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Induction Motor Parameter Monitoring System using Zig bee Protocol & MATLAB GUI: Automated Monitoring System

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Abstract: ***Monitoring and controlling of three phase induction motor plays a vital role in industrial and commercial users. A highly reliable and advanced ZigBee communication technique is used for the purpose. The present wired communication is more costly and not reliable due to physical factors. Its safety factors for humans cannot be predictable. A quick and reliable minimum cost system for monitoring and controlling the three-phase induction motor is prescribed in this paper. The data parameters from the motors such as like as phase currents, phase voltages, active power, reactive power, motor temperature, Motor speed, Power factor are recorded. The database from the digital signals is recorded and built to ON /OFF motor from remote location using MATLAB GUI. The motivation of this paper is to monitor and control the motor at the remote location with low cost and less time-consuming. Electrical parameters like Currents, Voltages, Power Factor, Temperature, speed are monitored using the graphical user interface and can be controlled using the wireless communication. To achieve this, a ZigBee prototype and an ADE7758 Energy Metering IC are interconnected which would communicate the motor parameters to ZigBee protocol which will be communicated and display on MATLAB GUI using RS232 as a serial communication. The implementation results convey that the prescribed system is of minimum hardware and also at optimum cost, gives higher definite and also safe for human as it switches ON/OFF remotely.***

Keywords: Three phase induction motor, MATLAB, motor parameters, Zigbee

1. Introduction

Small and medium scale industrial users use three-phase induction motors widely for its simple construction and also for its safety factors. Apart from its safer operation, induction motors undergo some unpredictable disturbance, causing faults which appear failure in the motor. Therefore several monitoring types have been prescribed to obtain a good supervisory system for the safe and reliable operation of the induction motor. [1], [2], [3], [11].

Voltage, current, speed and temperature information of the IM are imperative for a drive framework and execution of an induction motor is specifically influenced by these principal amounts. Be that as it may, amid persistent procedure of creation it winds up plainly hazardous and unsafe method to subset motor. In such cases, remote control and checking strategies turn into an extensive answer for dispense with these perils

Subsequently, remote information correspondence is utilized as a part of different ventures. Numerous scientists and analysts have been working in various courses on IM checking [2][4], on the grounds that observing of acceptance motor is a quick rising innovation for location of starting deficiencies. It stays away from the unforeseen disappointment of mechanical process. Observing systems can be delegated the conventional and the computerized strategies. On the off chance that the conventional observing frameworks are contrasted and PC based ones, customary techniques extensively lessen the effectiveness and affectability of the framework in light of the fact that numerous mechanical and electrical types of gear incorporated into the entire framework increment the ideal opportunity for recognizing abandons. Another detriment of the customary techniques is their cost, and plainly conventional strategies increment cost of frameworks while computerized frameworks diminish it [6]. In numerous plants and computerization applications, the correspondence needs are generally served by wired innovations. These correspondence frameworks have been particularly intended to meet the binding ongoing and dependability necessities found in numerous modern applications [1],[2]. Obviously, remote advancements ought to give a similar sort and nature of administrations to mechanical clients as the customary, wired innovations do [5], [8]. Notwithstanding, remote advances vary in various courses from wired ones. These distinctions show noteworthy difficulties for outline of system models, conventions, and instruments for mechanical and computerization applications [3], [11].A part of this, motor can be controlled and information can be gotten and passed in meantime by remote innovation. In this way, framework operation can be accomplished with no inconvenience. In writing, a few strategies have been exhibited for operation, observing, and distinguishing mechanical and electrical imperfections in three-stage acceptance engines [2], [3], [9], [11]. Electronically based security framework is portrayed for motor parameters, yet these have not been shown on a screen [3]. PLC-based blame insurance framework has been presented in [3], [11] which rubs sort of shortcomings on show, however, information cannot be show and put away and in addition, framework turns out to be expensive. Now and again, motor data have been utilized to show parameters of the motor in PC by wires. [2], [6], [11]. This designed system has for hardware and software categories which has voltage and current transformers, digital signal controller, a digital temperature analyzer, induction motor, a PC and finally ZigBee communication module. Monitoring and controlling of three-phase induction motor parameters has been

achieved reliably with help of GUI. This paper is organized in sequence starting from Section II which introduces Wireless application Protocols and similarly, Section III describes the proposed system with hardware and software details Section IV describes experimental framework and the results, and at last concluded with future scope of the system in section V.

