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ARM BASED REAL-TIME INDUCTION FAULT ANALYSIS

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ABSTRACT

Condition monitoring of induction motor have been a challenging task for the engineers and researchers mainly in industries. There are many condition monitoring methods, including vibration monitoring, thermal monitoring, chemical monitoring, acoustic emission monitoring . Current monitoring techniques are usually applied to detect the various types of induction motor faults such as rotor fault, short winding fault, air gap eccentricity fault, bearing fault, load fault etc.

In proposed system a new electrical protection system is introduced which is design by using embedded system. It is leading to significant reduction of cost and it is also fast. This continuously monitors the condition and in real time takes action for motor safety. This most effective and efficient system which can saves motor from damages.

Keywords: *ADXL accelerometer, ARM7 LPC2138, Induction motor, Real-time embedded system*

I. INTRODUCTION

Electromechanical energy conversion systems (motors and generators) are effectively employed for various industrial applications including renewable energy conversions, electric drive systems, mining, aircraft, and petroleum products, etc. The induction motors dominate other electro-mechanical rotating machines with respect to rotor inertia, maximum efficiency, highest speed capability, size, volume and cost [1]. Induction motors (IM) are the most popular drive systems, because of simple construction, low price, high reliability and easy maintenance. They are produced in a wide range of power. Despite high durability, they are not immune to breakdowns. The most frequent motor failures are: – stator faults (inter-turn short-circuits, broken winding), – rotor faults (broken rotor bars, broken rings) – bearing faults. The main causes of the failure genesis are:

– Long-lasting motor operation in the overload conditions

– Unbalanced voltage supply

– Insulation damage

– Mechanical load misalignment

– Improper utilization and wrong service

The on-line monitoring of induction motor condition is a very important issue in the industry [1]-[3]. Early detection of abnormal operating conditions of the motor prevents serious breakdown of the whole drive system. The evaluation of the technical condition of induction motors during their normal operation can be done using different measurement devices for on-line monitoring of basic electrical or mechanical signals. Unfortunately, the diagnostic equipment usually includes different special-purpose sensors and thus is very expensive. From the economical point of view, the application of such equipment is reasonable in high power drives [3]. On the other hand, low and medium power induction motors are mostly applied in industrial drives and play a crucial role in many industrial processes. For this reason the investigation of low-cost diagnostic solution is very important, because such inexpensive equipment can make the introduction of diagnostics in low and medium-power drives possible.

Condition monitoring and fault diagnostics are usually implemented by investigating the corresponding anomalies in machine current, voltage and leakage flux. Other methods [4-5] including monitoring the core temperature, bearing vibration level and pyrolyzed products, have been reported to diagnose fault conditions such as insulation defects [6], partial discharge [7] and lubrication oil and bearing degradation.

In our proposed we develop system for real time monitoring induction motor system using embedded based board. This system not only monitors real time faults but also switch off the motor on faults condition.

II. SYSTEM DESIGN

Figure shown below is the block diagram of our proposed system for induction motor fault detection it consists of microcontroller which is heart of our system, motor driver, induction motor, temperature sensor, current sensor and vibration sensor.

Vibration sensor measures vibration of induction motor periodically. If there is overload of vibration occurs then it is indicated by controller or corrective action taken by controller. Similarly readings are taken by temperature sensor as well as ADXL, during faulty condition microcontroller gives indication to the user or takes corrective action.

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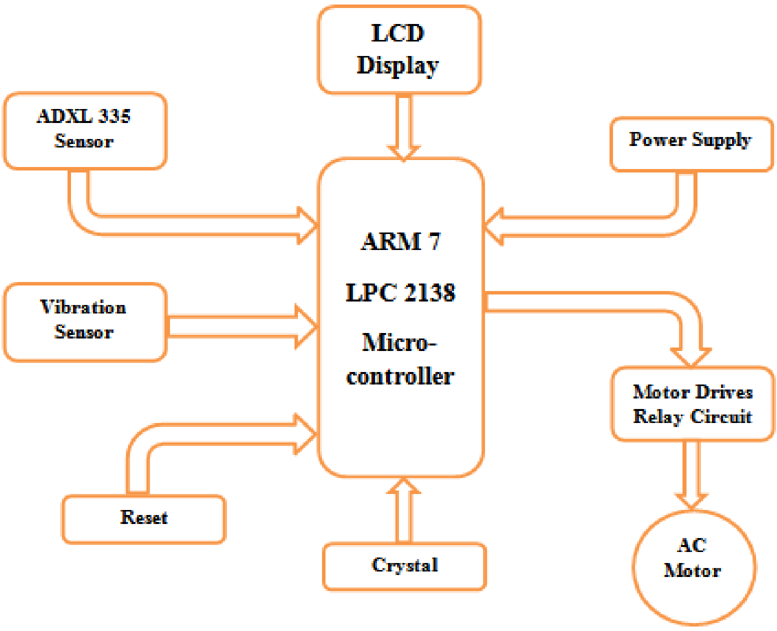

