iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 Issue: IV Month of publication: April 2017

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

An Automatic Close Loop Embedded System for Real Time Monitoring of Speed and Torque of Motor

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Abstract: The system proposed in this project aims at monitoring the torque and efficiency in induction motors in real time by employing wireless sensor networks (WSNs). An embedded system is employed for acquiring electrical signals from the motor in a noninvasive manner, and then performing local processing for torque and efficiency estimation. We are proposing a system for close loop operation which can work independently or remotely control by the central unit for industry application like caviar belt. The values calculated by the embedded system are transmitted to a monitoring unit through WSN. The base unit, various motors can be monitored in real time. An experimental study was conducted for observing the relationship between the WSN performance and the spectral occupancy at the operating environment. This study demonstrated that the use of intelligent nodes, with local processing capability, is essential for this type of application. The embedded system was deployed on a workbench, and studies were conducted to analyze torque and system efficiency.
Keywords: Efficiency estimation, embedded systems, induction motors, torque measurement, wireless sensor networks (WSNs).

I. INTRODUCTION

In an industrial environment, mechanical systems driven by electric motors are used in most production processes, accounting for more than two-thirds of industry electricity consumption. Regarding the type of motors usually employed, about 90% are three-phase ac induction based, mainly due to its cost effectiveness and mechanical robustness. Torque is one of the main parameters for production machines. In several industry sectors, torque measurements can identify equipment failure, which makes their monitoring essential in order to avoid disasters in critical production processes (e.g., oil and gas, mining, and sugar and alcohol industries). For decades, researchers have studied methods and systems for determining the torque in rotating shafts. There are basically two lines of study: direct torque measurement on the shaft, and estimated torque measurement from motor electrical signal. In most cases, the methods for direct torque measurement on the shafts are the more accurate. However, they are highly invasive, considering the coup ling of the measurement instrument between the motor and the load. Moreover, some of these techniques still have serious operational challenges. The estimated torque from the motor's electrical signals (i.e., current and voltage) makes the system less invasive, but it is less accurate when compared to direct measurement systems. There are problems, such as noise in signal acquisition, those related to numerical integration, and low levels of voltage signals at low frequencies. However, in many cases, high precision is not critical, and low invasiveness is required. There are different methods to measure efficiency in induction motors, which are based on dynamometer, duplicate machines, and equivalent circuit approaches. However, their application for in-service motors is impractical, because it requires interrupting the machine's operation to install the instruments. There are some simple methods for in-service efficiency estimation, like the name plate method, the slip method, and the current method. These methods present as the main limiting factors the low accuracy, estimative based on nominal motor data and the need of typical efficiency-versus-load curves.

II. METHODS AND MATERIAL

A. *Literature Survey*

Hsu and Scoggins presented the air-gap torque (AGT) for energy efficiency estimation. In, the AGT is also used to measure efficiency in a much less invasive manner. The AGT method can be employed without interrupting the motor operation and it is not based on the motor name plate .This method generally is more accurate than the other methods described earlier. [1] In this study, the AGT method was used for the estimation of the motor shaft torque and efficiency because it is the non-invasive method for

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determining torque and efficiency that has less uncertainty. [2] In the ORMEL96 method14, the efficiency is obtained from an equivalent circuit that is generated from the motor nameplate and the rotor speed measurement. [3] The installation of cables and sensors usually has a higher cost than the cost of the sensors themselves. Besides the high cost, the wired approach offers little flexibility, making the network deployment and maintenance a harder process. [4] After studying this paper we got to know that in this project firstly they are giving the supply to PIC microcontroller. Then controller generates the pulse generally 5 volts DC, the generated pulse is nothing but PWM signal. This is giving it driver circuit. The function of this driver circuit is to generate 12v DC pulse. This is necessary to switch/ triggering on MOSFET for triggering purpose. [5]

B. Working and Block Diagram

The WSN proposed in this project. Therefore, the communication among nodes and coordinator can be done with assistance of RF Module. For current measurement, CT coil are employed due to their robustness and non-invasiveness.

Transformers with grain-oriented core are used to measure the voltage between phases, which provide the voltages in the secondary and primary without delay. The acquisition and data processing unit (ADPU) is responsible for data acquisition and conversion, besides the data processing. The printed board power supply supplies the current and voltage for the sensors, the RF2.4 GHz transceiver, and the ADPU. The main element of the ADPU is a PIC16F877A, which is a digital signal controller designed for applications that require high processing capacity.

