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Load modeling for wide area power system

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ABSTRACT

The electrical loads have significant impacts on the dynamic performances of the wide area power system, and the dynamic behaviors of the power system can not be reproduced by the simulation system, unless the electrical load was modeled accurately. In the previous load modeling, the dynamics of the electrical load itself is of concern. Using such load models, the satisfied dynamic behaviors of the wide area power system can not be obtained by simulation. In this paper, a system-wide load modeling strategy is proposed. The electrical loads are firstly classified into a few categories using the component based load modeling method. According to the problems studied, the output variables of the power system are selected, and the objective function is constructed using the data from Wide Area Measurement System (WAMS). The trajectory sensitivities of the load model parameters with respect to the output variables are analyzed. Based on which, the key parameters playing important roles on dynamics of the power system are identified and included in further parameter estimation. The load models for the wide area power system are built simultaneously, and the system-wide load modeling method is implemented on the IEEE 39-bus system to evaluate its effectiveness.

1. Introduction

It has been well recognized that the electrical loads have significant impacts on the dynamic performances of the wide area power system, and the accurate load models are very important for the power system dynamic simulation and analysis [1–6]. Since the characteristics of the electrical load are random and changing, the load modeling is a difficult task [7]. In the past few decades, extensive studies have been carried out in the field of electrical load modeling. Two load modeling methods, namely component based method and measurement based method, are commonly used in the previous studies. To represent the electrical load characteristics more accurately, the measurement based method recently attracted more and more interests from power engineers and researchers [8–12]. In the measurement based method, the dynamic responses of the electrical load under a system disturbance are measured, and a set of parameters for the load model are obtained by the optimization strategy with the objective to minimize the difference between the simulated dynamic responses of the load model under the system disturbance and those measured. Using the measurement based load modeling method, the model for electrical loads connected at the load transformer, where the measurement equipment is installed, can be constructed, and the dynamics of the electrical load itself is concerned. Since there are hundreds of such electrical loads in the modern power system, it is difficult and uneconomical to established model for each electrical load, respectively. Hence, the system-wide load modeling has to be developed.

The initial work about the system-wide dynamic load modeling in WSCC was carried out in [13,14]. The simulation system was constructed to reproduce the dynamics of the outage occurred in western North America on August 10, 1996, and to verify the system dynamic models in [13]. It was found that if the load models were not properly set, the simulation system cannot show the similar damping as that of the actual system. It should be mentioned that numerous simulations were performed to search the suitable load model parameters. It takes quite long time to repeat many times' simulations, and it was not guaranteed to obtain the satisfied result. In [14], the impact of the electrical load, which was modeled by the composite load model, on the damping of the power system was studied. The sensitivity of the parameters of the composite load model was analyzed, and it is concluded that the percentage of motor modeled at the load bus has the largest sensitivity. The damping of the power system decreases with the increase of the percentage of the motor in the total load. However, as it was demonstrated in the paper, this work was a start in the system-wide load modeling, and the load modeling method for the wide area power system needs to be investigated further.

To build the system-wide load models, the measurements valid among the wide area power system are necessary. With the development of the wide area measurement system (WAMS), the system-wide measurements, which synchronized by the GPS, can be obtained. WAMS has been applied in power system monitoring,

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