Fig.1 System block diagram

1. Hardware Tools:

1.1 ARM7 Features -

- 32-bit ARM7TDMI-S microcontroller in a tiny LQFP64 package.
- 8 KB to 40 KB of on-chip static RAM and 32 KB to 512 KB of on-chip flash memory.
- 128-bit wide interface/accelerator enables high-speed 60 MHz operation.
- In-System Programming/In-Application Programming (ISP/IAP) via on-chip boot.
- USB 2.0 Full-speed compliant device controller with 2 KB of endpoint RAM.
- In addition, the LPC2146/48 provides 8 KB of on-chip RAM accessible to USB by DMA.
- Single 10-bit DAC provides variable analog output (LPC2142/44/46/48 only).
- Two 32-bit timers/external event counters (with four capture and four compare channels each), PWM unit (six outputs) and watchdog.

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2. ADXL accelerometer:

Fig2. ADXL Sensor

The ADXL335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ±3 g. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration.

III. METHODOLOGY

The user selects the bandwidth of the accelerometer using the CX, CY, and CZ capacitors at the XOUT, YOUT, and ZOUT pins. Bandwidths can be selected to suit the application, with a range of 0.5 Hz to 1600 Hz for the X and Y axes, and a range of 0.5 Hz to 550 Hz for the Z axis.

Several sensing functions provided are -

- Activity and inactivity sensing detect the presence or lack of motion by comparing the acceleration on any axis.
- Tap sensing detects single and double taps in any direction.
- Free fall sensing detects if the device is falling.

These functions are individually mapped to either of output interrupt pins which are push pull low impedance pins. The default configuration of the interrupt pins is active high. This can be changed to active low by setting the INT_INVERT bit in the DATA _FORMAT register. The major advantage is all functions can be used simultaneously, with only limiting feature that some functions may need to share interrupt pins.

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Features of the Hardware Developed are –

- A 2-layer printed circuit board (PCB), 1.20 inches X 2.20 inches form factor.
- A full bridge rectifier is used for power supply
- A 4-pin UART header to connect to an RS-232 interface cable.
- Reset/Download push buttons.
- Power indicator/ General Purpose LEDs.

1. Vibration sensor :

Fig.3 Vibration Sensor

The main chip: LM393, vibrating probe and Operating Voltage DC 3-5V.

1.1 Main features:-

- Having a signal output instruction.
- With a TTL level Signal, and the analog output signal.
- The output valid signal is high, the light goes out.
- The sensitivity is adjustable (fine-tuning).
- Wide detection range of vibration, no direction.
- With mounting holes, firmware installation flexible and convenient.

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1.2 Applications: Anti-theft devices, Electronic locks, Mechanical equipments, Vibration detection, Detection range bull's-eye counts vibration testing occasions.

All electric motors generate noise and vibration, and analysis of produced noise and vibration can be used to give information on the condition of motor. Even very small amplitude of vibration of machine frame can produce high noise. Noise and vibrations in electric machines are caused by forces which are of magnetic, mechanical and aerodynamic origin. For stationary signal MCSA best but for non-stationary signal it's not convenient option for non-stationary signal vibration monitoring is generally used. Four vibration properties are crucial to understanding and resolving the machine problems.

These include Amplitude, which indicate the level of severity of the measured condition. Frequency, which indicates the repetition rate of the contributing source or sources of the measured condition; Phase, which presents the timing relationship between two signals contributing to the measured condition; Modulation, the process by which the response amplitude at some frequency is varied by a lower frequency excitation response. With the help of this we can get detail information about asymmetry in motor [4].

2. Experimental setup and procedure :

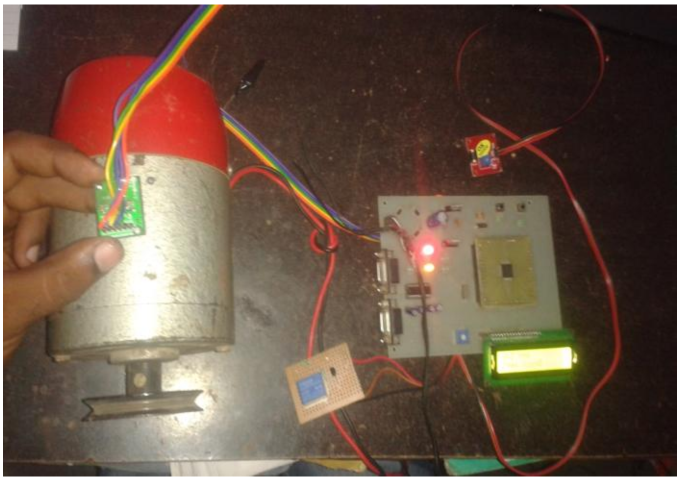

Fig.4 Experimental setup.