It has two integrated ADC, which perform simultaneous acquisition of the voltage and current sensors. The input/output channels can be used for user interface, and possible connections to auxiliary sensors and actuators. The values of torque and motor efficiency are transmitted using the RF 2.4 GHz Transceiver.

When there is a variation of load and efficiency will decreases or any mechanical disturbance in motor then relay driver will switch off the motor and buzzer will be on.

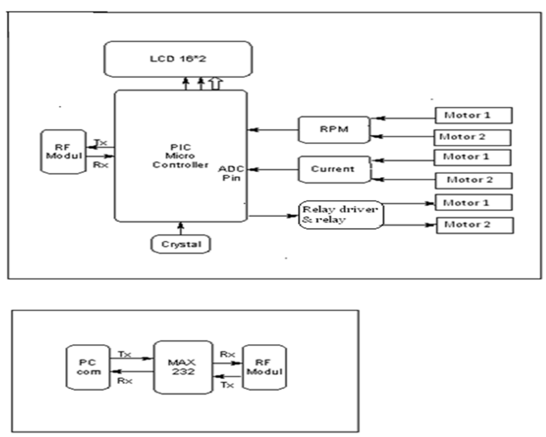

Fig.1 Block Diagram of proposed system

C. Implementation and Testing

1) Microcontroller PIC16F877A
2) Only 35 single-word instructions to learn
3) All single-cycle instructions except for program branches, which are two-cycle
4) Operating speed : DC – 20 MHz clock input DC – 200 ns instruction cycle
5) Up to 8K x 14 words of Flash Program Memory, Up to 368 x 8 bytes of Data Memory (RAM), Up to 256 x 8 bytes of EEPROM Data Memory
6) Pin out compatible to other 28-pin or 40/44-pin .

D. Analog Features

1) 10-bit, up to 8-channel Analog-to-Digital Converter (A/D)
2) Brown-out Reset (BOR
3) Analog Comparator module with:-Two analog comparators-Programmable on-chip voltage reference (VREF) moduleProgrammable input multiplexing from device inputs and internal voltage reference-Comparator outputs are externally

accessible.

E. Special Microcontroller Features

1) 100,000 erase/write cycle Enhanced Flash program memory typical
2) 1,000,000 erase/write cycle Data EEPROM memory typical
3) Data EEPROM Retention > 40 years
4) Self-reprogrammable under software control
5) In-Circuit Serial Programming™ (ICSP™) via two pins
6) Single-supply 5V In-Circuit Serial Programming
7) Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
8) Programmable code protection
9) Power saving Sleep mode
10) electable oscillator options
11) In-Circuit Debug (ICD) via two pin
12) Low-power consumption.

