International Research Journal of Commerce and Law
Volume 5 Issue 04, April 2018 ISSN: 2349-705X Impact Factor: 4.616
Journal Homepage: http://ijmr.net.in, Email: irjmss@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal

Diagnosis of rotor and stator fault by fast Fourier transforms and discrete wavelet in induction machine.

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Abstract— the goal of this article is to describe two approaches for diagnosing and detecting stator and rotor faults in induction machines in the presence of a broken bar fault at the rotor level and a stator inter-turn short circuit, both of which are effective solutions for the diagnosis of defects. They are based on the signature analysis of the stator current performed by the fast Fourier transform (FFT) in the stationary regime and the analysis performed by the discrete wavelet transform (DWT) in the no stationary regime. Because of the energy stored in each decomposition level, which is obtained by wavelet analysis, it is possible to determine the situation of each fault and distinguish between the different types of faults. Both the healthy and defective states of the induction machine were used to conduct the fault signature analysis.

Keywords: Induction motor, diagnosis, fault, broken bar, inter-turns short circuit, spectral analysis, FFT, discrete wavelet transform

I. INTRODUCTION

Induction machines were created specifically for electric drives and play a major part in production. Early detection of ITSC problems can prevent serious faults that could result in the stator core being destroyed. Shorted turns can be rewound and machine failure avoided if they are found early enough before the insulation fails. Rewinding a motor is usually faster than replacing the machine. On-line motor condition monitoring records the machine's operational characteristics so that its present state can be determined. The monitored signal's changes and trends can be utilized to predict the need for maintenance before a failure or substantial deterioration occurs. As a result, on-line status monitoring approaches for electrical equipment, namely transformers, generators, and induction motors in power plants, are gaining popularity. Several approaches for diagnosing induction motor faults have been developed in recent decades. The Park's vector approach is one of the easiest approaches for predicting the motor state and detecting the presence of a malfunction by monitoring the deviation of the current Park's vector. The creation of optimal control techniques for induction motors has advanced significantly over the last three decades. When a malfunction occurs, however, established algorithms become inefficient and potentially hazardous to the environment, necessitating industrials to develop predictive maintenance of induction machines. Many proposed methodologies in the literature are based on spectrum analysis of stator currents, voltage, and electromagnetic torque.

These approaches rely on Fourier's analysis to detect spectrum lines at specific frequencies (FFT software). These solutions are adapted for fixed speed applications and are very straightforward to apply. Furthermore, because electrical signals are not stationary in industrial applications with direct power supply, these methods are not well suited. Continuous time identification has recently been employed in diagnosis procedures. The goal of these methods is to use parameter estimate software and real operating data to detect and localize defects in squirrel cage induction machines. Failure detection through parameter estimation tests and validations necessitate a fault Modelling model.

A novel model has recently been suggested that enables for the diagnosis of stator failures in induction machines operating at different speeds. With this extremely simple model, a single short circuit element can be used to describe the defect in one phase. On the other hand, it is ineffective when multiple stator phases have defects at the same time. As a result, in this study, we suggest a generalization of this model using a separate short circuit element for each phase. Each short-circuit element permits the identification and localization of inter turn short circuits in the appropriate phase in the presence of defects in many phases. The Output-Error technique was used to identify the parameters of this model, which was combined with suitable physical knowledge to perform parameter estimate for diagnosis purposes. To replicate actual inter turn short-circuit at multiple levels, a customized 1.1 KW squirrel cage induction motor was conceived and built. The experimental results show a high level of agreement, indicating that stator defects may be diagnosed.

The suggested system can detect four types of motor problems and analyse an induction motor's failure state. In this project, a new fault finding technique is used to diagnose and detect stator and rotor problems in induction machines in the presence of a broken bar fault at the rotor level and a stator inter-turn short circuit using two techniques, which is an effective solution for defect diagnosis. They are based on the fast Fourier transform (FFT) in regime stationary and the discrete wavelet transform analysis of the stator current signature (DWT).

