Stator Current Harmonic Assessment of Induction Motor for Fault Diagnosis

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Abstract
This paper presents an assessment of motor current signature analysis for fault diagnosis of an induction motor. Single phasing fault has been considered and stator current harmonics are analyzed by assessing peaks and symmetry in harmonic spectrums both at normal condition and at fault condition. 'db4' is used for current signature analysis wavelet decomposition. A comparative observation is made based on the result obtained by computer simulation. Some distinct and significant changes are found at fault condition which may be very useful for diagnosis of such faults.

Keywords
Discrete Wavelet Transform, Kurtosis; Skewness, RMS, Mean Values, Single Phasing

I. Introduction

The squirrel cage ac induction motors are widely used in industry. This type of induction motors are the main workhorse of the industry due to its ruggedness, versatility and low manufacturing cost. This machine is very commonly used for industrial drives since it is cheap, robust, efficient and reliable. It also requires little maintenance and it has a reasonable overload capacity. In modern plants, many numbers of electric motors work together in manufacturing process. An unscheduled shut down occurs if only one of these motor fails. So, that is why any motor should be fault free otherwise total shut down of the complete process may occur.

Failures of motor can be classified in a number of ways. The majority of the motor troubles are categorized into four groups. These are: (a) unbalanced voltage effects (b) single phasing effects (c) overloading effects (d) environmental and maintenance effects.

A lot of research is going on motor fault diagnosis for long ago. Different fundamental concept for this purpose has been highlighted in this regard [1]. Euler-Lagrange's approach is a strong mathematical base on which different linear and non linear system can be characterized. This approach has been used [2] for modelling and monitoring motor health condition and different operating condition has been assessed [3-6] at normal and abnormal condition. For this purpose different electrical quantities have been defined under sinusoidal, non sinusoidal, balanced or unbalanced conditions [7]. In some approaches, non electrical parameters like air gap flux, vibration, eccentricity, etc have also been considered. For fault analysis, use of stator current is widely accepted and different methods using Motor Current Signature Analysis (MCSA) for diagnosis [8-11]. Wavelet decomposition, PSD, Fuzzy based logic systems have been introduced for motor fault diagnosis. [12-14]. Pattern recognition and Concordia assessment are done with MCSA [15-16]. Some fault diagnosis techniques have been done in Park domain [17-19]. Different features of motor current have been extracted at fault condition [20-22]. Some assessment have been done both in Clarke and Park domains [23-26] using stator current Concordia. Kurtosis and Skewness have been studied for fault detection [27].

In this paper, single phasing of an induction motor has been considered. At normal condition a three phase induction motor is fed by balanced three phase power supply. In most of the case a little bit generation of odd harmonics have been observed. The fault single phasing refers to loss of one of the three phases at the stator terminals. At this, condition negative sequence component generates along with positive sequence components and the resultant stator current rises. The negative sequence components have been assessed in [21]. The stator current at single phasing has also been assessed using feature pattern extraction method [21]. In this paper, the stator current drawn by the induction motor from power supply has been analyzed by harmonic assessment using wavelet decomposition.

II. Computer Modeling

The analysis has been done by computer simulation using MATLAB. A three phase induction motor of 3 HP, 220 V, 1725 rpm has been modeled. Three phase balanced power is fed to the motor as shown in fig. 1. Different measuring units are connected to monitor the stator current A switching unit is connected in phase C. The motor is first run at normal condition and then single phase is implemented at phase C using the switching unit.

III. Stator Current Analysis

In single phasing condition current through phase C becomes zero but currents through other healthy phase A and B increases. Healthy phase currents are captured and then assessed using Discrete Wavelet Transform (dwt). In this work, wavelet as 'db4' has been used. Healthy phase currents are decomposed at different dwt levels and at each level, the peak value and symmetry of harmonics spectrum are assessed by measuring kurtosis, skewness, rms and mean values. The wavelet decomposition based result obtained corresponding to healthy phase A is shown graphically in fig. 2, 3, 4 and 5. Dashed line corresponds to single phasing condition and solid continuous line corresponds to normal condition for all the mentioned figs.

