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Identification of Optimal Features for Fast and Accurate Classification of Power Quality Disturbances

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Abstract - This paper presents a classification method for power quality (PQ) disturbances by using efficient features of the PQ signals for an accurate classification with minimum computational complexity. Overall, 16 disturbance classes, including some combined disturbances, are considered based on the IEEE 1159 standard. A 6.4 kHz sampling rate is used on 10 cycles of distorted waveforms for the feature extraction by using different transform functions. The sequential forward selection, genetic and maximum relevance minimum redundancy algorithms are used for a precise selection of features. The selected features are input to different classifiers and their outputs are compared to find the best classifier. The effectiveness of the proposed method is studied for de-noised signals and the required features and classifier algorithms are presented for an optimum accuracy (99.31%) in lower computational complexity and higher accuracy (100%) in expense of computational complexity. Some features are presented for high accuracy classification of noisy signals with different noise levels without the requirement of de-noising preprocess. Accuracy of the method is validated by different simulation studies including the 3.2 kHz sampling rate for reduced computational complexity. As an alternative test method, the distorted waveforms generated by the Electro-Magnetic Transient Program (EMTP) are accurately classified.

***Index Terms*— Power Quality disturbances, PQ Measurement, Feature extraction, PQ characteristics, Pattern recognition, Disturbances classification.**

I. Introduction

Modern power systems face disturbances generated by increasing levels of non-linear loads, electronic devices and highly penetrated distributed energy resources. Monitoring of disturbances in voltage and current signals is now in big demand by the industry. The monitoring instruments can collect various disturbance data such as harmonic spectrum, harmonic deviation, total harmonic disturbance, etc., which can be processed to analyse power quality (PQ) signals. The offline and/or online identification of different disturbances by such measurements is a big challenge as a technique for continuous monitoring can be difficult and time-consuming. It is therefore logical to develop techniques for automatic disturbance identification, which are applied directly or by means of feature extraction and pattern recognition.

There are numerous reports and papers in the literature addressing the PQ disturbance classification. In general, the disturbance classification consists of three steps: 1- signal analysis and feature extraction; 2- feature selection; and 3- disturbances classification. Different algorithms are proposed in the literature for each step. In [1-6] the wavelet transform (WT) is used for signal analysis and feature extraction. The signal is decomposed into some levels by the WT and features such as wavelet coefficients energy and entropy are extracted. In [3] a method is also proposed for disturbance identification. In [4] other statistic characteristics such as skewness and kurtosis are extracted. In [7-12] the S transform (ST) is used for signal analysis and feature extraction. The ST results in a two-dimension matrix with complex elements, which is used along with frequency cantors to extract the required features. For example, in [8] the 25 Hz cantors are produced and their energy are considered as the features. Other statistic characteristics such as standard deviation and variance are also extracted from amplitude cantor based on time, frequency cantor based on time, and phase curve [9-11]. In [13] the time-time transform (TTT) is used along with the ST for feature extraction. The Hilbert transform (HT) is used in [14-16] for signal analysis and feature extraction. In these references, the empirical mode decomposition (EMD) is used for signal conditioning before