distinguish the islanding conditions and quickly detach DG from distribution system. If there are vast changes in loading for DG after loss of the fundamental power supply, then islanding conditions are effortlessly identified by checking a few parameters. In this paper, for detection of islanding operation of DGs, two parameters are they are voltage unbalance and total harmonic distortion of the current.

Calculation of Voltage Unbalance

For the most part, despite the fact that the loading for DG has minimal changes after the loss of main source, because of the changes of the systems and the load, the voltage unbalance fluctuates. Along these lines, on the off chance that we continue monitoring the unbalance of three phase output voltage of the DG, at that point it is conceivable to adequately recognize an islanding operation of DG. With a specific end goal to do this, we characterize the voltage unbalance at the observing time by using equation (1) which is given by

$$VU_t = \frac{NS_t}{PS_t} \times 100 \qquad (1)$$

Where PS_t and NS_t represents the magnitude of positive and negative sequence of voltage at time *t*, correspondingly. This characterizes the one sequence average of voltage unbalance which is given in equation (2), furthermore characterizes the voltage unbalance fluctuation which is given in equation (3), which measuring how much the observed voltage unbalance variations from the steady state and ordinary loading conditions.

$$VU_{avg,t} = \frac{1}{N}\sum_{i=0}^{N-1} VU_{t-i} \tag{2}$$

$$\Delta VU_t = \frac{VU_{avg,s} - VU_{avg,t}}{VU_{avg,s}} \times 100 \tag{3}$$

Where N indicates sampling number per cycle, t indicates monitoring time, and $VU_{avg,s}$ indicates reference value originally set for normal loading conditions. After $VU_{avg,s}$ is originally set, if ΔVU_t remains within -100% through +50% for per sequence, $VU_{avg,s}$ is updated by $VU_{avg,t}$ to receive the normal load variation.

Calculation of total harmonic distortion of current

The changes in the loading for DG due to loss of main power source obviously result in variations on the harmonics of the current. The total harmonic distortion of current at observing time t is given by

$$THD_t = \frac{\sqrt{\sum_{h=2}^{H} I_h^2}}{I_1} \times 100 \tag{4}$$

Where I_h is rms of the harmonic elements h and I_1 is rms value of fundamental element. The average of THD_t per cycle is given in equation (5) and the variations for observed THD at time t from the normal condition is given by equation (6).

$$THD_{avg,t} = \frac{1}{N}\sum_{i=0} THD_{t-i} \tag{5}$$

Detection of islanding condition:

After the calculation of changes in voltage unbalance and total harmonic distortion of current, now we formulate a condition for detection of islanding condition which is given below

$$RULE: \{(\Delta THD_t > +75\%)\ or\ (\Delta THD_t < -100\%)\}$$
$$\{(\Delta VU_t > +50\%)\ or\ (\Delta VU_t < -100\%)\}$$

If ΔTHD_t and ΔVU_t satisfies the above condition the proposed method detects as islanding condition

LOCATION OF FAULT CURRENT LIMITER

In order to identify the location of fault current limiter we have formulated as nonlinear optimization problem, and different objectives were considered in this study. The objective function consists of minimization of power loss,

Minimization of Power loss:

Optimal placement of FCL can be performed with the reason for minimizing power loss. The aggregate real power loss is computed by using equation (6) which is given as follows:

$$P_{loss} = \sum_{i=1}^{N_b} R_i \times |I_i|^2 \quad (6)$$

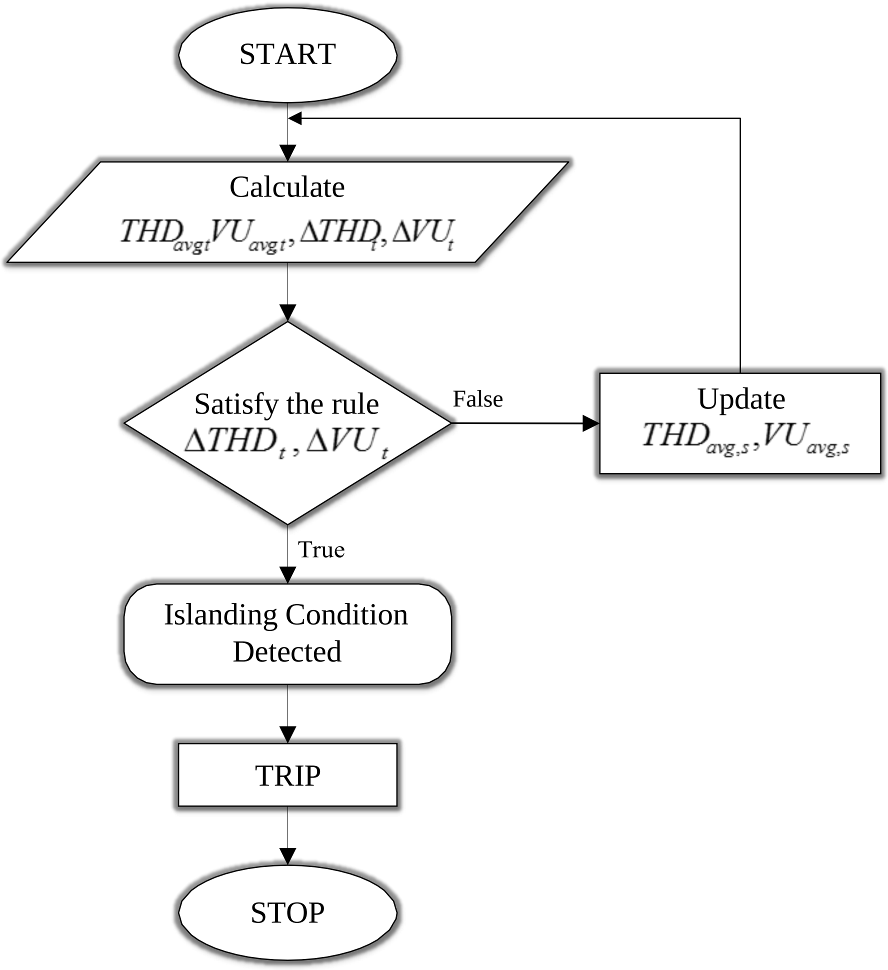

Figure: Flow Chart for Islanding Detection

where R_i represents resistance of i^{th} branch, I_i is actual current of i^{th} branch, and N_b indicates number of branches in the network.

From figure we can see that how islanding condition detected by observing the parameters of voltage unbalance and harmonic distortion of current. Once the islanding mode is detected it gives trip signal and the system is isolated. If it is not detected then the system is analyzed during the occurrence of fault and fault current produced is limited by using fault current limiter

CONCLUSION

This paper presents efficient islanding detection alongside optimal location of fault current limiter (FCL) placement in an distribution network associated with different DGs. Total Harmonic Distortion of the current and voltage unbalance of the terminal output are utilized as the observing parameters for power islanding detection. The combination of FCLs into distribution network gives a compelling approach to stifle huge fault currents and may get to impressive reduction in investment cost on higher limit CBs

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