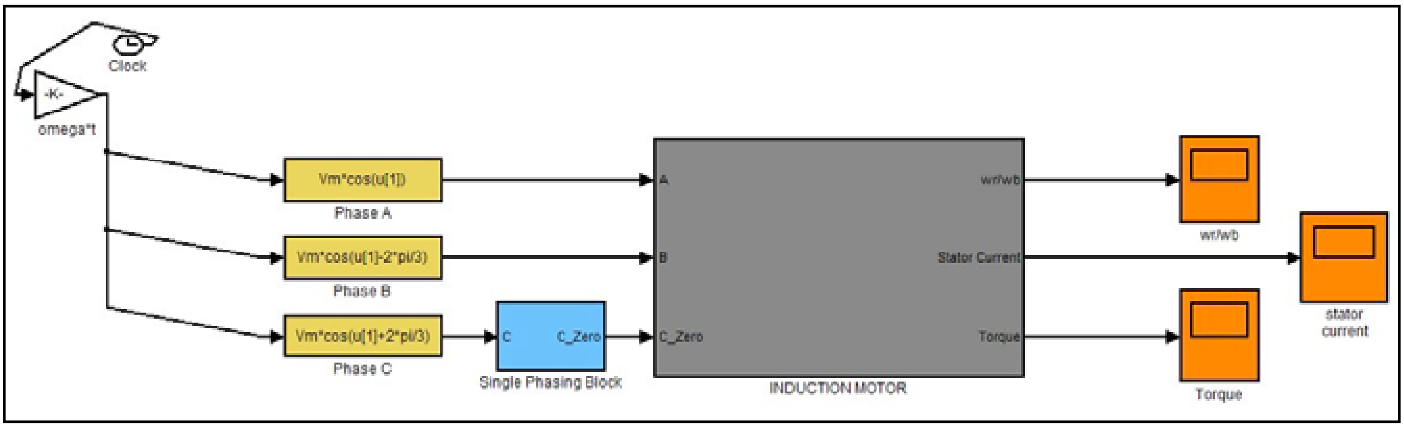

Fig. 1: Experimental Model for Assessment of Single Phasing of an Induction Motor

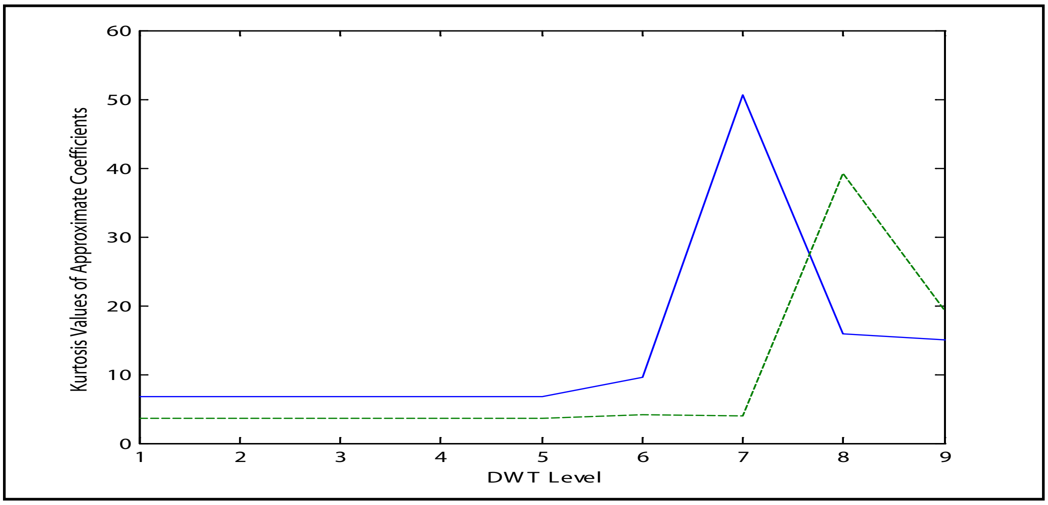

Fig. 2: Kurtosis Values of Approximate Coefficients for Phase A Current Plotted With Respect to dwt Decomposition Level

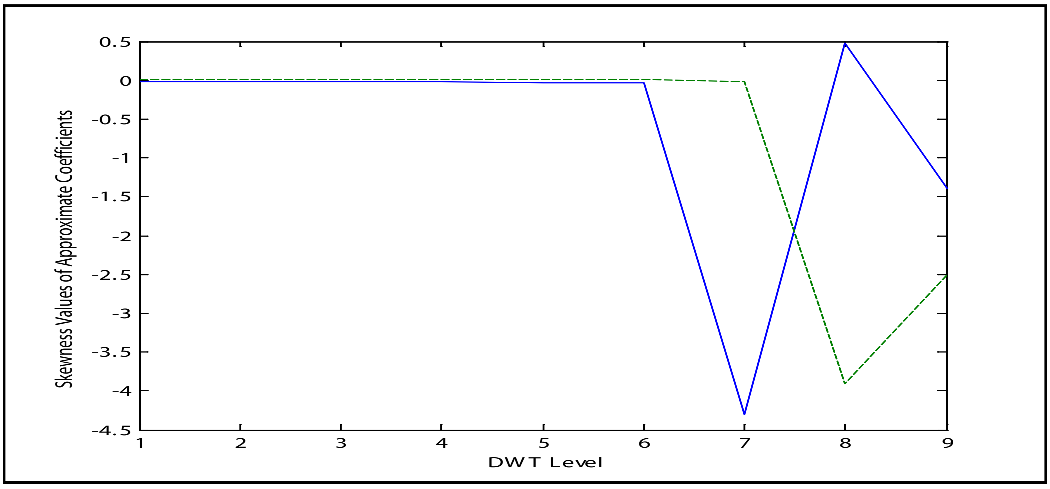

Fig. 3: Skewness Values of Approximate Coefficients for Phase A Current Plotted With Respect to dwt Decomposition Level