Accelerometer is used for taking reading of 2D x and y axis values. In our system we are monitoring the reading of sensor by serial protocol on PC.
From these reading we can minter the fault conditions by setting limit for each type of fault of induction motor.

2.1 Experimental procedure is as follows: -

- Insert power cable of ARM7 board into the holder.

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- Insert the UART cable USB slot.
- Push the on/off switch to the on position to power up the board. The green LED blinks to indicate that the board is logging data.
- TURN ON the induction motor.
- Monitor the reading using putty software.

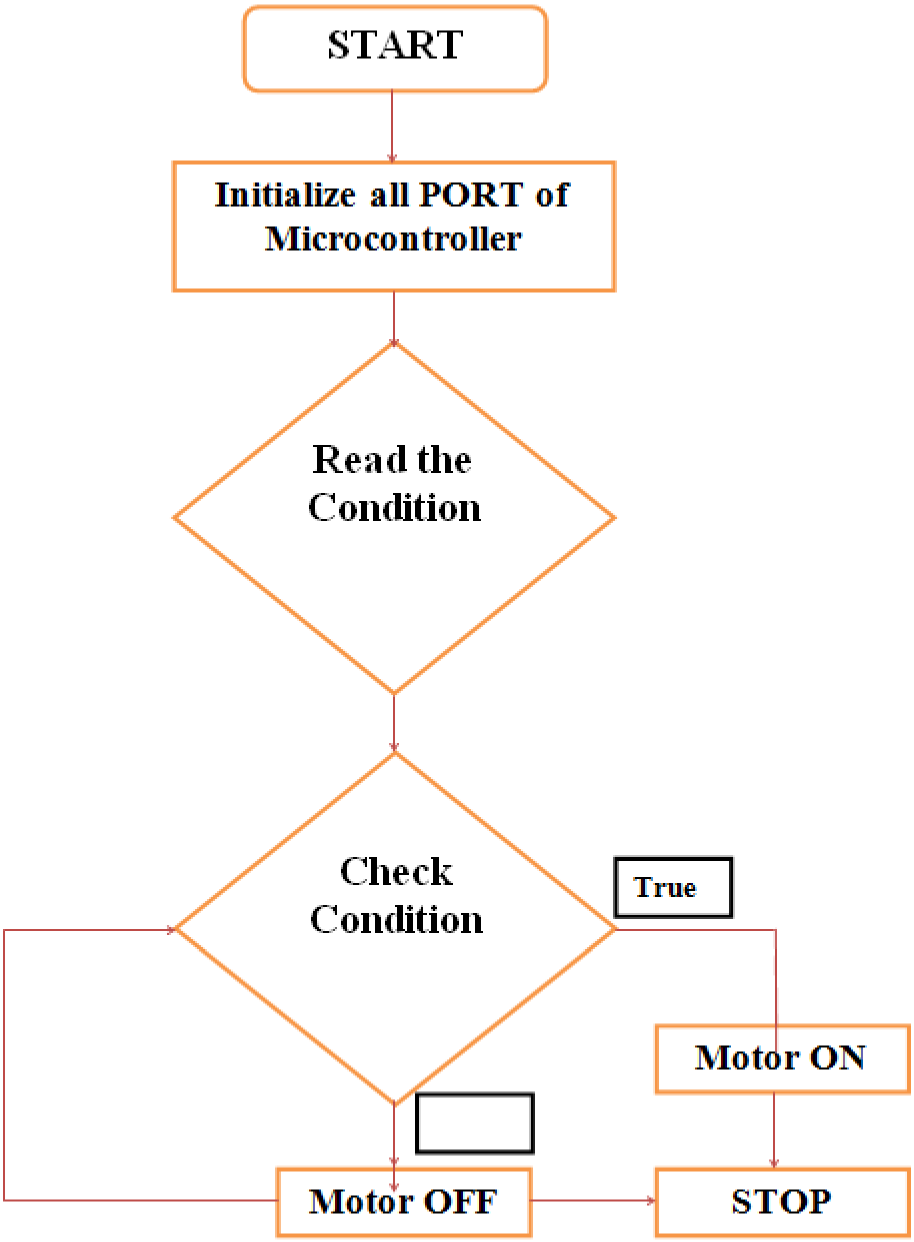

Fig.5 Data flow diagram of proposed system

2.2 Steps:-

- First we initialize the port pin so we can use them for our application.
- Then monitoring the parameter with respect to their threshold.
- If the parameter crosses the threshold it automatically Switch off motor safely.