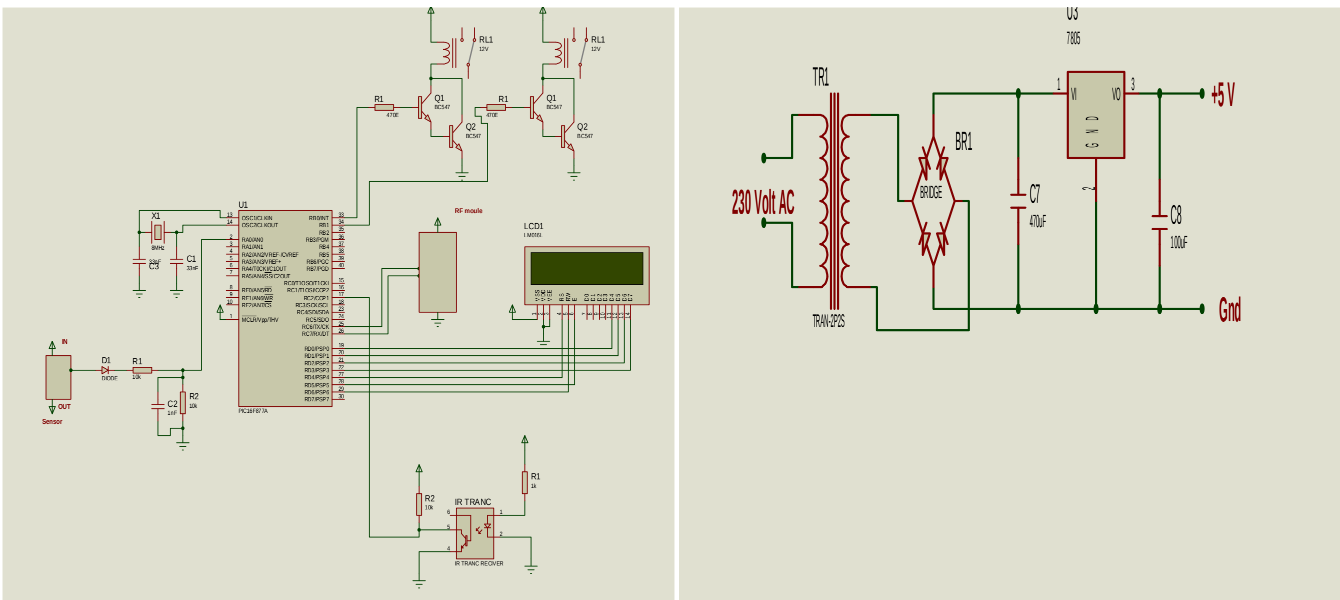

Fig.2: Circuit Diagram

F. Tools to be Used

1) PIC Microchip Programmer and Its software.
2) 12V DC power supply.
3) Operating system [Windows98, 2000, 2003, XP, Vista].
4) Personal Computer.
5) PIC Micro controller Compiler (hi –tech c).
6) Schematic and Layout Design Software.
7) Multi-Meter or volt-meter, Soldering Iron, Visual Basic 6.0.

G. Calculations

Full-load torque is the torque to produce the rated power at full speed of the motor. The amount of torque a motor produces at rated power and full speed can be found by using a horsepower-to-torque conversion. To calculate motor full-load torque, apply this formula:

1) $T = \frac{HP \times 5252}{rp}$

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Volume 5 Issue IV, April 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

2) Efficiency=(torque*speed)/(voltage*current)

3) HP = $\dfrac{\text{torque* rpm}}{5252}$

T=torque(lb-ft)
HP=horsepower
5252=constant
rpm = revolutions per minute

III. RESULT

The main benefits of the automatic close loop embedded system for real time monitoring of speed and torque of motor as compared to conventional method as follows:

A. Immediate shows the condition of working motors.
B. Accurate information about the speed, torque, efficiency of running motors.
C. Transmits the results with every instant.
D. Accuracy increases as against the manual process of testing motor parameters.
E. Due to proposed system, operating life of motors will be increases.

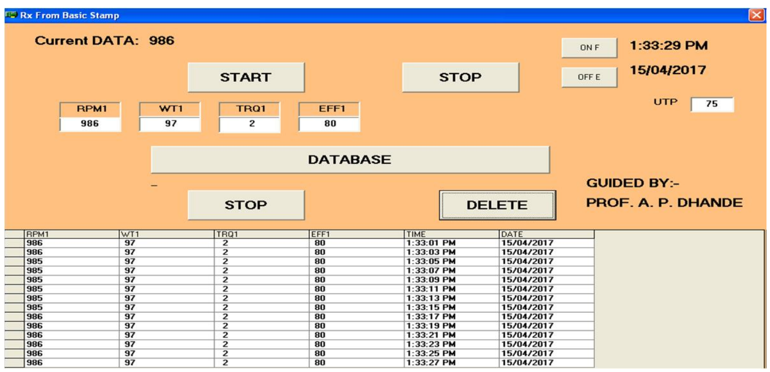

Fig.3 Gnerated Database

Fig.4: Motor reading

Fig.5: Assembly photo

Volume 5 Issue IV, April 2017
ISSN: 2321-9653

Fig. 5, depicts the WSN proposed in this paper. End nodes are composed by the embedded systems located close to the electric motors. The values of motor voltage and current are obtained from the sensors, and the embedded system performs the processing for determining the values of torque, speed, and efficiency. Information obtained after the processing are transmitted to the base station through the WSN. Depending on the distance between end nodes and the coordinator, it may not be possible to achieve direct communication, due to the radio's limited range and the interference present on the environment, among other factors. Therefore, the communication among nodes and coordinator can be done with assistance of routers.

Fig.6: Database Graph

IV. CONCLUSION AND FUTURE WORK

This paper presented an automatic close loop embedded system for real time monitoring of speed and torque of motor. We used this system for close loop operation which can work independently and control by the central unit for industry applications. The calculations for estimating the targeted values are done locally and then transmitted to a monitoring base unit through a WSN. As future work, we intend to conduct more detailed performance studies, considering a network with a larger number of nodes in an industrial plant. Finally, we intend to develop spectrum-aware protocols to allow the radios to choose their operation channels dynamically, allowing the embedded systems to self-adapt to the operating environment, improving the quality of service of the network. It is also desirable to conduct more detailed dynamic analysis of the workbench used for validation, especially with regard to reducing losses at nominal load.

