

A Review on Wireless Sensor System of Fault Detection of Motor Arrays

Neelam Soni¹, Vinay Jain²

^{1,2}Dept. of Electronics and Telecommunication, SSGI, Durg, C.G., India

Abstract:- Fault detection and isolation are important to improve the safety and reliability of practical control systems. Induction motor especially three phase induction motor plays vital role in the industry due to their advantages over other electrical motors. Therefore, there is a strong demand for their reliable and safe operation. If any fault and failures occur in the motor it can lead to excessive downtimes and generate great losses in terms of revenue and maintenance. Therefore, an early fault detection is needed for the protection of the motor. In the current scenario, the health monitoring of the induction motor are increasing due to its potential to reduce operating costs, enhance the reliability of operation and improve service to the customers. The health monitoring of induction motor is an emerging technology for online detection of incipient faults. The on-line health monitoring involves taking measurements on a machine while it is in operating conditions in order to detect faults with the aim of reducing both unexpected failure and maintenance costs. In the present paper, a comprehensive survey of induction machine faults, diagnostic methods and future aspects in the health monitoring of induction motor has been discussed.

Keywords- Fault detection, Wireless sensor system, Motor arrays, Induction motors

Literature Survey

Sunisa Sornmuang and Jittiwut Suwatthikul (2011) Condition maintenance (CBM) has attracted more attention and interest due to its advantages over the conventional breakdown-based or time-based maintenance. CBM of electrical machines such as motors is based on using data obtained by real-time condition monitoring, and fault detection and diagnosis to recommend an optimized maintenance. This paper presents an application of an Artificial Neural Network (ANN) for detecting a very small fault in a bearing shield of an induction motor. The experimental results show that the incipient fault can be efficiently detected. An alarm may be activated so that corrective actions are promptly taken before the detected fault manifests itself to be further serious failures. The paper has presented an application of artificial neural networks to bearing fault detection. A feed forward network was implemented to detect a very small fault in a bearing shield. The network was trained with real vibration data collected from a test bench. The results show that the incipient fault can be efficiently detected by the implemented network. Future work will focus on multiple faults and testing robustness of the system.

BEN HAMED Mouna et al. (2014) in this paper, fault detection and isolation of a DC motor is discussed. Dynamic space parity approach is used to detect faults. Based on structural residual method, the theoretical symptoms matrix is established. The later is compared to an experimental one to isolate the faults. The validity and usefulness of the fault detection and isolation algorithms are thoroughly verified with experiments on 1kw DC motor using a dSpace system with DS1104 controller board based on digital signal processor (DSP) TMS320F240. An approach based on dynamic space parity for fault detection and isolation is presented in this paper. The validity of the fault detection and isolation algorithms are verified with experiments on 1kw DC motor using a dSpace system with DS1104 controller based on DSP TMS 320F240. From these tests, it is shown that the used algorithms have successfully detected and isolated actuator and sensor faults. All high performances of the used method depend on the performance of the used model. Generally, this model is established using mathematical equations and some hypotheses leading to modeling errors when these hypotheses aren't satisfactory. To improve the performances of the used algorithms, a robust model is to be used. This will be the subject of author's future work.

Shubhasish Sarkar et al. (2013) Induction motor plays a key role in ensuring functional execution and smooth progression of modern industries. But due to several harsh operational environments, different types of faults, in the form of stator winding fault, rotor fault etc. develop in the motor. If these faults, which are mostly minor in nature initially, don't get detected in earlier stages then they may inflict major damage in the motor and consequently may disrupt the plant's production capacity. So far, several studies primarily focusing on signature, model and expert system based techniques have been performed for conditioning monitoring of induction motors. Among all these techniques MCSA (Motor Current Signature Analysis) technique has been identified to be the most effective tool for diagnosis of induction motor faults. Most of the traditional condition and monitoring methods, using MCSA, that have been used till date are offline. Such offline analysis leads to delayed fault detection, resulting in plant production being eventually hampered, thus indirectly increasing the production cost. That is why, modern day industries demand online fault diagnosis methods which would analyze faults in real time and prevent any unforeseen

production mishaps. FPGA or DSP where the signal is processed in hardware unit can be used for online analysis. This paper deals with 3-phase induction motor stator current acquisition using LABVIEW, FPGA embedded with NI cRIO-9075 real time controller and NI-9227 analog current input module looking towards online fault diagnosis.

ADOUNI Amel et al. (2012) This paper deals with a fault detection and isolation (FDI) of a DC motor described by linear dynamic models. Dynamic space parity approach is used to detect sensor and actuator faults. This approach is based on obtaining an input-output description of a given system and transforming it into the parity equations. Therefore, the theoretical symptoms matrix is established. The later is compared to an experimental one to isolate the faults. The validity and usefulness of the fault detection and isolation algorithms are thoroughly verified with experiments on 1kw DC motor using a dSpace system with DS1104 controller board based on digital signal processor (DSP) TMS320F240. An approach based on dynamic space parity for fault detection and isolation is discussed in this paper. The validity of the fault detection algorithms is verified with experiments on 1kw DC motor using a dSpace system with DS1104 controller based on DSP TMS 320F240. From these tests, it is shown that the used algorithms have successfully detected. All high performances of the used method depend on the performance of the used model. This work has successfully detected the different type of fault but it need to continue in order to isolate them for that reason we suggest to ameliorate it as a result to identify the element affected by fault to improve the performances of the used algorithms, a robust model is to be used. This will be the subject of author's future work.