These values are set according to the induction motor fault analysis i.e x and y axis faults and vibration analysis.

Table1. Rule for induction motor control

Channel X	Channel Y	Channel Z	Vibration M	Motor ON/OFF	Logic
X>=70	Y>=70	Z>=75	Vib>=50	Motor OFF	OR Logic
X<50	Y<50	Z<55	Vib<40	Motor ON	AND Logic

IV. RESULTS

The experimental results show the mechanical fault such as mechanical looseness and misalignment. Non rotating looseness causes the highest vibrations compared to other types of faults. The highest vibrations are in the direction where stiffness is the smallest, stiffness is usually least in horizontal direction. Loose bolts, rust or cracks results in loose foundation, which may further lead to failure or collision. Looseness can affect the induction motor magnetic circuit by causing variation in the air gap. Such a problem can cause vibration at 2X rotational frequency. The next mechanical fault of our interest are misalignment, this type of fault generates reaction forces and torques in the coupling, and finally torque oscillations and dynamic air gap eccentricity in the driving machine. Moreover, these mechanical phenomena appear at even harmonics of the rotational frequencies of the driven parts. Amplitude and frequency modulations strongly increase in the low-frequency range when a shaft misalignment occurs, and more precisely at even harmonics of the drum rotational frequency.

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Display Results with directions -

X > = 70 , so X direction Fault has been occured and detected

Similarly it will occur for Y and Z respectively.

V. CONCLUSION

The ARM controller had the advantage of the C compiler that was reasonable in price, free updates of the complier, a free development environment and a single supplier of software and hardware. Although embedded C programming has the disadvantage of not knowing the real time nature of the code it is producing, it was implemented and proved to be effective and efficient .In this thesis, ARM7 microcontroller is used to implement the integrated motor protection scheme considering the above advantages.

REFERENCES

[1] S. Nandi, H. A. Toliyat, Li Xiaodong, “Condition monitoring and fault diagnosis of electrical motors – a review”, IEEE Trans. Energy Coversion, vol.20, pp.719-729, no.4, 2005.

[2] J. Faiz, B. M. Ebrahimi, M. B. B. Sharifian, “Different faults and their diagnosis techniques in three-phase squirrel-cage motors- a review”, Electromagnetics, no.26, pp.543-569, 2006.

[3] Bellini, F. Filippetti, G. Franceschini, C. Tassoni, R. Passaglia, M. Saottini, M. Giovannini, A. Rossi, “On-field Experience With Online Diagnosis of Large Induction Motors Cage Failures Using MCSA”, IEEE Trans. on

Ind. Applications, vol.38, pp.1045-1052, no.4, 2002 P. J. Tavner and J. Penman, "Condition Monitoring of Electrical Machines", Letchworth, England: Research Studies Press Ltd., 1987.

[4] Shuo Chen, "*Induction Machine Broken Rotor Bar Diagnostics Using Prony Analysis*", A Ph.D Thesis submitted to the School of Electrical and Electronic Engineering of the University of Adelaide, April 2008.

[5] Olav Vaag Thorsen and Magnus Dalva, "A survey of Faults on Induction Motors in Offshore Oil Industry, Petrochemical Industry, Gas terminals, and Oil Refineries", IEEE Transactions on Industry Applications, vol. 31, no. 5, September/October 1995.

[6] William Torbat Thomson and Mark Fenger, "Industrial Application of Current Signature Analysis to diagnose Faults in 3-Phase Squirrel Cage Induction Motors", Pulp and Paper Industry Technical Conference, Conference Record of 2000 Annual, pp. 205-211, 19-23 June, 2000.

[7] Andrew M.Knight and Sergio P.Bertani, "Mechanical Fault Detection in a Medium-Sized Induction Motor Using Stator Current Monitoring", IEEE Transactions on Energy Conversion, vol. 20, no.4, pp. 753-760.

[8] Neelam Mehala and Ratna Dahiya, "Condition Monitoring Methods, Failure Identification and Analysis for Induction Machines", International Journal of Circuits, Systems and Signal Processing, vol. 3, no. 1, pp. 29-35, 2009. J. U. Duncombe, "Infrared navigation—Part I: An assessment of feasibility (Periodical style)," WASET Trans. Electron Devices, vol. ED-11, pp. 34–39, Jan. 1959.