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Optimal Overcurrent Relays Coordination in Microgrid Using Cuckoo Algorithm

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Abstract

Microgrid(MG) is a controlled branch of Distributed Generations(DGs) and loads in distribution network and offers more potential in DGs operation and control. MG can operate with and without utility grid (Island mode). The operation of this system in islanded mode requires sophisticated control and protection schemes. MG protection should be capable of fault detection with appropriate sensitivity and selectivity in both rigid-connected and islanded modes. This paper presents solving the issue of short circuit level difference in both modes using fault current limiter (FCL). Overcurrent(O/C) relays coordination and fault current limiter impedance are selected in such a way that protection system has a suitable operation for both modes. For this purpose, artificial intelligence methods of Particle Swarm Optimization (PSO) algorithm and Cuckoo algorithm have been used to achieve optimal relays coordination and fault current limiter impedance. The under study grid is a small MG related to Tehran Oil Refinery and the simulations have been running using MATLAB. The results indicate that fault current limiter can be used to solve the problem of short current level difference in both modes and Cuckoo algorithm is a more effective method for optimization applications.

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Keywords: Microgrid; Overcurrent Relays; Fault Current Limiters; Cuckoo Algorithm; Particle Swarm Optimization Algorithm.

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1. Introduction

MGs are very important for many centers such as hospitals, prisons, office buildings and military bases. In grid connected mode, MG exchanges power with main grid and supplies auxiliary service. In the Island mode, proper control and protection systems are needed to prevent problems such as imbalanced active and reactive powers of production and consumption, poor load distribution, frequency and voltage stability. Therefore, power system protection against faults is one of the most vital parts of it.The impact of DG on protective coordination depends on size, location and technology type of DG[1-3]. The effect of DG is surveyed on the short circuit current level and protective relay coordination [4–7]. Fault current limiter is used to limit the effect of DG on coordination of the O/C [8-10]. Many attempts have been made in the past to coordinate different types of O/C relays. The problem of setting O/C relays has been stated and solved as a linear programming (LP) problem in [11]. Optimization methods are the main proposed methods tools to set the optimized O/C relays. The settings of each relay are determined with regard to the constraints and the objective function by optimization algorithms [12-14]. Although presented algorithms in the last works have a good performance, but regard to the studies about refinery network which have done in this paper, proposed Cuckoo algorithm has higher precision and convergence speed in contrast to PSO and resulted to the optimized responses.

2. The Role of Fault Current Limiter in Microgrid Protection

Different short circuit level of MG in two modes and low fault current of sources with power electronic converters are two major problems in MG protection. With synchronous sources, short circuit level in the island mode is in a relatively good condition and thus typical O/C relays can protect it. Fault current limiter can be used to solve the problem of short circuit level difference [8, 9].

3. Particle Swarm Optimization (PSO)

PSO algorithm launches with the production of a random primary population [9,14]. Each optimization problem has N variables (Nvar) and thus the problem solving atmosphere will have Nvar dimensions. The velocity of the particle in new iteration is updated in accordance with the following formula [9]:

$$V_{i,j}(t+1) = WV_{i,j}(t) + C_1 r_{1,j}(t)\left|y_{i,j}(t) - x_{i,j}(t)\right| + C_2 r_{2,j}\left|\hat{y}_{i,j}(t) - x_{i,j}(t)\right| \quad (1)$$

$y_{i,j}(t)$ is the memory of individual intelligence and $\hat{y}_{i,j}(t)$ is the memory of swarm intelligence of particle i in iteration j. r_1 and r_2 are the pseudorandom sequences that are used the influence algorithm randomly. C_1 and C_2 are the accelerator factors that control the distance of the movement of a particle in an iteration. W is the weight inertia that controls PSO convergence. Weigh inertia (w) is obtained according to Equation (2) [9]:

$$w = w_{max} - \frac{w_{max} - w_{min}}{iter_{max}}.iter \quad (2)$$

Where, $iter_{max}$ is the highest number of iterations and iter is the number of iterations performed until the present [9,13].

4. Cuckoo Optimization Algorithm

In Cuckoo optimization algorithm “habitats” are the possible answer to the problem. In an optimization problem with Nvar variable, each habitat is an array of 1 × Nvar. The flowcharts of PSO and Cuckoo optimization algorithm are shown in Fig 1 and 2.