Application of the Wavelet Transform for the Fault Detection in Induction Motors Using Transient Stator Current Signal

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Abstract

In this paper, a method for the diagnosis of rotor fault in the induction motors has been investigated. It is based only on the analysis of the transient stator current by using the discrete wavelet transform (DWT). Using the simplified dynamic model of the squirrel cage induction motor taking account the fault (broken rotor bars) and the discrete wavelet transform (DWT), in order to extract the different harmonics components of the stator currents. The performance presented by using of the DWT. It is ability to provide a local representation of the non stationary current signals for the healthy machine and with fault (two adjacent broken rotor bars).

1. Introduction

Condition monitoring and fault diagnosis of electrical machines is extremely important in any industrial setup as the loss of even one machine can have far reaching consequences. Thus huge research effort is being put worldwide to develop fool proof method of fault diagnosis as summarized in [1]. Among several cause of failure of motor encompassing electrical and mechanical faults, the most common rotor broken bars [1].

In order to preserve a high level of machine integrity, it is necessary to assess the condition of the machine. Many fault detection methods have been proposed, but their established techniques contain many aspects which can be improved.

The most popular methods of induction machine condition monitoring utilize the steady-state spectral components of the stator quantities. These stator spectral components can include voltage, current and power and are used to detect turn faults, broken rotor bars, bearing failures and air gap eccentricities. Presently, many techniques that are based on steady-state analysis are being applied induction machines [2]. Diagnostic method to identify the above faults may involve several different types of fields of science and technology.

Several methods are applied to detect the faults in induction motors such as Fourier transform and Wavelet transform analysis.

Wavelet transform is a method for time varying or non-stationary signal analysis, and a new description of spectral decomposition via the scaling concept. Wavelet theory provides a unified framework for a number of techniques, which have been developed for various signals processing application. One of its feature is multi-resolution signal analysis with a vigorous function of both time and frequency localization. This method is effective for stationary signal processing and non-stationary signal processing. Mallet's pyramidal algorithm based on convolutions with quadratic mirror filter is a fast method similar to FFT for signal decomposition of the original signal in an orthonormal wavelet basis or as a decomposition of the signal a set of independent frequency bands. The independence is due to the orthogonality of the wavelet function [3], [4].

2. Wavelet Transform

The ability to provide variable time-frequency resolution is hallmarks of wavelet transform. Wavelet transform is relatively new mathematical technique, which is used to analyze signal in nature. It is becoming the focus point of much science, and is fondly delighted tool by scientists. It plays a very important role in signal and information processing [4], [5].

2.2. Discrete Wavelet Transforms Description (DWT)

The wavelet transformation is processes of determining how well a series of wavelet functions represent the signal being analyzed. The goodness of fitting of the function to the signal is described by the wavelet coefficients. The result is a bank of coefficients associated with two independent variables, dilation and translation. Translation typically represents time, while scale is a way of viewing the frequency content. Larger scale corresponds to lower frequency meaning there by better resolution. The most efficient and compact form of the wavelet analysis is accomplished by the decomposing a signal into a subset of translated and dilated parent wavelets, where these various scales and shifts in the parent wavelet are related based on powers of two. Full representation of a signal can be achieved using a vector coefficients the same length as the original signal.

Considering a signal consisting of 2^m data points, where m is an integer. DWT requires 2^m wavelet coefficients to fully describe the signal. DWT decomposes the signal into m+1 levels, where the level is denoted as j and the levels are numbered i= -1, 0, 1, 2, 3…m-1. Each level i consists of $j=2^i$ wavelet translated and equally spaced $2^m/j$ intervals apart.

The $j=2^i$ wavelets at level i are dilated such that an individual wavelet spans n-1 of that level interval, where N is the order of wavelet being applied. Each of the $j = 2^i$ wavelets at level i is scaled by a coefficient $a_{i,j}$ determined by the convolution of the signal with the wavelet. Notation is such that i corresponds to wavelet dilation and j is the wavelet translation in level i [6-8].

The forward wavelet transform determines the wavelet coefficient $a_{i,j}$ of j wavelet at each level i. For the signal f(n), the DWT is:

$$a_{i,j} = \sum_{n} f(n).\psi_{i,j}(n) \quad (1)$$