V. ACKNOWLEDGMENT

We would like to acknowledge the faculties of Electronics & Telecommunications Department, P. R. Pote (Patil) Welfare & Education Trust's college of Engineering & Management, Amravati for their valuable support.
I Miss Pranali R. Vairale specially like to express my sincere thanks to my guide Prof. A. P. Dhande and respective faculties for their motivation and useful suggestions which truly helped me in improving the project work.

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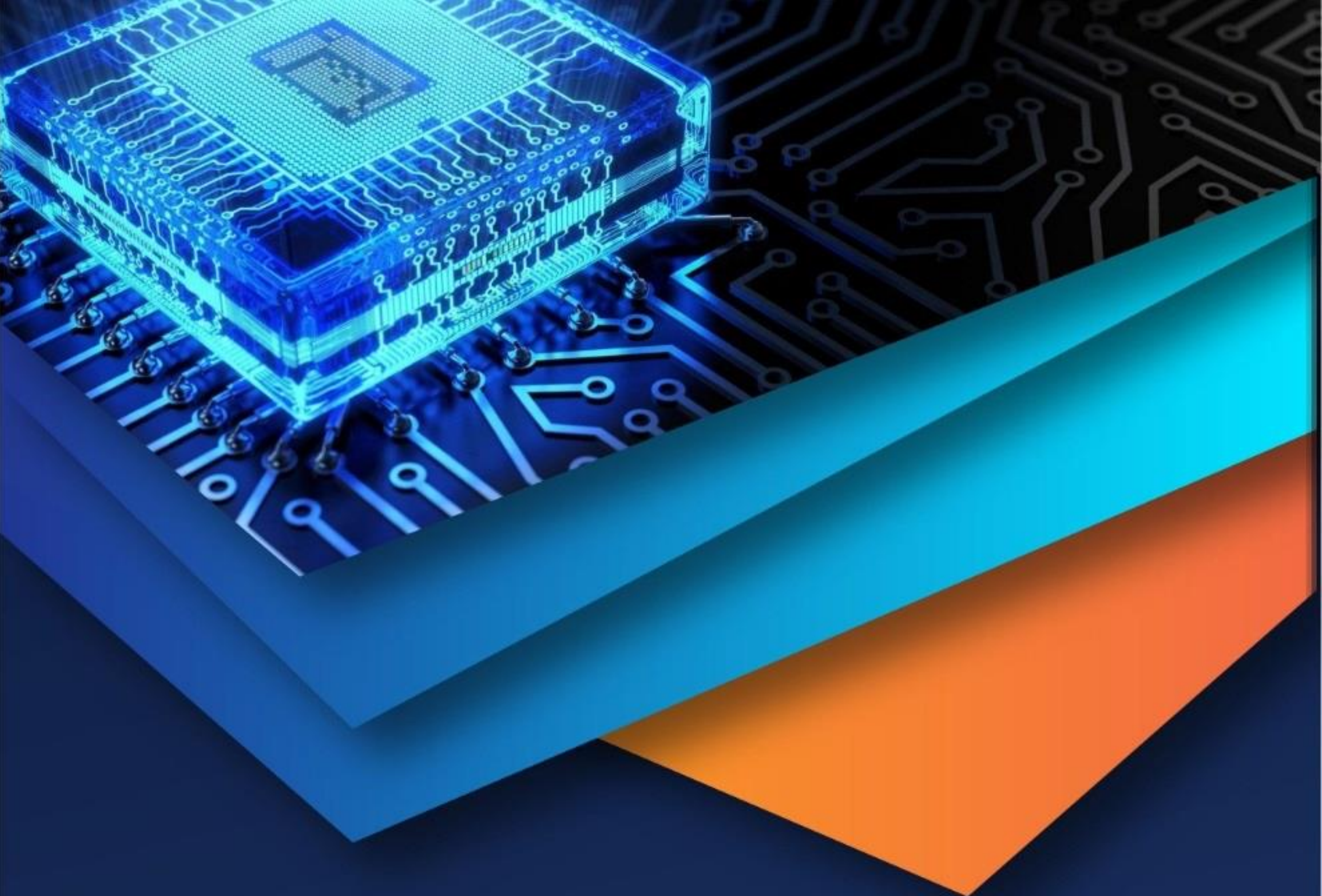

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