Chapter 9

PMU Placement Optimization for Fault Observation Using Different Techniques

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ABSTRACT

This chapter presents different techniques for obtaining the optimal number of the phasor measurement units (PMUs) that may be installed in a smart power grid to achieve full network observability under fault conditions. These optimization techniques such as binary teaching learning based optimization (BTLBO) technique, particle swarm optimization, the grey wolf optimizer (GWO), the moth-flame optimization (MFO), the cuckoo search (CS), and the wind-driven optimization (WDO) have been developed for the objective function and constraints alike. The IEEE 14-bus benchmark power system has been used for testing these optimization techniques by simulation. A comparative study of the obtained results of previous works in the literature has been conducted taking into count the simplicity of the model and the accuracy of characteristics.

INTRODUCTION

In order to make the electrical power systems more reliable, stable, and controllable; state estimation of the transmission network is necessary (Bei, X., et al, 2008; Allemong, J., et al, 1982; Abbasy, N.H., Ismail, H.M., 2009). The Phasor Measurement Unit (PMU) is a tool for measuring the voltage and current those are synchronized by using the global positioning system (GPS) satellite. Integrated with the GPS receiver (Yin, H., Fan, L., 2010; Mohammadi-Ivatloo, B., 2009), the power station including the Phasor Data Concentrator (PDC), which is used for analyzing the PMU data, can receive the synchronous data from each PMU in real time (Valenti, M. C., Feliachi, A., 2002).

State estimation of power network may allow the scheduling generation and interchange; monitoring outages and scheduling alternatives; supervising scheduled outages; scheduling frequency and time corrections; coordinating bias settings; and emergency restoration of system (Waheed Ur Rahman, et al,

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2012). This can be achieved either by state estimation algorithms (Phadke A. G., Thorp J. S., 2008) or by means of PMUs with extreme precision, time synchronization, and excellent performance. Measuring state estimation is achieved through complex bus voltages (Baldwin, T. L., et al, 1993) that enable the estimation of the neighborhood bus voltage magnitudes and angles by using the line flow measurement (both real and reactive power). The static and dynamic behaviors of the power grid may be obtained from the information gathered by PMUs.

Faults that occur in the transmission line may be either permanent or temporary (Mosavi, M. R., Akhyani, A. A., Rahmati, A. 2012; Xu, B., 2006). Permanent fault may lead to a broken transmission line or a power generator malfunction; this causes different signals during the pre-fault and post-fault. This can be easily detected and located. However, the temporary fault may cause insulator flashover, which may lead to full insulator breakdown if it occurs frequently. This emphasizes the importance of PMU-based fault location technique (Dambhare, S., et al, 2008; Shahraeini, M., Javidi, M. H., 2011).

Nowadays, Wide Area Monitoring System (WAMS) that is considered the most advanced system to detect disturbances and avoid a bulk blackout is based on the PMUs . It aims to maintain the dynamic stability in the whole power network (Phadke A. G., 1993). This is implemented by synchronizing and recording the acquired data from systems in distributed locations through new computing and communication technologies. Upon their delivery to the central control station, these data are measured and analyzed from any point of the power network. In addition to its ability to monitor the static stability of the network (as traditional SCADA), WAMS enables the controllers to recognize unusual activities within the power network such as instability in the network voltage, to analyze the network oscillation, and to detect fault location. Thus, using the data provided by PMUs installed in some appropriate buses of a power grid, one can construct a new type of measuring system to improve the observability and the precision of the power system state estimator. The observability depends on the type, the number and the geographic distribution of measurements (Nuqui R. F. and Phadke A. G., 2005). Several methods (Milosevic B. and Begovic M. 2003; Xu B. and Abur A. 2005; Dekhandji, F. Z., et al, 2019; Chakrabarti S. and Kyriakides E. 2007; Chakrabarti S. and Kyriakides E. 2008; Hajian M., A., et al, 2007; Charu, S., and Barjeev, T. (2011) were considered when formulating the optimal placement of monitoring devices for fault location.

In this research work, a binary teaching learning based optimization (BTLBO) algorithm (Rao, R.V., et al, 2011 ; Rao, R.V., et al, 2012; Rao, V.J., Savsani, J.B., 2012; Rao, R.V., Patel, V.K., 2012; Tankasala, G. R., et al, 2012) for the optimal placement of phasor measurement units (PMUs) is proposed. The optimal PMU placement problem is formulated to minimize the number of PMUs installation subject to full network observability at the power system buses during the fault. The effectiveness of the proposed method is verified by the simulation of IEEE14-bus and compared with previous developed techniques.

FAULT ANALYSIS USING PMU

PMU-based fault location technique is achieved through monitoring the synchronized fault voltages, calculating the line currents between these buses, and forming bus injection currents at two terminals of the faulted line. Thus, calculation of fault locations can be indirectly investigated.

A PMU placed at a given bus of the network can measure both the phasor voltages and phasor currents of all lines incident to that bus. Thus, the entire parameters of a bus can be made observable by placing judiciously PMUs at specific buses of the network. As shown in Fig.1, most power transmission

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