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Three-phase harmonic distortion state estimation algorithm based on evolutionary strategies

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ABSTRACT

This paper presents a new methodology to estimate unbalanced harmonic distortions in a power system, based on measurements of a limited number of given sites. The algorithm utilizes evolutionary strategies (ES), a development branch of evolutionary algorithms. The problem solving algorithm herein proposed makes use of data from various power quality meters, which can either be synchronized by high technology GPS devices or by using information from a fundamental frequency load flow, what makes the overall power quality monitoring system much less costly. The ES based harmonic estimation model is applied to a 14 bus network to compare its performance to a conventional Monte Carlo approach. It is also applied to a 50 bus subtransmission network in order to compare the three-phase and single-phase approaches as well as the robustness of the proposed method.

1. Introduction

Assessing the impact of harmonic sources to the performance and behavior of electric power systems is a relevant and complex aspect concerning power quality.

When one admits harmonic injections to the power system as known parameters, actions can be devised in order to mitigate the impact of the harmonic distortions throughout the network. This is generally carried out by the design and utilization of passive or active harmonic filters. However one should realize that in most cases the sources of harmonic distortions are not known [1].

Although power quality meters are becoming less costly, it is still economically unviable to design power quality monitoring systems where meters are to be installed in all network buses.

In such a condition, when a few sites are selected for the installation of power quality meters, the use of a harmonic distortion state estimation algorithm is highly recommended.

The harmonic distortion state estimation (HDSE) consists of a process which is the reverse of a simulation process. Simulators determine the power system response to harmonic injection in one or more locations, whereas estimators evaluate the harmonic injections when the power system responses are given by a set of measurements [2].

The HDSE methodology consists in an efficient and economic tool to be used in power quality monitoring systems, so that harmonic distortions can be estimated throughout the network. The HDSE algorithm is based on the network topology and the corresponding harmonic frequency admittance matrices, passive (linear) loads and power quality meter locations and measurements [3].

Intelligent computation can be used as a good hand to evaluate harmonic sources, as it is herein proposed. Evolutionary strategies (ES) are interesting options due to their easy implementation, especially when simulation algorithms for the specific problem are well known. The implementation and speed of ES are important aspects when comparing to conventional techniques.

Estimation of the network harmonic distortion states is a complex problem since one should base its formulation on minimum and reliable data coming from a few power quality meters. Many aspects might result in discrepancies between the real and simulated systems. Besides meter calibration, important issues such as data communication and network data fidelity are really important. Another important aspect is related to the synchronization data from different power quality meters, which is dealt with in this paper in an innovative and viable manner.

Harmonic estimation is generally considered as two classes of problems. The first one concerns the estimation of the harmonic content in a measured waveform whereas the second one regards the estimation of harmonic distortions in non-monitored buses of an electric power system by using information from power quality meters in monitored buses as reference (harmonic propagation). Several works concerning the first class of problems are addressed

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