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Induction Motor Condition Monitoring and Controlling Based on IoT

G. Mamatha[1*], A. H. Thejaswi[2]
[1]*Scholar, Department of Electrical and Electronics Engineering, Jawaharlal Nehru National College of Engineering, Shivamogga, India*
[2]*Professor & HoD, Department of Electrical and Electronics Engineering, Jawaharlal Nehru National College of Engineering, Shivamogga, India*

Abstract*: Technology has advanced significantly in recent years, making our lives easier, faster, and more enjoyable. This paper describes how to use the Internet of Things to control and monitor induction motors (IoT). Because it can be utilized from anywhere via Wi-Fi, the IoT is more convenient and efficient for controlling systems. The major goal of this intelligent system is to prevent induction motor failure by implementing preventative actions. Induction motors are used in a variety of applications such as electric vehicles, industries, and agriculture areas because of its many advantages such as self-starting, low cost, high power factor, and sturdy design. As a result, using the best available smart protection technique, it is vital to detect flaws in motors at an early stage in order to increase motor efficiency and ensure safe and reliable operation. The speed, voltage, current, temperature, vibration, humidity, and other electrical, mechanical, and environmental parameters of the induction motor can be monitored remotely because faults in these parameters cause severe damage to the motors and also cause problems for applications that use the induction motor. A collection of sensors for acquiring the motor parameters in real-time and a relay for controlling the motor are used in this system for monitoring and regulating Induction utilising IoT. The suggested system will use an IoT-based platform to gather and process induction motor parameters in real-time. The collected data is saved in the cloud and can be retrieved via a web page. Alerts will be sent out if any of the monitored parameters' threshold limitations are exceeded. The information from the sensors is received by the microcontroller unit, which processes the sensed data. If an aberrant value is detected, the automatic system generates a control signal to switch on or off the motor.

***Keywords*: Induction motor, IoT, low cost, high power.**

1. Introduction

A motor is a device that turns electrical energy into mechanical energy. Mechanical energy can be delivered to a variety of loads.

Single and three-phase induction motors, as well as other special-purpose motors, operate on an AC supply and are referred to as ac motors.

An induction motor is made up of two primary components.

1) stator which is stationary
2) rotor which is a rotating part.

The electromagnetic induction concept underpins the operation of induction motors.

When a three-phase supply is applied to the stator winding, a rotating magnetic field is created, which induces an emf in the rotor, which causes the rotor to rotate.

A. *Application of Induction Motors*

- For driving fans, blowers, water pumps, grinders, lathe machines, printing machines, and drilling machines, squirrel cage type motors with moderate torque and steady speed characteristics are preferable.
- Slip ring induction motors have a strong beginning torque that can reach maximum torque. As a result, they can be used in lifts, hoists, elevators, cranes, and compressors.

B. *Speed Control of Induction Motor*

In practice, controlling the speed of an induction motor is required for particular applications, which can be accomplished using one of two approaches.

1) From the stator's perspective
2) From the rotor's perspective

1. From the stator side, it includes the following methods.

a) v/f control
b) Supply voltage control
c) Adding rheostats in stator circuits

2. From the rotor side, it includes the following methods.

a) Adding external resistance in the rotor circuit
b) Cascade control
c) Injecting slip frequency voltage into the rotor circuit

3. v/f control

When the supply frequency is altered, the value of the air gap flux changes as well, which can cause saturation of the stator and rotor cores, resulting in a sudden increase in the motor's no-load current. As a result, when the supply frequency is altered, the voltage must also be modified to keep the (v/f) ratio constant.

To achieve smooth speed control without damaging the motor performance, we must feed variable voltage variable

*Corresponding author: amoghabandrikalli@gmail.com

frequency to the induction motor utilizing converter and inverter circuits in this technique.

C. Supply Voltage Control

The supply voltage affects the induced emf in the rotor at standstill. When the supply voltage is reduced below the rated value, the torque produced decreases. However, to supply the same load, the same torque must be developed, therefore the value of slip rises, causing motors to respond by operating at a slower speed and lowering the supply voltage, resulting in the torque produced remaining constant. As a result, the motor operates at a lower speed to produce the appropriate load torque.

However, because of the lower voltage, the current drawn by the motor increases in this manner. The motor may overheat as a result of the increased current. There will be a need for more voltage shifting equipment. A minor change in speed necessitates a significant change in voltage. As a result, this technique is rarely used in practice. This speed control approach is appropriate for motors operating fan-type loads.

D. Cascade Control

When various speeds are necessary, this form of speed control is preferred. Two induction motors are installed in the same shaft in this way. One motor should be of the slip ring type, known as the main motor, and the second motor, known as the auxiliary motor, might be of the slip ring or squirrel-cage type.

The main motor's stator receives a three-phase supply, while the auxiliary motor's supply is obtained at a slip frequency from the main motor's slip rings. This is known as motor cascading.

Cumulative cascading occurs when the torque produced by both acts in the same direction. Differential cascading occurs when the torques produced are in opposite directions.

2. Related Work

Induction motors are used extensively in industrial applications. Induction motors have a considerable advantage in terms of construction durability and simplicity. It can function in any setting and is relatively affordable. This paper provides information on how to instal an IoT (Internet of Things) based remote control and monitoring system of an induction motor in industries for safe and cost-effective results. Temperature, vibrations, external moisture RPM, induction machine load current and voltage are all monitored by the transducer modules and sensors and sent to the (Arduino) processing unit. It will examine and display the parameters. The processing unit (Arduino) communicates with the gateway module to transfer data to a cloud database for remote monitoring. To avoid system failure, this paper shows how to control the start and stop of an induction machine using both automatic and manual methods. It also includes an industrial application to make the system more user-friendly and speedier [1].

For industrial applications, the induction motor has remained the most popular form of motor. Monitoring and managing induction motor parameters is critical in many applications, and there are numerous strategies for doing so. This study examines the use of the Internet of Things [IOT] to remotely monitor and control a three-phase induction motor. Temperature, current, and voltage of the induction motor are monitored by a sensor and transducer module, which sends the data to the processing unit, which displays the data on the server. To avoid any system failures, the system also provides automatic and manual control ways for stopping and starting the induction motor via the server gateway. The implementation of this plan will improve the machine's working efficiency by continuously monitoring for malfunctions and determining preventive maintenance. [2]

IoT Based Parameter Monitoring of Three Phase Induction. With new evolving technologies, condition monitoring has become an essential study area for diagnosing defects in induction motors. The condition-based monitoring of induction motors has long been a challenging problem for technicians, engineers, and researchers, particularly in industrial applications such as railways, pumps, conveyors, blowers, elevators, and mining. Due to their durable structure, lack of brushes, sophisticated power electronics, and ability to adjust the motor's speed, induction motors are now the favoured choice among industrial motors. Many industrial processes use induction devices as actuators. Induction motors are dependable, although they are subjected to some unfavourable stresses, resulting in flaws and failure. Monitoring an IM is a rapidly developing method for detecting early flaws. This study offers a wireless induction motor control and monitoring system based on the Internet of Things protocol for safe and cost-effective data exchange in industrial applications. A microcontroller-based system is utilised to collect and store data, as well as provide control signals to stop or start the induction machine. An Ethernet shield is used to connect the system to the Internet of Things. [3]

Implementation of IOT (Internet of Things) for induction motor monitoring and control in a variety of applications including electric vehicles, industries, and agriculture. Various writers have presented a block diagram approach to IOT-based monitoring and control of induction motors in this review. Temperature, speed, current, voltage, and other parameters of an induction motor can be remotely monitored and supplied to a processing unit for analysis, allowing essential measures to be taken, particularly under abnormal conditions, for improved dependability and efficiency. Wifi allows access to the info from anywhere on the planet. [4]

The Internet of Things (IoT) is at the centre of today's rapid technological progress (IoT). A large number of items are efficiently networked, particularly in industrial automation, resulting in condition and controlled monitoring to boost production. The goal of this project is to develop and use IoT technology to monitor and diagnose the status of induction motors by recording key performance indicators. To gather and process induction motor parameters, the suggested technique uses an IoT-based platform. The information gathered can be saved in the cloud platform and retrieved via a web page. Also, for any breach of desired limits of parameters under monitoring, timely alarms will be received, allowing fast action to be taken to avoid unnecessary motor downtime, saving time and money.

Continuous monitoring of the equipment, receiving alerts, and data availability for predictive maintenance are all advantages of this system. [5]

3. Methodology

A. Control & Condition Monitoring of Induction Motor

Unbalanced three-phase power supply, overcurrent, overvoltage, overloading, vibration, bearing and winding temperatures, stator and rotor winding failure, ambient temperature, and external moisture are all factors that affect induction motor performance. As a result, the above factors must be controlled, and induction motor monitoring is essential for efficient and dependable motor operation.

Condition monitoring is the process of recognizing and maintaining a machine's operational parameters before a failure arises. By anticipating motor health based on real-time data, it improves operation efficiency, lowers maintenance costs, and prevents motor damage.

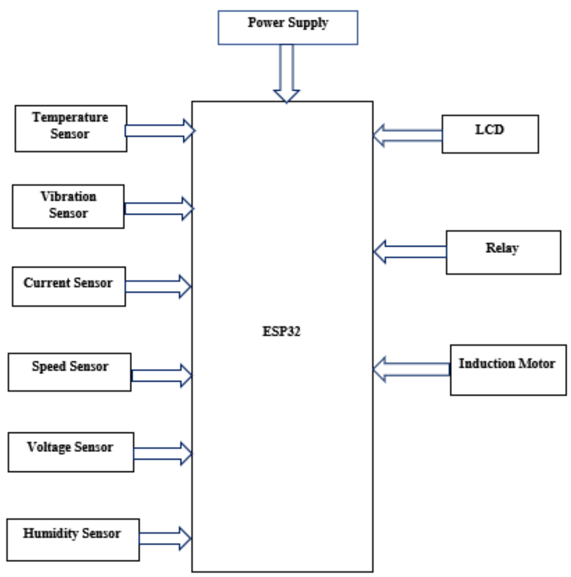

Fig. 1. Block diagram of the proposed system

There are two parts to the proposed system. The first is software, and the second is hardware, for monitoring and controlling motors in normal and abnormal situations utilizing various sensors and IoT. Different defects are simulated in the software section, such as over-voltage, over-current, over-speed, vibration, temperature, and so on, and the results are observed. The data from the various sensors is delivered to the controlling device, which is an ESP32 microcontroller, under the hardware section. The data processing programme is programmed into the microcontroller.

The ESP32 has a total of 39 digital pins, of which 34 can be used as GPIO for connecting LCDs, relays, and other devices. It contains 18 ADC channels for attaching sensors, 3 UART interfaces, 2 I2C interfaces, and built-in Wi-Fi and Bluetooth functionality via I2C/UART interfaces, reducing the communication stack and facilitating the connection of other electrical devices to the ESP32. As a result, it's ideal for IoT applications.

When the power supply is turned on, the stepdown transformer and bridge rectifier in this system lower the 230v AC supply to 12V Dc, ensuring that the ESP32 microcontroller and other components connected to it receive the necessary power. The sensors used in this project will sense motor parameters including as voltage, current, speed, and temperature, and send the information to the ESP32. The temperature sensor, speed sensor, vibration sensor, and PZEM-o4t module send data to the microcontroller, which it processes according to the instructions. The information gathered is then transferred to the LCD and the Blynk server.

I2C communication technique is used to connect the LCD to the microcontroller. It means it communicates with the ESP32 using two pins: SDA (Serial Data pin) and SCL (Serial Clock pin), and then the LCD shows voltage, current, speed, and other information about the motor.

The PZEM-004T V3 module is used in this system to measure the voltage, current, power, and power factor of the induction motor load. The PZEM-004T V3 is a serial communication device. UART2 (Universal Asynchronous Receiver/Transmitter) connects its RX pin to the TX pin of the ESP32 microcontroller, and the TX pin to the RX pin of the ESP32 microcontroller. That is, data is sent without the use of a clock signal.

The motor speed is measured by the speed sensor, which is connected to the RX0 pin of the ESP32, and the motor vibration is measured by the vibration sensor, which is connected to the GPIO13 pin of the ESP32.

The speed of the induction motor is controlled by the proposed system's silicon controller rectifier. To adjust speed, the SCR's rectified output will be applied across the motor.

By receiving commands from the internet, the microcontroller gets data from the sensors and sends control signals to the relay. When an aberrant value such as over-voltage, over-current, over-speed, or temperature is detected, the relay will control the functioning of the induction motor by turning it ON/OFF. The representation is as shown in the Figure 1.

B. Components Employed

1) Power supply

The power supply is used to provide the desired dc voltage, which can then be utilised to power the system's other circuits. Our circuit's components run on 5 volts DC, yet we get 230 volts AC from the mains. As a result, a step-down transformer and a rectifier can be used to obtain a 12V DC supply. Due to the presence of ripples in the signal, the corrected output is referred to as pulsing DC. To eliminate ripples in the output voltage, a capacitor is utilised in the filter circuit. The 12V Dc is decreased to 5V by utilising the positive voltage regulator chip 70512V. As a result, the necessary fixed voltage (5V) can be obtained.

2) Condition monitoring sensors

The state of the 3phase induction motor is continuously monitored while it is running using lightweight, easily customizable sensors. The DHT11 sensor, which has two primary elements for sensing temperature and humidity, is employed in the proposed work. An NTC sensor or thermistor is used to measure temperature. Thermistors are semiconductor materials that change resistance in response to temperature changes. This allows us to determine the temperature of the surrounding surroundings. The DHT11 contains two electrodes for humidity measurement. The resistance between electrodes changes as the moisture level in our environment changes. The humidity of the surroundings may be easily determined as a result of this shift.

The PZEM-004T module measures motor current and voltage and features a TTL serial data transfer port for connecting to an Arduino Uno. The result is displayed on Arduino's LED. The motor speed is measured using a hall effect sensor. The LCD displays the signals that have been detected. A displacement sensor that uses electromagnetic eddy current technology to monitor vibration is used.

The data from the sensors is received by Arduino, which processes it before sending it to cloud storage. The result is then kept in the local centre, where users can receive the alert message and utilise it to manage the applications.

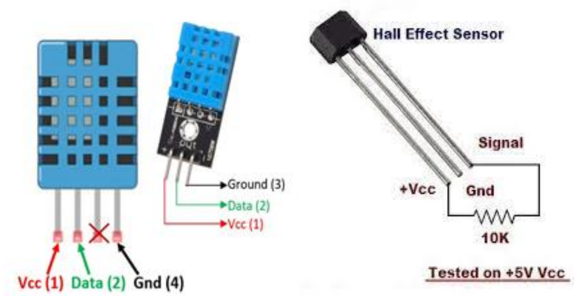

Fig. 2. DHT11 sensor

Fig. 3. PZEM-004T

3) Liquid Crystal Display (LCD)

The data obtained from the sensors is shown on a 16*2 LCD display in this project. It has a total of 16 pins. The LCD's backlight is controlled by the Anode and Cathode pins. The LCD contrast and brightness are controlled by Vo (LCD Contrast). We can fine-tune the contrast by using a simple voltage divider and a potentiometer. The R/W (Read/Write) pin on the LCD is used to regulate whether you're reading or writing data to the display. To distinguish commands from data, the RS (Register Select) pin is used. The R/W (Read/Write) pin on the LCD is used to regulate whether you're reading or writing data to the display. The display is turned on using the E (Enable) pin. The pins D0-D7 (Data Bus) carry the 8-bit data we deliver to the display.

Fig. 4. LCD

4) Relay

A 5V relay is utilised in this project, which is directly connected to the Arduino. The Arduino's pulse signal is sent to the relay. If the sensor data has an aberrant value, Arduino identifies it and sends a command to the relay. A single pole single throw relay was employed in this project. NO (usually open), NC (normally closed), 5V, GND, and the common pin are the five pins on the relay. The relay does not require an additional power supply because Arduino supplies adequate power. The relay operates on the electromagnetic principle, which means that when power is applied to it and the state of the switch is changed, the relay functions as an electromagnet, controlling the device linked to it.