2. Wireless Application Protocol

The different types of the wireless network protocol for Personal Area Network (PAN) are Bluetooth, ZigBee and NFC and for Local area network is IEEE 802.11 (Wi-Fi). Bluetooth is one of the most established remote conventions still comprehensively accessible and was made in the 1990s to impart information amongst telephones and other battery-controlled gadgets. Bluetooth requires a less amount of power to operate than Wi-Fi and most other wireless protocols. Bluetooth associations just capacity over generally short separations, frequently 30 feet (10 m) or less and bolster moderately low information rates, as a rule, 1-2 Mbps. The most adaptable network for home automation or the industrial environment is the Zigbee which use the very less power compared to the Bluetooth bolsters just low information rates - 0.25 Mbps for Zigbee and just around 0.01 Mbps for Z-Wave. Zigbee (IEEE 802.15.4) is a wireless based technology suitable for high-level communication protocols used to create personal area networks with small, low-power digital radios. The main advantages of ZigBee over Bluetooth are

- Only 8 cell nodes can be connected through Bluetooth, but ZigBee can connect more than 65,000 cell nodes at the same time.
- Zigbee has the self-healing technology but the Bluetooth does not have such technology
- Bluetooth runs on Frequency Hopping Spread Spectrum technique while Zigbee uses Direct Spread Spectrum technique

Zigbee system architecture as shown in fig. 1 consists of three different types of devices such as Zigbee coordinator, Router and End device. Every Zigbee network must consist of at least one coordinator which is the root and bridge of the network [13]. The coordinator is subject to dealing with, putting away the data, accepting and transmitting information operations. Zigbee switches go about as channel that grants information to go through from and to different devices. End devices have confined functionality to communicate with the creator nodes such that the battery power is preserved. The number of routers, coordinators and end devices leans on the type of networks such as star, tree and mesh networks.

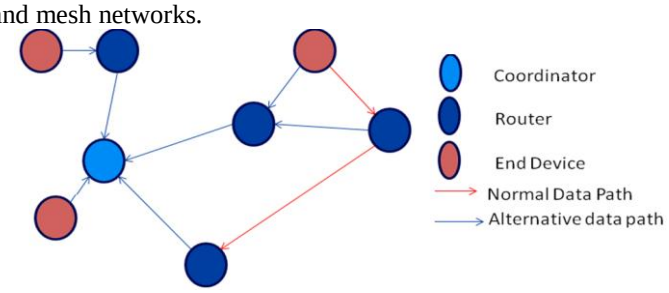

Figure 1: Architecture Diagram

As shown in fig. 2 Zigbee consists of protocol layers such as PHY, MAC, network, security and application layer. The first two layers are covered in IEEE 802.15.4 WPAN standard and the latter two are covered ZigBee alliance.

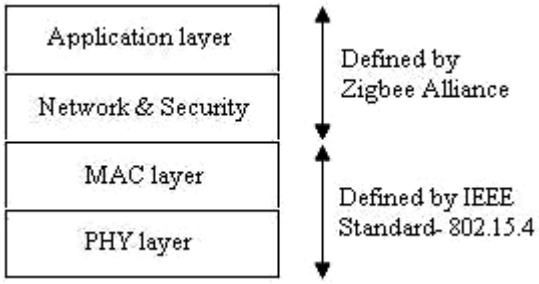

Figure 2: Zigbee stack protocol

Application Layer:
A single ZigBee node supports up to 240 application objects called endpoints. An endpoint specifies a specific application, provides control and management commands.

Network Layer:
Ad-hoc On-demand Distance Vector Routing protocol (AODV) is used at the network layer.

Security Layer:
If security is enabled, ZigBee device will start up using a 128 bit

MAC Layer:
The MAC frames are divided into following four major categories, which is used by ZigBee devices to establish a connection to the PAN by exchanging system information.

1) Beacon
2) Data
3) Acknowledgement
4) MAC command [12].

3. Proposed System

The schematic block diagram of the proposed system shown in fig 3. The paper presents the ideal method to measure the parameters of the three-phase induction motor and also to control the motor from a remote location. This section three is divided into two parts. Hardware and the software requirement for the proposed framework are described. Any requirements are needed to assemble for achieving the desired design in the system model. As listed as sensing devices and motors, temperature measuring sensors, transducers...etc.

