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Active power reserve estimation of two interconnected microgrids

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Abstract

This paper presents the optimization of active power reserve of two alternating current (ac) interconnected microgrids. The main objective is to meet the power demand completely while satisfying the system constraints. Optimal control theory was used to solve the estimation problem. The active power from all the sources is taken as control variables. The effectiveness of the proposed model is shown through the simulation results of the network model.

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Keywords: Active power reserve; power demand; microgrid; optimisation-control.

1. Introduction

Electrical network operators have a number of duties that focus on maintaining reliability. Reliability and quality of supply of any electrical system are maintained by managing and controlling of the active and reactive power reserves [1–3]. The load variations can occur any time in the power system and control strategies should be taken to correct or to restore its balance [4]. Also, the load prediction cannot be 100% accurate and the power reserves can help to mitigate the effects of load forecast errors. The power reserves are very useful and highly needed, its help to compensate any load deviation and to avoid system collapse or blackout. This is why for the purpose of security the interconnected microgrids cannot operate without power reserves.

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In recent times, large numbers of power systems operate near their power constraint limits because of the growing demands from their customers. The integration of renewable energies resources (RES) into the power system is an asset for network operators [5]. Despite the problems raised by this integration, these RES can be used to make the network operations to become more reliable and to secure the supply. Spinning reserves address the reliability concerns due to loss of generation as well as the unpredictable dynamics due to forecasting errors for RES simultaneously [6-8]. The research in [9] have discussed on the provision of power reserves by wind turbines with constant power control. The model shows that wind turbines with constant power control can be used to provide power reserves. A case study of reserve setting and steady-state security assessment using wind power uncertainty forecast was presented in [10]. In [11], a methodology was developed to support system operators in defining the operating reserve needs, taking into account conventional generation outages, load forecast uncertainty and wind power forecast.

This research introduces the application of optimal theory to solve the estimation of the active power of two interconnected microgrids. The contribution of this paper is the establishment of the model for optimization that maximizes the use of renewable energy sources and to optimise the active reserve power for two interconnected microgrid. The linprog solver in Matlab was used for all the optimization problem.

2. Optimization of active power reserve in the microgrids

2.1. Network model

Fig.1 shows the proposed interconnection of two microgrids system where: $P_{G1}, P_1(t)$, $P_2(t)$, $P_3(t)$, $P_4(t)$, $P_5(t)$, $P_{L1}(t)$, $P_{L2}(t)$, $P_{L3}(t)$; the total generated power, the power generated form the main sources of area 1, the active power from wind farm, active power from solar-PV, the power from battery energy storage, the active load demand 1, load demand 2 and load demand 3 in area 1 respectively. And $P_{G2}, P_7(t)$, $P_8(t)$, $P_9(t)$, $P_{10}(t)$, $P_{11}(t)$, $P_{L4}(t)$, $P_{L5}(t)$, $P_{L6}(t)$; the total generated power, the power generated form the main sources of area 2, the active power from wind farm, active power from solar-PV, the power from battery energy storage, the active load demand 4, load demand 5 and load demand 6 in area 2 respectively.

2.2. Mathematical model

For Area 1: the mathematical model describing the power flow supplying load demand in microgrid 1 is given by:

$$P_1(t)+P_2(t)+P_3(t)+P_4(t)-P_5(t)=P_{L1}(t)+P_{L2}(t)+P_{L3}(t) \tag{1}$$

The model of Equation (1) can be derived by:

$$P_{G1}-P_{L1}(t)-P_{L2}(t)-P_{L3}(t)=0 \tag{2}$$

Model Equation (2) will be taken as the first objective function of the model. To ensure the uninterrupted or continuity of power supply to some important loads, the following constraints should be respected:

$$P_{G1} \geq \left[P_{L1}(t)+P_{L2}(t)+P_{L3}(t)\right] \tag{3}$$

The constraint on load flow direction in some specified branches can be expressed as follows:

$$P_{L1}(t)\geq 0,\ P_{L2}\geq 0 \text{ and } P_{L3}(t)\geq 0 \tag{4}$$

For Area 2: the mathematical model describing the power flow supplying load demand in microgrid 2 is given by: