Park’s Transformation for Electric Power Quality Recognition and Classification in Distribution Networks

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ABSTRACT

This paper presents a novel algorithm for recognizing and classifying the power quality events based on Park’s transformation, where the three rotating abc phases are transferred to three equivalent stationary dq0 phases (d-q reference frame). This transformation is implemented, either for three-phase or single phase circuits. The proposed algorithm transferred the utility signal to a complex phasor (transformation from time domain to frequency domain). The magnitude of this phasor depends on the magnitude of the signal either a three-phase or a single phase signal. The proposed technique produces the complex phasor loci that depend on the type of power quality event; voltage sags, voltage flickers, voltage swell, and harmonics. The time of starting the disturbance is chosen randomly and the length of disturbance is arbitrary. Implementation of this technique is succeeded in recognizing and classifying the power quality events. Simulated results are presented within the text, for three-phase and single phase events.

Keywords: Park’s Transformation, Power Quality Events, Sags, Swell, Voltage Flickers and Harmonics

1. INTRODUCTION

Power quality is an issue that has generated much interest to both electric utilities and customers today. With the increased use of complex and sensitive electronic circuitry, any slight variation in magnitude, frequency or purity of the waveform can often affect and lead to expensive failures of equipment. The performance and operation of this equipment may unavoidably cost customers in lost time and revenue. Efficient simulation tools are important to simulate the causes and effects of these power quality problems, possibly saving large amount of time and money especially in
today’s challenging and competitive environment. In addition, through the development of technologies and instruments, highly developed power quality monitoring tools are available in respond to meet domestic and international standards.

Nowadays distribution utilities face the problem of power quality, especially for deregulated markets. The electricity customers are looking for a good quality power, pure sinusoidal signal, to protect their devices and equipments from failure or damage. As such these utilities are looking for an accurate technique that able to recognizes and classifies power quality events such as voltage sags, swell, momentary interruption, voltage flickers and harmonics so that a suitable action is taken to filter out these disturbances. Till today no available instrument can be used to monitor these events, since their time of occurrence is too short to be observed. For example, voltage sages duration time is about 0.5-30 cycle with typical magnitude of 0.1-0.9 p.u, these characteristics can be observed by tracing the RMS versus time. The figure gives power supply voltage disturbances.

In the last decade, the power engineers are paid attention to power quality problems, and many algorithms are developed and tested for the purposes they are invented. Abner (2011) presents the basics of two techniques, named as the modified harmonic domain and the modified dynamic harmonic domain, proposed for calculating steady and dynamic states, respectively. These techniques have their fundament in the harmonic domain with a substantial improvement: the inclusion of inter harmonics in either steady or dynamic state. This is performed through the use of the discrete Fourier transform which allows an arbitrary frequency-domain discretization, thus permitting the representation of inter harmonics. In Albu and Heydt (2003), a potential problem area in using RMS values in power quality assessment are identified and discussed. The RMS can be computed either using a fixed window (s-RMS) or a moving average technique (m-RMS). In both cases, RMS is a function of window length, and is a constant function for periodic signals of fundamental period (Huang, Lin, & Kuo, 2011), proposes a chaos synchronization (CS)-based detector for power-quality disturbances classification in a power system. The Lorenz chaos system realized a CS-based detector to track the dynamic errors from the fundamental signal and the distorted signal, including power harmonics and voltage fluctuation phenomena. A CS-based detector uses dynamic error equations to extract the features and construct various butterfly patterns. The probabilistic neural network is an adaptive classifier that performs pattern recognition. The particle swarm optimization algorithm is used to estimate the optimal parameter and can heighten the accuracy.

Gursoy and Niebur (2009) explore the use of a statistical signal processing technique, known as independent component analysis (ICA) for harmonic source identification and estimation. If the harmonic currents are statistically independent, ICA is able to estimate the currents using a limited number of harmonic voltage measurements and without any knowledge of the system admittances or topology.

In Eldery, El-Saadany, and Salama (2005), an algorithm for tracking the voltage envelope based on calculating the energy operator of a sinusoidal waveform is presented. This algorithm is used to evaluate the instantaneous changes in the amplitude and so track the envelope of the waveform. The algorithm is fast and robust and uses only a few samples to calculate the energy. It is not sensitive to the noise or the distortion in the waveform. The results show the capability of the algorithm to track different shapes of envelopes associated with high signal-to-noise ratio (SNR). However, there will be a delay between the actual and the tracked envelope, due to using the lead/lag networks.

Arruda, Kagan, and Ribeiro (2010) present a methodology to estimate 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 main advantage in using such a technique relies upon its modeling facilities as well as its potential to solve fairly complex problems.
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