II. .LITERATURE SURVEY

This research proposes an online induction motor diagnosis system that employs motor current signature analysis (MCSA) and custom signal-and-data-processing algorithms. MCSA is a stator-current signal-based approach for motor diagnosis. The suggested system detects four types of problems in induction motors: rotor bar and end ring breaking, stator winding short-circuits, bearing cracks, and air-gap eccentricity. Although MCSA is one of the most powerful online methods for diagnosing motor defects, it has significant flaws that diminish a motor-diagnosis system's performance and accuracy. As a result, advanced signal-processing and data-processing techniques are proposed. For achieving MCSA efficiently, they are made up of an optimal-slip-estimation method, a proper-sample-selection strategy, and a frequency auto search algorithm. The suggested system can detect four types of motor problems and analyse an induction motor's failure state.

The main goal of this research is to describe a discrete wavelet transform (DWT) that may be used to identify stator inter-turn defects in three induction motors. This method is based on the examination of stator current in both normal and abnormal situations. It was feasible to resolve the problem of confusion between the sorts of defects above the short-circuit defect by using the energy stored in each decomposition generated by wavelet analysis.

The discrete wavelet transform is used to diagnose faults in induction machines in this paper. The wavelet decomposition can be used to derive information about a system's health from a signal over a wide range of frequencies. This investigation is carried out in both the temporal and frequency domains. For the stator current analysis, the Daubechies wavelet is chosen. Wavelet components tend to be effective in identifying a variety of electrical issues. We shall look at the issue of damaged rotor bars, end-ring segment, and stator phase loss during operation in this paper.

III. PROPOSED METHODOLOGY

The neural network is then fed the down sampled values, and the detailed and approximation coefficients are calculated. When the samples are allowed to pass through the high pass and low pass filters, detailed coefficients and approximation coefficients are obtained, as illustrated in Fig 1.

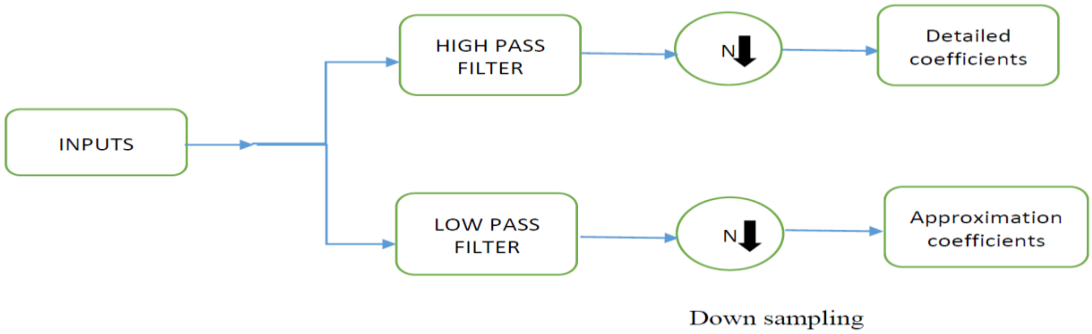

Fig 1: Block diagram of discrete wavelet transforms (DWT)

A fast Fourier transform (FFT) is an algorithm that computes the discrete Fourier transform (DFT) of a sequence, or its inverse (IDFT). Fourier analysis converts a signal from its original domain (often time or space) to a representation in the frequency domain and vice versa.

The DFT is obtained by decomposing a sequence of values into components of different frequencies. This operation is useful in many fields, but computing it directly from the definition is often too slow to be practical. An FFT rapidly computes such transformations.

IV. MATHEMATICAL MODELLING

Fig 1, Where N=2 which specify the down sampling of the coefficients, Block diagram of discrete wavelet transform (DWT) As in the pyramid algorithm proposed by Mallat , the DWT coefficients at an arbitrary level j can be computed from the DWT coefficients of its previous level j+1, which is expressed as follows :

$$cj\ (k) = \Sigma\ ho\ (m-2k)\ cj+1(m) \quad (1)$$

$$dj\ (k) = \Sigma\ h1\ (m-2k)\ cj+1(m) \quad (2)$$

Where cj and dj are the scaling coefficient and the wavelet coefficient of level j respectively, whereas ho (n) and h1 (n) are the dilation coefficients corresponding to the scaling and wavelet functions respectively. The dilation coefficients ho (n) and h1 (n) are also the coefficients of a low pass and a high pass filter respectively. As a result, the scaling and wavelet coefficients at level j are obtained by filtering the scaling coefficients at level j+1 using an analysis quadrature mirror filter bank (QMF). Scaling coefficients at level j+1 is obtained by combining the scaling and wavelet coefficients at level j:

$$c_{j+1}(k) = \Sigma\, c_j (m)\, h_0' (k-2m) + \Sigma\, d_j (m)\, h_1' (k-2m) \quad (3)$$

Each level of the 2-D DWT operation requires two stages of 1-D DWT operations. First, 1-D DWT is performed on the row data, producing high pass and low pass outputs. A second stage 1-D DWT is executed on the columns of the high pass and low passes outputs of the first stage to obtain four sub-images. Further decomposition can be made on the sub-image in a similar way. In this way, an image is decomposed into a set of sub-images with various resolutions corresponding to the different scales.