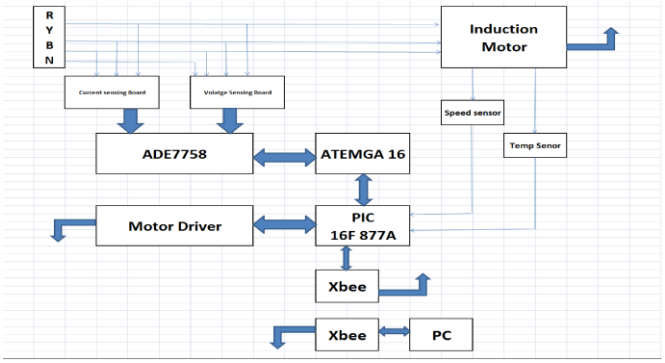

Figure 3: Proposed system Block Diagram

A) Hardware description

A totally enclosed three-phase induction motor of 3hp, 1400 rpm motor is used. The two voltage transformer of 230/3V transformation ratio are connected and the Secondary Voltage is of 2.5 ± 0.625, 0.1% accuracy is calculated. A two current sensing transformer of range 25A is used. By the DSC algorithm, three phase current and voltage are calculated. A 16-bit DSC ADE7758 measure the motor winding temperature and finally communication.

A motor temperature signal, two current signals and two voltage signals are used as the input to the analog to the digital module of the digital signal controller. Fig. 4 and fig. 5 displays the current detecting and voltage detecting circuit correspondingly in which output is given to the analogue to digital converter channels of the DSC.

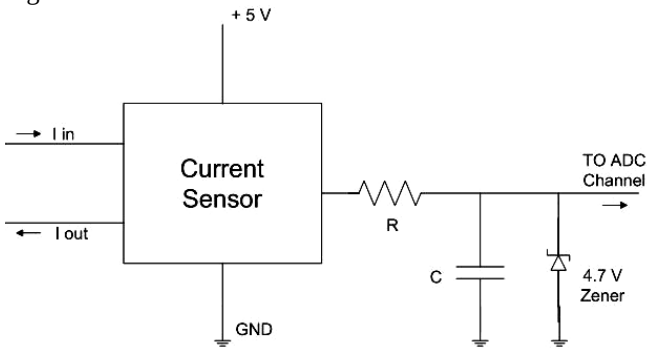

Figure 4: Current detecting Circuit

Figure 4 shows the current transducers which are based on Hall Effect, designed and used for measuring electrical current (both direct and alternating). These Current Transducers are smaller and lighter than most other different types of current transducers. They have no air-gaps, no magnetic stray field, and they are very quiet as shown in figure 4. These Current Transducers have an error less than 0.1%. It can be used to monitor, protect, and control electrical systems for the energy management.

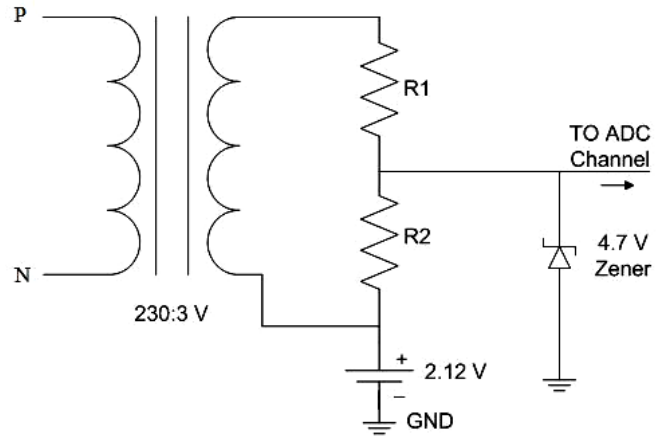

Figure 5: Voltage detecting Circuit

The voltage divider circuit for one phase contains 1kΩ fixed resistor and a 2.5kΩ variable resistor connected in series. The voltage across 2.5kΩ is given to analog channel of ADE7758 figure 5. The same voltage divider circuit is for another phase. Only two voltage sensor circuits are built to measure R & Y phase voltage. The third phase voltage is calculated by the digital signal controller algorithm.

B) Software

The software requirement of the proposed system is very less. The parameters of the motor such as phase voltage, phase current, reactive power, active power, motor temperature, speed, Power factor are gathered from the digital signal controller and send to coordinator through the router and then at last transfigured to PC over RS232 communication protocol network. MATLAB GUI (Graphical User Interface) is the user-friendly display to reveal the parameters on the screen to analyze and control the motor by executing the controlling commands.

The home screen of the MATLAB PC interface is illustrated in fig. 6.

