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A load shedding scheme for DG integrated islanded power system utilizing backtracking search algorithm

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Genetic algorithm (GA)

Abstract In a dispersed generation (DG) integrated distribution system, several technical issues should be resolved if the grid disconnects and forms an islanded system. The most critical challenge in such a situation is to maintain the stability of the islanded system. The common practice is to reject several loads through a load shedding scheme. This study introduces a development of an optimal load shedding scheme based on backtracking search algorithm (BSA). To handle this optimization problem, a constraint multiobjective function that considers the linear static voltage stability margin (VSM) and amount of load curtailment is formulated. It also handles the load priority and various operating conditions of DGs. The performance of the proposed load shedding scheme was evaluated through an extensive test conducted on the IEEE 33-bus radial distribution system with four DG units considering several scenarios such as load shedding under various operating points and at various islands using the MATLAB® software. Moreover, the effectiveness of the proposed scheme was validated by comparing its results with those obtained using the genetic algorithm (GA). The optimization results indicate that the proposed BSA technique is more effective in determining the optimal amount of load to be shed in any islanded system compared with GA.

1. Introduction

Considering the development of new technologies through the years, the idea of immediately disconnecting all of the dispersed generations (DGs) to prevent equipment damage and eliminate safety hazards is inapplicable. Moreover, some standards and regulations have been created to prevent islanding hazards, and distribution network operator companies have

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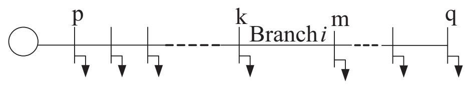

Figure 1 Typical radial feeder of distribution system.

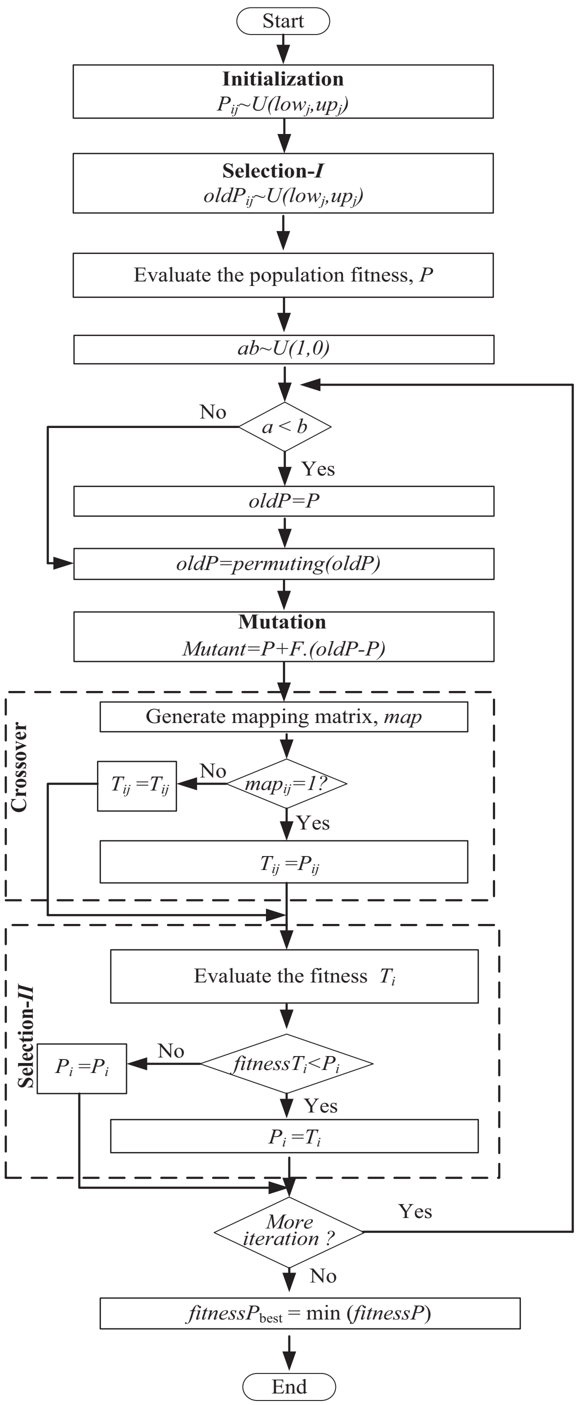

Figure 2 General flowchart of BSA.

the primary duty to protect the network and its customers from the hazards [1]. The technical hurdles to achieve a safe and smooth operation of islanded events are speed governor response, range of operating power, voltage and frequency control, earthling or equivalent protection of the island operation, and resynchronization to the grid. Among these technical hurdles, voltage and frequency control tends to occur more frequently, of which load shedding is considered the most effective technique to overcome the problem.

Generally, automatic load shedding has two types. The first type is under-frequency load shedding (UFLS), which is designed to rebalance load and generation within an electrical island once the unbalanced system is created. The second type is under-voltage load shedding (UVLS), which is utilized to prevent local area voltage collapse and to directly respond to the voltage condition in a local area. The UVLS scheme aims to shed load to restore reactive power relative to demand, to prevent voltage collapse, and to contain a voltage problem within a local area rather than allowing it to spread in a wide area. By contrast, automatic UFLS is designed for extreme conditions to stabilize the balance between generation and load after electrical island formation and to drop sufficient load to allow the frequency stabilization in the island. However, the UFLS is ineffective if instability or voltage collapse occurs within the island. Moreover, the most common factor that contributes to power blackout is voltage instability [2]. Thus, effective load shedding is crucial to prevent total system collapse. Improper load shedding would cause a high number of blackouts.

Various load shedding schemes have been proposed by researchers, in which the most applicable method is optimal load shedding using computational intelligence techniques, such as artificial neural network (ANN), adaptive neuro-fuzzy inference system (ANFIS), fuzzy logic control (FLC), genetic algorithm (GA), and particle swarm optimization (PSO). For instance, [3] suggested controlling the voltage stability during load shedding using FLC. The simulation results indicate that load shedding based on FLC can successfully stabilize and restore the system to the nominal value. However, the principal limitation of this technique is that the rules of FLC should be applied correctly depending upon the system under study. The study in [4] demonstrated the application of GA for determining the optimal load shedding scheme, with and without DGs at the network. This optimization aimed to minimize the sum of curtailed load and system losses. Furthermore, the location and the amount of load to be shed in the power system can be determined based on the GA application according to [5]. However, it is observed that the GA required a longer computation time in determining the amount of load shed, thus limiting its use for online application [6,7]. A new algorithm for the steady-state load shedding strategy was proposed in [8], in which an alliance algorithm considering the effect of demand priorities on the operation of the power system during emergencies was introduced. Differential evolution is subsequently applied for anticipatory load shedding based on voltage stability [9]. An application of bacterial foraging algorithm optimization was likewise presented to evaluate the optimal load shedding scheme with the objective of minimizing the total power losses, voltage stability index value, and total cost of load shed [10]. Although all of these techniques can determine the optimal load shedding scheme, extensive research is still required to enhance the performance of computational intelligence techniques.

Various voltage stability indicators, power losses, and amounts of MW to be shed are used in optimization evaluation. Similar to other indicators, the static voltage

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