Optimization Methods for Optimal Power Quality Monitor Placement in Power Systems: A Performance Comparison

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Abstract: This paper presents a performance comparison between three optimization techniques, namely, quantum-inspired binary particle swarm optimization, binary particle swarm optimization and genetic algorithm in application to optimal power quality monitor (PQM) placement method for voltage sag assessment. The optimization handles the observability constraints based on the topological monitor reach area concept and solves a multi-objective function in obtaining the optimal number and placement of PQMs in power systems. The objective function consists of two functions which are based on monitor overlapping index and sag severity index. All the optimization algorithms have been implemented and tested on the IEEE 34-node, the 69-bus and the IEEE 118-bus test systems to evaluate the effectiveness of the aforementioned techniques. The results show that QBPSO provide a better optimal solution than the standard binary particle swarm optimization and the existing genetic algorithm by 56% and 31%, respectively. The validation test illustrated that the optimal PQM placements can detect and record the voltage sag events due to any fault occurrence in the systems.

Keywords
Quantum-inspired binary particle swarm optimization, topological monitor reach area, multi-objective function, binary particle swarm optimization, genetic algorithm

1. Introduction

Power quality has been treated as a prominent issue which demands utilities to deliver good quality of electrical power to end users especially to industries having sensitive equipment. Among all the power disturbances, voltage sags are the most frequent and give severe impact on sensitive loads [1]. It may cause failure or malfunction of sensitive equipment in industries which eventually leads to huge economic losses. This type of power disturbance is defined by IEEE standard 1159-1995 as a voltage reduction in the RMS voltage to between 0.1 and 0.9 per unit (p.u.) for duration between half of a cycle and less than 1 minute [2]. Thus, more work should be done in monitoring of voltage sags in order to mitigate such disturbances.

In the conventional power quality monitoring practice, monitors are installed at all bus in a power distribution network to monitor voltage sags. However, [3] showed that reducing the number of monitors will reduce the total cost of monitoring system and also reduce redundancy of data being measured by monitors. Thus, new methods are required for selecting minimum number and the best locations of monitors to ensure that any event leading to voltage sag is captured. In [3]-[7], the concept of monitor observability is utilized to find optimal placement of power quality monitors in transmission systems. However, this concept is not suitable for radial distribution networks. Therefore, there is a need to develop a new optimal placement method of PQM that is applicable for both transmission and distribution systems.

A few optimization techniques have been used to solve the optimal PQM placement problem in the last few years. In [3], the PQM placement method based on covering and

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