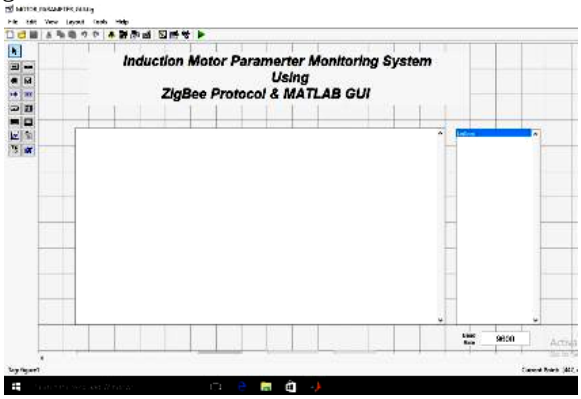

Figure 6: MATLAB GUI home screen

After coding the program, it is configured to the computer, with Zigbee communication protocol successfully. Sending and receiving of data can be executed through the ZigBee communication protocol and its respective baud and it can be displayed in GUI.

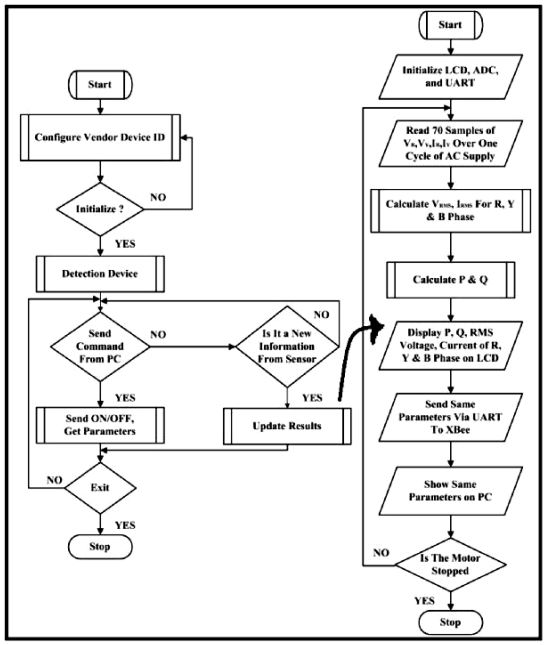

Figure 7: Flowchart Illustration

A step by step flowchart illustrates the action procedure for the implementation system as shown in fig 7. The action comprises of two main steps as 'normal operation' and 'initialize and configure'. The initialization and

configuration parts are illustrated in left side and the other parts are elaborated at the right side on fig. 7.

4. Experimental Framework and Result

Experimental setup of the proposed system is shown in figure 8 to figure 11. Figure 8 shows the full setup of the proposed system with an induction motor. Figure 9 shows the measuring circuit which consists of the voltage sensor, a current sensor, ZigBee protocol, temperature sensor and starter. Figure 11 shows the induction motor parameters result in the MATLAB GUI.

Figure 8: Experimental Setup

Figure 8 shows the full experimental setup of the proposed system, in which the 440V three phase induction motor has connected to the parameter analyzing the circuit and finally it will be displayed digitally on the computer using the RS232 serial communication.

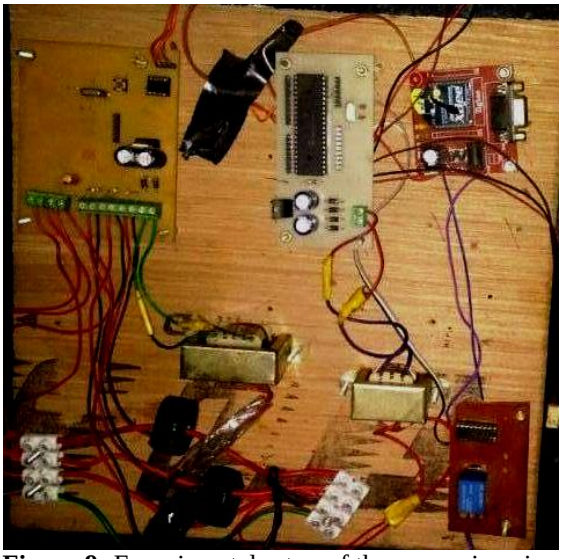

Figure 9: Experimental setup of the measuring circuit

Figure 9 shows the experimental setup of the measuring circuit which consists of two signals for voltages, two signals for currents & one signal for temperature are given to the analog channels of DSC and also we can give one signal for speed as the digital input to DSC for speed measurement.

Figure 10: Zigbee communication network

Figure 10 shows the ZigBee module, which is used as a communication medium between the motor and remote user. The ZigBee is connected to the router which will build a secured gateway for communication. When the motor starts the parameters will be communicated through the coordinator and then to the ZigBee router.

