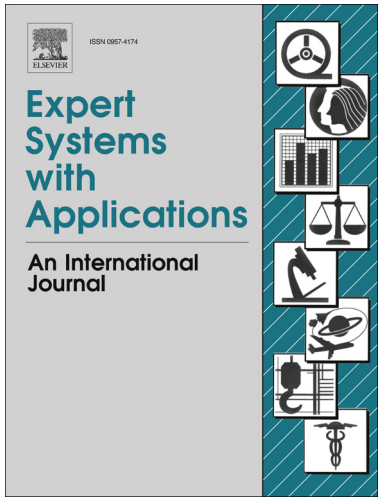

An Investment Decision Model for the Optimal Placement of Phasor Measurement Units

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Abstract

Safe operation and reliability of the electrical power systems necessitate full observability of the power grid. Phasor measurement units (PMUs) are the state-of-the-art intelligent devices that collect synchronized phasors of voltages and currents in real time. It is not economically justifiable to install PMUs at all buses of the power grid. Hence, designing the PMUs network and determining their optimal placement in the power grid is an investment decision. In this paper, we propose a new investment decision model to determine the optimal placement of PMUs that guarantees the full observability of the power grid. Network observability rules are applied to reduce the capital cost of installing PMUs. A problem-specific genetic algorithm is developed to determine the optimal investment decision. The $N-1$ reliability requirement of the power grid has been integrated in the model as well to obtain the resilient network design against all single contingencies such as failure of a PMU or a transmission line. Furthermore, a two-phase investment plan is proposed, which provides the power system investors with more flexibility and avoids unnecessary investment costs. In the first phase, PMUs are installed to achieve full observability of the power grid whereas additional PMUs will be installed in the second phase to guarantee the full observability in case of single contingencies. To test the efficacy of the proposed model, experiments are conducted on multiple IEEE test systems with and without considering zero-injection buses. The results are compared to the other methods such as integer linear programming and heuristic methods. The analysis shows that the proposed approach is promising and verifies its efficacy.

Keywords: Phasor measurement unit, Optimal placement, Network observability, Genetic algorithm

1. Introduction

Wide-area monitoring and full network observability of electrical power systems in real time was impractical until the emergence of phasor measurement units (PMUs). PMUs are the intelligent measurement devices that measure synchronized phasors of voltages and currents in real time