

Denoising Electrical Signal via Empirical Mode Decomposition

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Abstract

Electric signals are affected by numerous factors, random events, and corrupted with noise, making them nonlinear and non-stationary in nature. In recent years, the application of Empirical Mode Decomposition (EMD) technique to analyze nonlinear and non-stationary signals has gained importance. It is an empirical approach to decompose a signal into a set of oscillatory modes known as intrinsic mode functions (IMFs). Based on an empirical energy model of IMFs, the statistically significant information content is established and combined. In this paper, we demonstrate an approach to detect power quality disturbances in noisy conditions. The approach is based on the statistical properties of fractional Gaussian noise (fGn).

1. Introduction

A signal obtained from any system is never a perfect reflection of the actual measurement. Rather, a signal is always corrupted by noise introduced by the device itself or by other means. Therefore, an observed signal is a combination of actual information and noise,

$$x(t) = s(t) + n(t) \quad (1)$$

where $x(t)$ is the observed signal, $s(t)$ is the actual measurement, and $n(t)$ is the noise. The unknown amount and type of noise present in the data can lead to misinterpretation of the phenomena reflected by the signal.

In this paper, we study an electrical power signal corrupted with noise and disturbances. A 50 Hz sinusoidal voltage signal of 2 volts peak to peak amplitude is shown in Fig. 1. A constant supply of normal voltage with less than 10% variations is considered as good power supply quality. With increasing use of solid state switching devices, nonlinear load switching, rectifiers, inverters, and improper load balance, the power quality degrades. Thus, power quality monitoring has gained tremendous importance in recent years [1, 2]. Power disturbances based on effects, duration, and intensity can be divided into five categories, voltage fluctuations, transients, harmonics, power outages, and electrical noises. Among all the

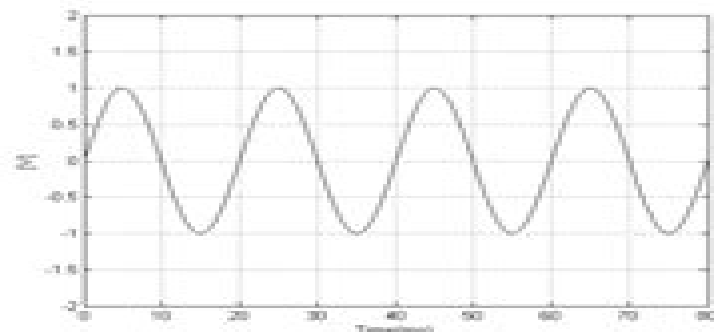


Fig. 1. Normal voltage signal.

disturbances, electrical noise is the most common.

Electrical noise is generally white noise. Consider a signal $z(t)$ of the form,

$$z(t) = s(t) + y(t) \quad (2)$$

where $y(t)$ is the power disturbance. The detection of $y(t)$ in noisy conditions is a challenging task. The application of signal processing tools for noise removal and power quality monitoring is been studied extensively [3-5]. Wu et al. discusses the limitations of various existing denoising approaches in signal processing [6]. Wavelet transform based power quality monitoring received wide attention because of its ability to handle nonlinear and non-stationary signal [7-9]. Santoso et al. detected power disturbances using wavelets and classified them accordingly using pattern recognition techniques [10, 11].

In this paper, we demonstrate the performance of EMD in detecting power disturbance in noisy conditions. The EMD approach originally proposed by Huang et al. is a highly adaptive decomposition technique [12]. It decomposes any complicated signal into a finite set of functions called intrinsic

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