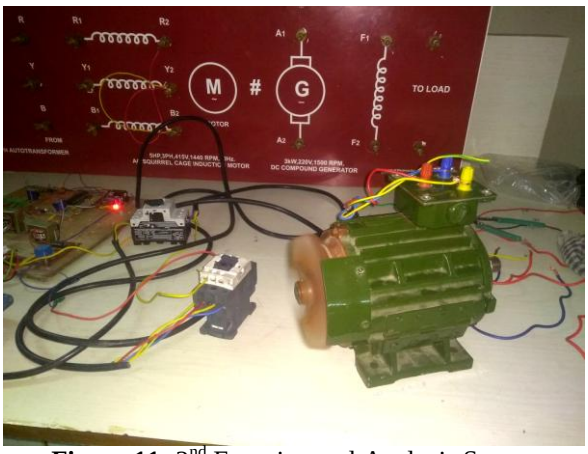

Figure 11: 2nd Experimental Analysis Setup

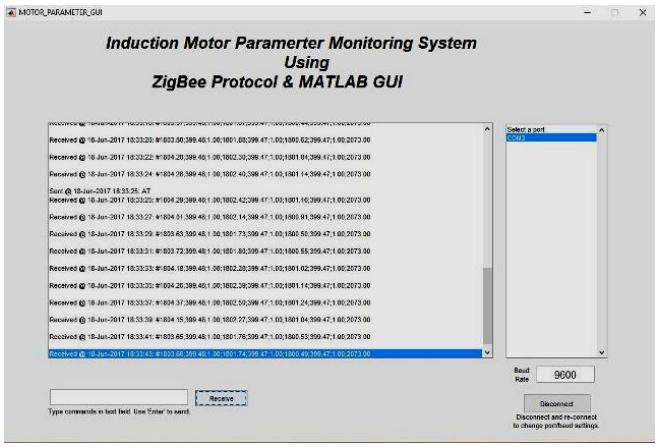

Figure 11: MATLAB GUI Results-1

Figure 11 shows the RMS phase voltage variation with the time. This GUI results displaying voltage variation results working on mat lab functionalities.

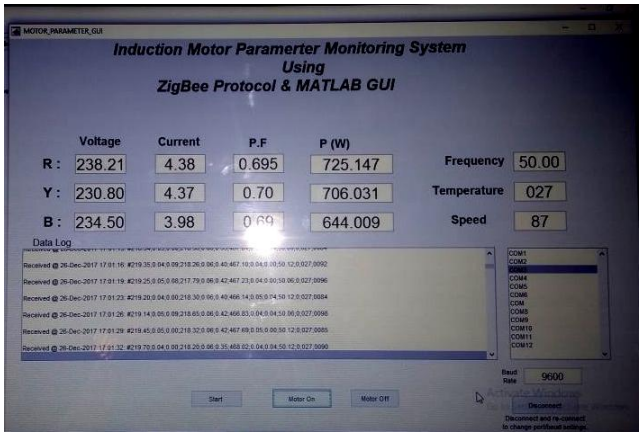

Figure 12: MATLAB GUI Results-2

Figure 12 shows results y varying frequency, temperature, and speed for producing results. It displays voltage variation from varying inputs functionalities. The speed of 3 phase induction motor is controlled by varying number of poles, by control over voltage supply, by frequency control.[14] A modern application is powerful by using computing devices in it like technologies used like small-sized low-power using 802.11, Bluetooth, ZigBee depends on the real-time application. [15]

5. Conclusion and Future Work

This proposed system executes the induction motors parameters remotely and if there is any fault occurred, the induction motor can be power ON/OFF at any time at the remote location. The proposed system has tested and observed successfully in terms of communicating the parameter between ZigBee and computer and also in terms of in terms of integrating the measuring circuit to the induction motor. The developed system has large benefits for both small and medium scale industries. The performance of the induction motor can be recorded and in case of a fault condition, the protection is also provided and displayed in the MATLAB GUI. The system also gives safety for the human by powering ON/OFF remotely when the fault occurs. Finally, this system is the cost-effective and less time-consuming project by reducing the human visiting.

The proposed system is configured only for phase current, phase voltage, reactive power, active power, motor temperature, Motor speed, Power factor and power ON/OFF with the usage of ZigBee and MATLAB GUI. This system can be extended to analyze the motor parameters like humidity condition, chemical properties, vibration severity parameters can be monitored by connecting some sensors this system with some few alterations to the program structure.

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