Rajesh Patel et al. (2006). This paper assesses the effectiveness and reliability of monitoring techniques for real-time fault detection in bearings of induction motor. The bearing failure modes and the characteristic bearing frequencies associated with the physical construction of the bearings are examined. Experimental results of vibration spectra with different faults are included, for a 7.5kW Cage Induction Motor, to demonstrate the effectiveness of the proposed scheme. Several ball bearings with known faults have been used in the experimental work.

Sunisa Sornmuang and Jittiwut Suwattikul (2011) Condition-based maintenance (CBM) has attracted more attention and interest due to its advantages over the conventional breakdown-based or time-based maintenance. CBM of electrical machines such as motors is based on using data obtained by real-time condition monitoring, and fault detection and diagnosis to recommend an optimized maintenance. This paper presents an application of an Artificial Neural Network (ANN) for detecting a very small fault in a bearing shield of an induction motor. The experimental results show that the incipient fault can be efficiently detected. An alarm may be activated so that corrective actions are promptly taken before the detected fault manifests itself to be further serious failures. The paper has presented an application of artificial neural networks to bearing fault detection. A feed forward network was implemented to detect a very small fault in a bearing shield. The network was trained with real vibration data collected from a test bench. The results show that the incipient fault can be efficiently detected by the implemented network. Future work will focus on multiple faults and testing robustness of the system.

Sourov Roy et al. (2017) A healthy PV array has a specific impedance between node pairs, and any ground fault changes the impedance values. Reflectometry is a well-known technique in electromagnetics, and it could be exploited to detect fault and aging related impedance variations in a PV system. A fault detection algorithm using the spread spectrum time domain reflectometry (SSTDR) method has been introduced in this paper. SSTDR has been successfully used for detecting and locating aircraft wiring faults. However, the wide variation in impedance throughout the entire PV system, which is caused by the use of different materials and interconnections makes PV fault detection more challenging while using reflectometry. Unlike other conventional ground fault detection techniques specifically developed for PV arrays, SSTDR does not depend on fault-current magnitudes. Therefore, SSTDR can be used even in the absence of the solar irradiation, which makes it a very powerful fault detection tool. The proposed PV ground fault detection technique has been tested in a real-world PV system, and it can confidently detect PV ground faults for different configurations of PV arrays (single and double strings) and fault resistances (0.5, 5, and 10 Ω). Moreover, it has been experimentally verified that our proposed algorithm works at low irradiance and can detect specific ground faults that may remain undetected using conventional ground fault detection and interrupter (GFDI) fuses.

Roy McCann (2013) This paper develops a new feedback control method for fault detection and real-time compensation of unbalanced three-phase motor drive systems. This method is based on an extension time-domain symmetrical component theory where a new transformation is used to express the sequence components in state-space form. This transformation relies upon P decomposition of the instantaneous sequence components (DISC transformation). Unlike previous analysis techniques, this method models the dynamics of positive and negative sequence components for systems with arbitrary resistance, inductance, and capacitance in a systematic manner. Dynamic models derived using the DISC transformation are well suited for real-time compensation and fault detection in three-phase motor drives. This paper develops the theory of the DISC transformation and gives an application to the optimal compensation of B permanent

magnet synchronous motor drive with a resistance imbalance. Experimental measurements from a laboratory inverter are provided to confirm the theoretical development.

Jorge O. Estima et al. (2013) Three-phase inverters are currently utilized in an enormous variety of industrial applications, including variable speed ac drives. However, due to their complexity and exposure to several stresses, they are prone to suffer critical failures. Accordingly, this paper presents a novel diagnostic algorithm that allows the real-time detection and localization of multiple power switch open-circuit faults in inverter-fed ac motor drives. The proposed method is quite simple and just requires the measured motor phase currents and their corresponding reference signals, already available from the main control system, therefore avoiding the use of additional sensors and hardware. Several experimental results using a vector-controlled permanent-magnet synchronous motor drive are presented, showing the diagnostic algorithm effectiveness, its relatively fast detection time, and its robustness against false alarms.

Bilal YOUSSEF (2007) In this paper, a recently developed graphical signatures generation tool is used for system faults detection of induction motors (IM). The underlying diagnosis problem corresponds to variations affecting four of system's parameters, namely, the resistances and inductances for both stator and rotor. It is shown that this diagnosis method enables early detection of all considered faults using one graphical signature generated from the measurements of the stator current. The proposed detection procedure can be easily applied in a real time diagnosis context.