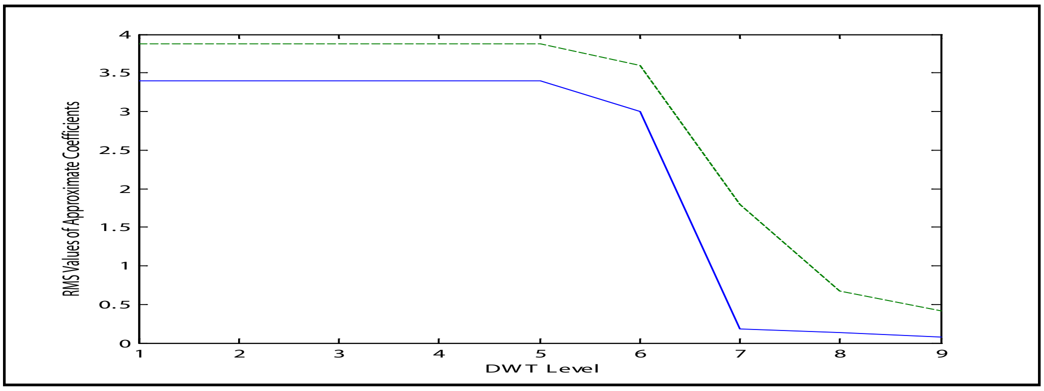

Fig. 4: RMS Values of Approximate Coefficients for Phase A Current Plotted With Respect to dwt Decomposition Level

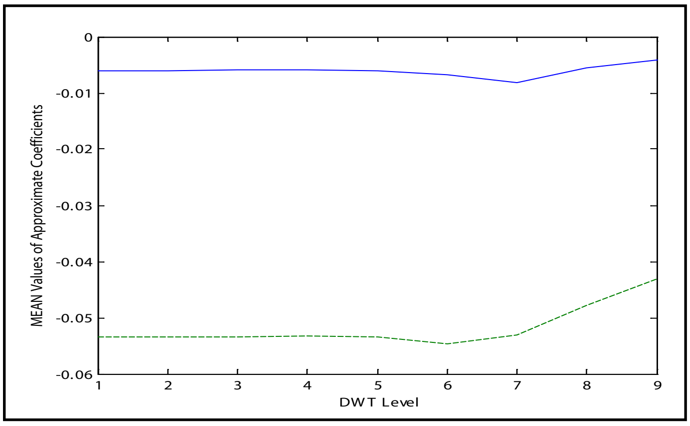

Fig. 5: Mean Values of Approximate Coefficients for Phase A Current Plotted With Respect to dwt Decomposition Level

IV. Observation

Kurtosis values of approximate coefficients for phase-A current have been plotted with respect to dwt decomposition level in fig. 2. In this fig. there is clear difference between two plots and difference between two plots is maximum in dwt decomposition level 7, which is clear indication of single phasing condition. Fig. 3, depicts the skewness values of approximate coefficients for phase-A current in normal and faulty conditions. From fig. 3, it is clear that in faulty condition or single phasing condition the magnitude of skewness value is increased with respect to normal condition from dwt decomposition level 5 and the difference is highest in level 7 between the two plots, which may be the clear indication of single phasing. Fig. 4, is used to show the differences of RMS values of approximate coefficients for phase-A current in two conditions. There is a clear difference between the two plots and difference is maximum in dwt decomposition level 7, though the differences between the two plots is constant up to level 5 in fig. 4. Fig. 5, depicts the plot of mean values of approximate coefficients for phase A current in two conditions. In this figure between the two plots it is clear there is always a clear and almost constant difference between these two plots, which can be used to identify the single phasing that or faulty condition for the above mentioned induction motor.

V. Conclusion

In this paper, Skewness, Kurtosis, RMS and Mean values of approximate coefficients of harmonic spectrums have been measured in normal and faulty condition to detect the single phasing condition of an induction motor. Though single phasing was occurred in phase C and dwt have been done for healthy phase A current and all the parameters have been calculated. The observation shows clear difference of those parameters at faulty condition from normal condition. This indicates that continuous measurement, monitoring and comparison can be done for diagnosis of fault like single phasing.

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