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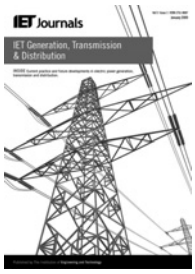

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Optimal daily scheduling of reconfiguration based on minimisation of the cost of energy losses and switching operations in microgrids

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Abstract: Network reconfiguration has been involved in energy loss reduction by considering the time-varying nature of loads. Nowadays, with the integration of intermittent micro-sources (MSs) to the power grid, optimal configuration should be determined corresponding to the variations in loads and generations. In this study, optimum reconfiguration instants are achieved based on the switching operations and energy losses costs. Moreover, the sequence of selecting loops for reconfiguration is optimised in conjunction with the time intervals by a joint optimisation algorithm. Furthermore, a simple branch exchange method of reconfiguration is modified in the presence of MSs. Discrete genetic algorithm (DGA) is employed to optimise the reconfiguration instants as well as the sequence of selecting loops. By applying the proposed method, the total operating cost of the network is reduced significantly, compared to optimum fixed configuration and hourly reconfiguration policies. The proposed algorithm is evaluated on a real-life 77-bus distribution system with two interconnected MSs.

1 Introduction

During recent years, a tremendous number of micro-sources (MSs), for example, solar cells and wind turbines, have been integrated by microgrid management system (MMS) in order to eliminate the reliance on fossil fuels and reduce the greenhouse emissions [1]. One of the cardinal goals of MMS is to minimise the losses of microgrids (MGs) [2]. It represents an indispensable requirement for microgrid operators (MGOs) to reduce losses in MGs to diminish the operating costs. A fairly large body of literature has been devoted to reduce loss in distribution systems. These methods can be generally categorised into four main classes: optimal conductor selection and/or replacement [3, 4], capacitor placement [5–7], distributed generation placement [8, 9] and reconfiguration [10, 11]. In [12, 13], a combination of the aforementioned methods are developed for the purpose of minimising energy loss in a real distribution network.

The other categorisation in the area of loss reduction is a dichotomy: the first one is the method that ignores the time-varying nature of loads and minimises power loss at specific time, for example, at the time of peak load [5, 10]. The second one is the approach that considers the time-varying nature of loads and reduce energy loss over a period of time, for example, over a day [6].

In this context, the time-varying nature of loads is considered in the network reconfiguration problem by two approaches. The first one is that the reconfiguration is employed for achieving a fixed configuration or minimum energy loss for a period of time [12, 14]. In the second one, hourly reconfiguration is performed by assuming that the network is equipped with the remotely operated tie switches [15]. The advantage of the first method is that the number of switching operations is minimal. However, the drawback of these studies is that due to uncertain nature of loads, network loss is not optimal for a fixed network configuration over a period of time, for example, over 24 h, if online reconfiguration facilities and MMS are provided. In order to achieve optimal losses in the presence of MSs, configurations, which may vary from time to time, should be determined corresponding to the load and generation variations. Therefore, with MG development, as it is shown in this paper, optimal hourly reconfiguration can result in better loss reduction using network reconfiguration compared to optimal fixed configuration. Furthermore, the overall cost of myriad switching operations for hourly reconfiguration may exceed the cost of reduced energy loss. In this case, network reconfiguration is ineffective for economic reasons. As it is shown in this paper, this problem would be especially considerable when there are some intermittent MSs, that is, photovoltaic systems, energy storage equipment and plug-in hybrid electric vehicles (PHEVs) as controllable loads and dispatchable generators utilised throughout the network. However, none of the previous studies on reconfiguration has considered such switching operations costs together with instants of reconfiguration. Consequently, it motivated the authors of this paper to undertake a detailed study on optimal daily scheduling of reconfiguration which specify reconfiguration

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