V. SIMULATION RESULTS

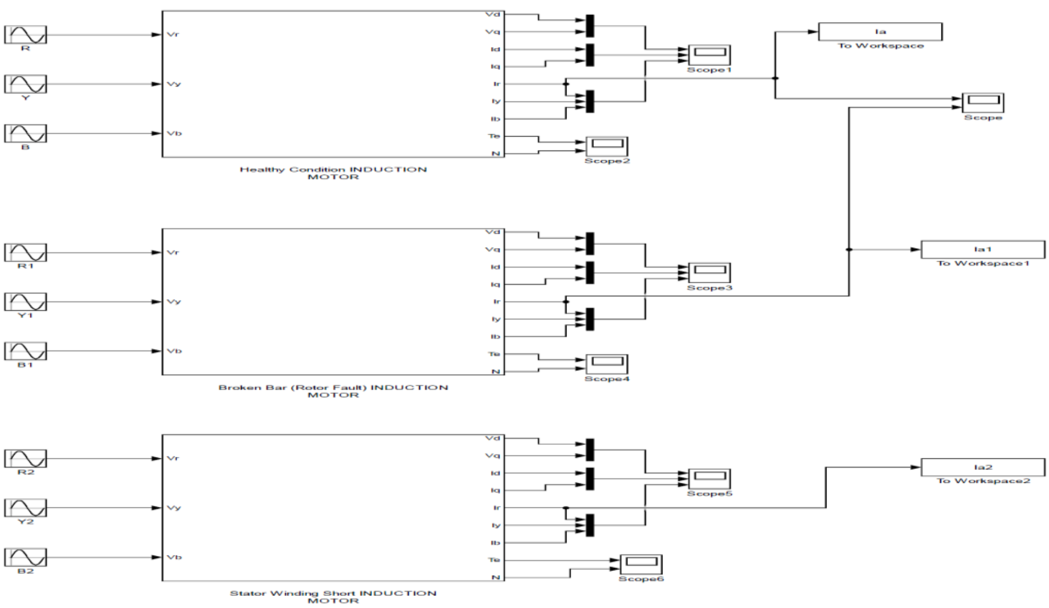

Fig 2: MATLAB/ Simulation model of the proposed fault diagnosis method of

Induction machine.

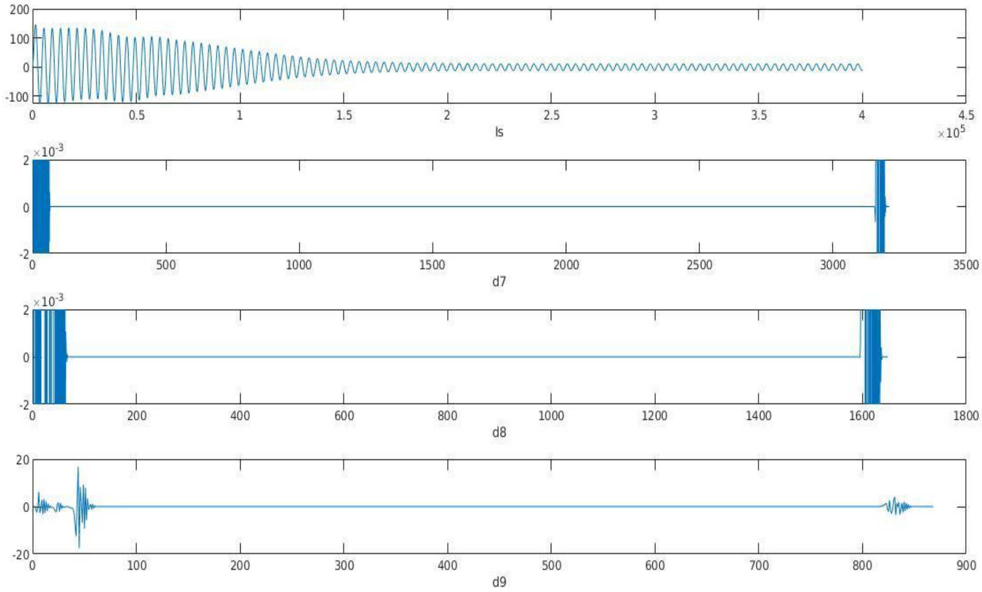

Fig 3: Estimated Healthy Currents of Induction machines.