Ilhan Aydin et al. (2016) -Induction motors are the most utilized motor types of industrial applications. They are robust and have a simple structure. However, they can be exposed to some faults because of hostile environments. Many methods have been proposed for detection of faults at line-feed induction motors. However, fault diagnosis methods for inverter-fed induction motors are quite limited. In this study, a new fault detection method is proposed to detect stator related faults for inverter-fed induction motors. The proposed method takes three-phase current signals and applies the park's vector transform. The principal component analysis is applied to two park's vector components. The features obtained by applying principal component analysis are given to fuzzy logic and the severity of stator related-fault is determined. The proposed algorithm is implemented on a STM32F746 microprocessor and good results have been obtained.

Bilal Akin et al. (2010) In this study, apart from the conventional applications, it is reported that the reference frame theory approach can successfully be applied to real-time fault diagnosis of electric machinery systems as a powerful toolbox to find the magnitude and phase quantities of fault signatures with good precision as well. The basic idea is to convert the associated fault signature to a dc quantity, followed by the computation of the signal's average in the fault reference frame to filter out the rest of the signal harmonics, i.e., its ac components. As a natural consequence of this, neither a notch filter nor a low-pass filter is required to eliminate fundamental component or noise content. Since the incipient fault mechanisms have been studied for a long time, the motor fault signature frequencies and fault models are very well-known. Therefore, ignoring all other components, the proposed method focuses only on certain fault signatures in the current spectrum depending on the examined motor fault. Broken rotor bar and eccentricity faults are experimentally tested online using a TMS320F2812 digital signal processor (DSP) to prove the effectiveness of the proposed method. In this application, only the readily available drive hardware is used without employing additional components such as analog filters, signal conditioning board, external sensors, etc. As the motor drive processing unit, the DSP is utilized both for motor control and fault detection purposes, providing instantaneous fault information. The proposed algorithm processes the measured data in real time to avoid buffering and large-size memory needed in order to enhance the practicability of this method. Due to the short-time convergence capability of the algorithm, the fault status is updated in each second. The immunity of the algorithm against non-ideal cases such as measurement offset errors and phase unbalance is theoretically and experimentally verified. Being a model-independent fault analyzer, this method can be applied to all multiphase and single-phase motors.

Turker Ince et al. (2016) —Early detection of the motor faults is essential and Artificial Neural Networks (ANNs) are widely used for this purpose. The typical systems usually encapsulate two distinct blocks: feature extraction and classification. Such fixed and hand-crafted features may be a sub-optimal choice and require a significant computational cost that will prevent their usage for realtime applications. In this paper, we propose a fast and accurate motor condition monitoring and early fault detection system using 1D Convolutional Neural Networks (CNNs) that has an inherent adaptive design to fuse the feature extraction and classification phases of the motor fault detection into a single learning body. The proposed approach is directly applicable to the raw data (signal) and thus eliminates the need for a separate feature extraction algorithm resulting in more efficient systems in terms of both speed and hardware. Experimental results obtained using real motor data demonstrate the effectiveness of the proposed method for real-time motor condition monitoring.

Lei Zhang and Pang Li (2017) A fault tolerant position estimation for Switched Reluctance Motor (SRM) is proposed in the paper based on relationship between inductance and rotor position. First, the particular position signal is obtained by comparing the real-time flux linkage with the particular position flux linkage, the position is estimated by the particular position signal. Second, the delay method is used based on inter-phase independence under the phase fault, the fault phase position is estimated by the normal phase the particular position signal. Finally, the experimental have been implemented in a 12/8 structure SRM prototype. The results show that the proposed methods are verified the correctness and feasibility.

Fernando Alvarez-Gonzalez et al. (2016) —Hardware-in-the-loop (HIL) testing methods can facilitate the development of control strategies in a safe and inexpensive environment particularly when extreme operating conditions such as faults are considered. HIL methods rely on accurate real-time emulation of the equipment under investigation. However, no validated tools for real-time emulation of electrical drives under fault conditions are available. This paper describes the implementation of a high-fidelity real-time emulator of a Permanent Magnet Synchronous Motor (PMSM) drive in a platform suitable for HIL tests. The emulator is capable of representing the drive operation under both healthy conditions and during inter-turn stator winding faults. Nonlinearities due to saturation, higher order harmonics, slotting effects, etc. are accounted for using four-dimensional look-up tables obtained by finite element analysis (FEA). The proposed model is computationally efficient and capable of running in realtime in a FPGA platform and is validated against simulations and experimental results in a wide range of operating conditions. Potential applications of the proposed emulation environment to the development of drive control, fault detection and diagnostic algorithms are proposed.

Conclusion

This paper presents a wireless sensor network for early detection and monitoring of motor system failures. The system has been designed to merge various parameter measurements in real-time, improving the detectability of faults. The monitoring of the motor system involves the measurement of several quantities, namely vibrations, temperature and current consumption.

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