Using ANN to Estimate the Voltage of Unobservable Buses When One PMU or its Communication Fails

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Abstract. In monitoring system, the PMUs send their data to a control center. If one PMU fails or its communication fail, the data of that PMU do not send to the control center. This lack of data leads to some unobservable buses. In this paper, Artificial Neural Network (ANN) has been used to estimate the voltage of unobservable buses. We implement this method in IEEE 14-Bus.

Key words

PMU, State Estimation, Artificial Neural Network (ANN), IEEE 14-Bus test system.

1. Introduction

Due to progress on Global Positioning System (GPS), the PMUs become available and can be used to get data from different points of a power system. This data is necessary for the supervisory control applications or on-line states assessment of a large scale power system. PMUs are able to take the online phasor measurements. This simultaneous measurement is achieved with voltage and current waveforms sampled by GPS signals. The ability of simultaneous measurement of PMUs, improve the monitoring, control and in turn the security level of power networks [1].

The Number of PMUs in a network is limited, because these devices are expensive and they cannot be installed on all buses. Due to placement of these devices a lot of papers have been published [2]. A lot of methods have been used to find the minimum number of needed PMUs and their places in a network [3], [4] and [5].

In this paper, we focus on situations that one PMU or its communication failed. In such a situation some parts of network become unobservable. This unobservability is dangerous, because maybe it causes to voltage collapse or other problems [6]. So, there must be one way to overcome this problem. One way is to use the traditional system on that area. But, the way that has been presented in this paper is to use the ANN to estimate the parameters of unobservable part of network.

2. PMU Failure

PMUs can get the magnitude and phase of voltage of the bus that is connected to, and the magnitude and phasor of current of lines that are connected to that bus and send them to a control center. So the PMUs need some communication tools which send their data to the control center. If one PMU fails or its communication have problem, the data of that PMU does not send to the control center. This lack of data leads to some unobservability in network.

In this paper, the ANN has been used to estimate the voltages of unobservable buses. The power network has been simulated by DIgSILENT software and the ANN has been carried out in MATLAB software.

The ANN should be trained by the results of the load flow analysis. The different scenarios have been randomly selected for different load or generation levels, which are generated by using Mont-Carlo method. In this method, a random number (N) between 1 and N_b (the number of buses) is generated. This number determines the number of buses, which should be changed. If a bus is a PQ or PV bus, in order to change its parameters, scenario 1 or 2 should be selected, respectively.

In the scenario 1, the load active power is randomly selected in the prespecified margin, as follows:

$$P_{L,i}^{PQ} \in \left[P_{L,i}^{\min} \quad P_{L,i}^{\max} \right] \tag{1}$$