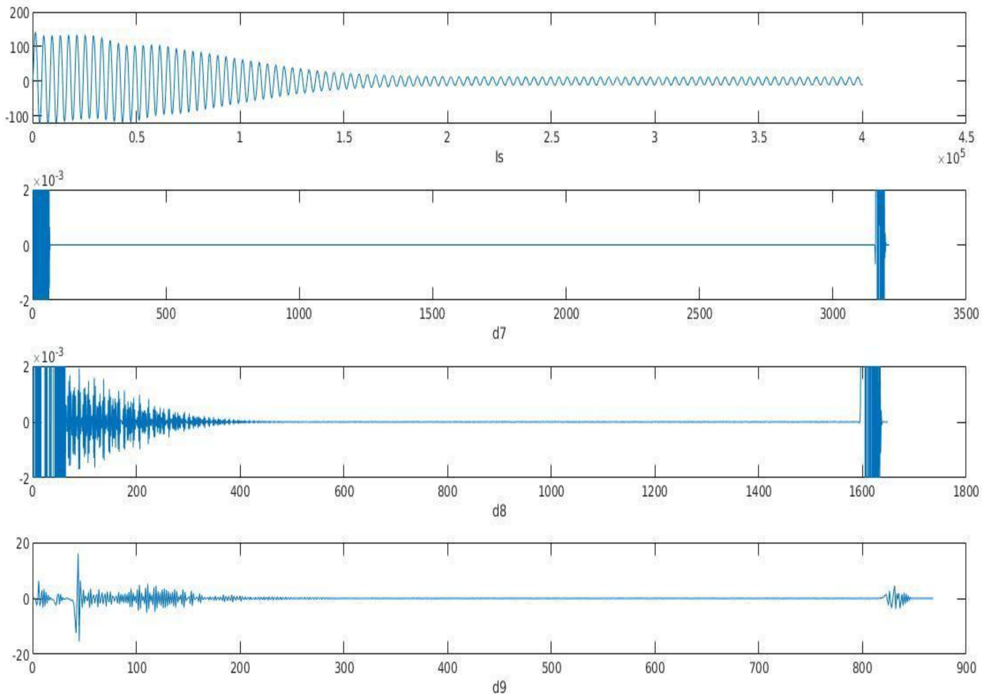

Fig 4: Estimated rotor broken bar fault current of induction machines

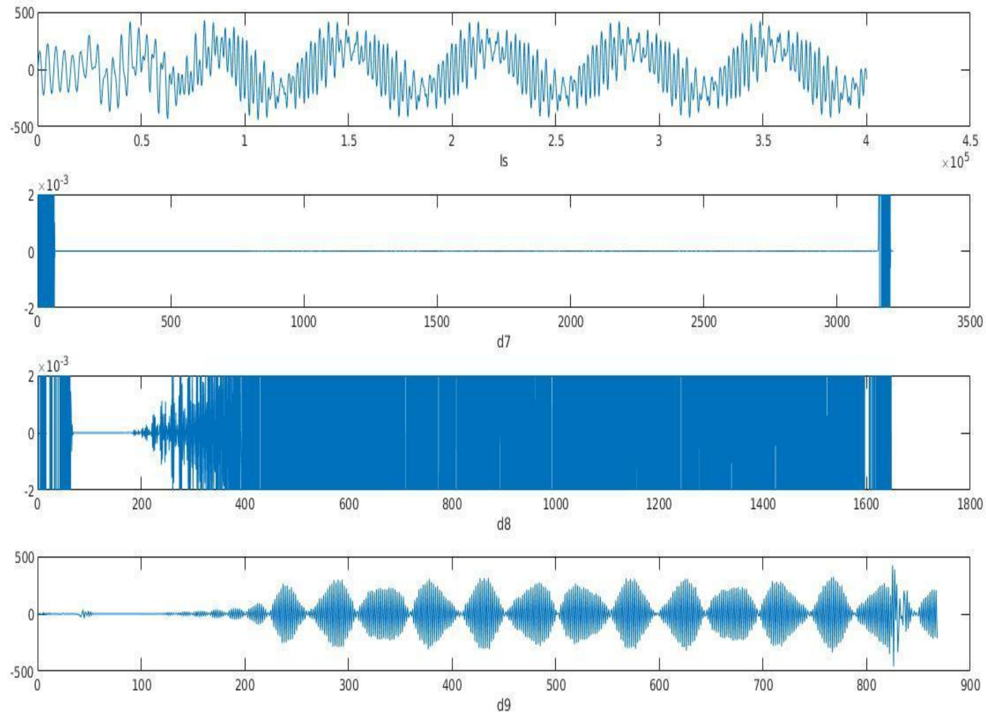

Fig 5: Estimated stator winding short circuit fault current of induction machines.

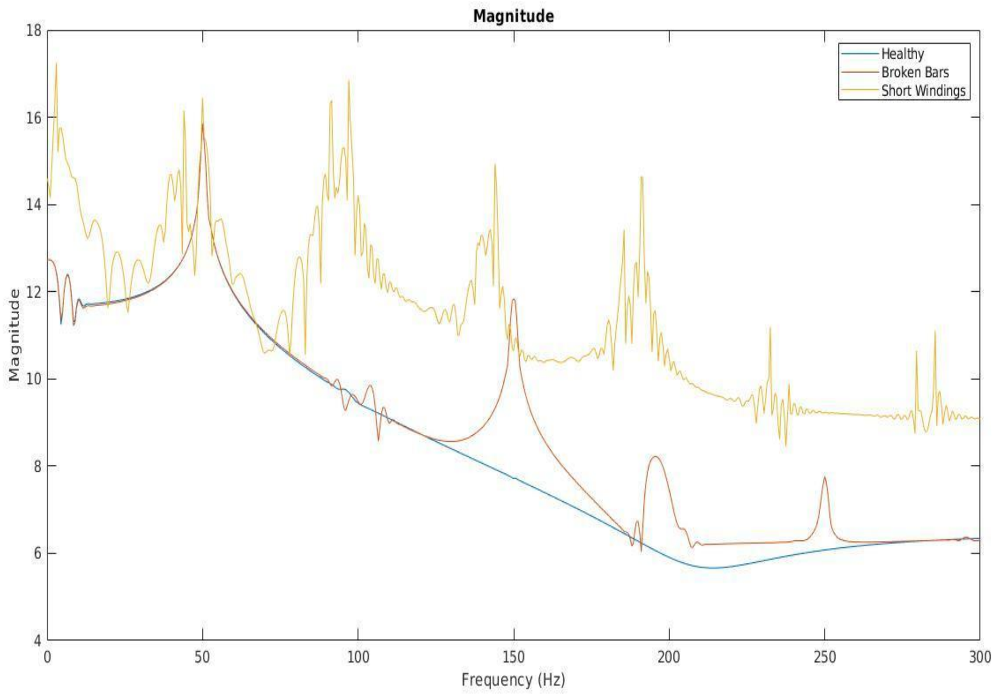

Fig 6: Estimated healthy condition, rotor broken bar fault current & stator winding short circuit fault current of induction machines.

VI. CONCLUSION

We may say the following things after examining all of the chapters addressed in the report and comparing the simulation results: A new approach of fault diagnosis and control for induction motors was presented in this paper. This method can identify, localize, and control healthy fault currents, even if the faults occurred in a sequential order. The rotor broken bar fault diagnosis is based on the dq factor; in this circumstance, we have one broken bar in one phase and no problem in the other two phases. However, if four broken bars are separated into three phases or single phases, each of which takes a-phase current, b-phase current, and c-phase current as inputs, the output current will fluctuate accordingly. The dq factor is capable of on-line monitoring the state of current in the stator winding inter turn short fault. When the signal decomposes in the A50 condition, the output current increases, and d7 shows little changes, while d8 and d9 show a big amplitude peak in the output side. The proposed approach is appropriate for induction motor safety-critical applications because it keeps the system functioning even when catastrophic failures occur.

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