Fig. 5. Relay

4. Implementation

This project involves utilising an ESP32 microcontroller to monitor and control an induction motor via the Internet of Things (Internet of Things).

The ESP32 has 39 digital pins in total. The remaining 34 pins can be utilised as GPIO, while the rest are used as input pins only. It has 18 channels for 12-bit ADC (Analog to Digital Converter) and two channels for 8-bit DAC (Digital to Analog Converter) (Digital to Analog Converter). It also has 16 PWM output channels, two I2S interfaces, three UART interfaces for TTL communication, three SPI interfaces, two I2C interfaces, and ten capacitive sensor GPIOs for detecting induced fluctuations.

Multiplexing is a feature of the ESP32 that allows the programmer to use any GPIO pin for PWM or other serial communication through the programme.

I2C technology is used to link the LCD (Liquid Crystal Display) 16*2 line to the ESP32. The PCF8574T Remote 8bit expander for I2C bus is used to connect the LCD to the I2C bus. The LCD's SCL (Serial Clock pin) and SDA (Serial Data pin) are linked to pins 17 (GPIO22) and 14 (GPIO21) of ESP32.

The PZEM-004T V3.0 or Version 3 energy meter is connected to the ESP32 via serial communication (UART). The TX pin of the PZEM-004T V3 is connected to the ESP32 microcontroller's 8th pin (GPIO16), while the RX pin of the

PZEM-004T V3 is attached to the 16th pin (GPIO17) of ESP32 microcontroller. The PZEM-004T energy meter is connected to the ESP32 hardware via serial2. The data is sent serially to the ESP32 with a 9600 baud rate via the PZEM-004T. The DHT11 sensor measures temperature and humidity and is linked to the ESP32's 4th pin (GPIO15). The displacement sensor (vibration sensor) is attached to the ESP32's 34th pin (GPIO13). And the load is connected to the ESP32's 5th pin via a +5V Relay. To measure the motor speed, a speed sensor is linked to the RX0 pin on the ESP32.

There are several techniques for controlling the speed of an induction motor, however the SCR (Silicon Controlled Rectifier) is used in this suggested work to regulate the speed of an induction motor. Ac motors' speed may be easily adjusted by manually varying the stator voltage with the use of an SCR.

The SCR controller's OUT terminal is connected to the PZEM-004T's 48th pin and relayed through a current transformer (CT). CT is attached to PZEM-004T's 5th and 6th pins. To measure voltage and current, the SCR's COM terminal is linked to the PZEM-004T's 7th pin and the motor.

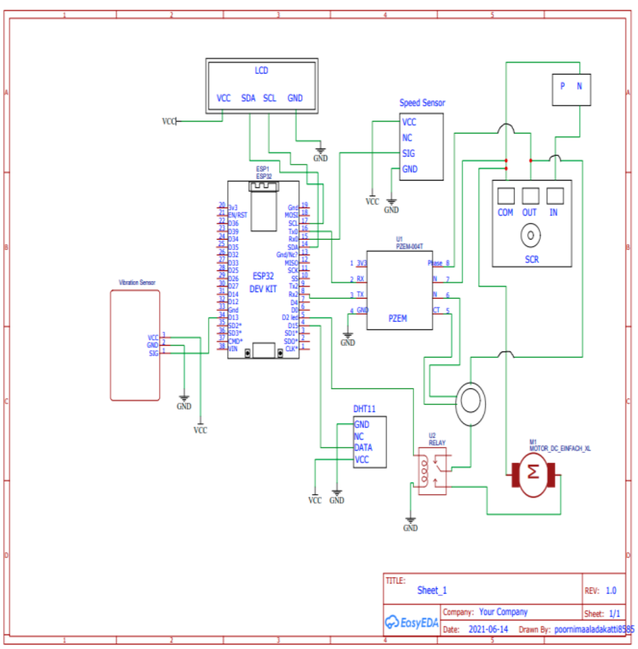

Fig. 6. Schematic block diagram for the proposed simulation model

A. Flow Chart

The flow of data can be sensed the steps involved in the implementation phase. The figure 7 shows the flowchart of the proposed system.

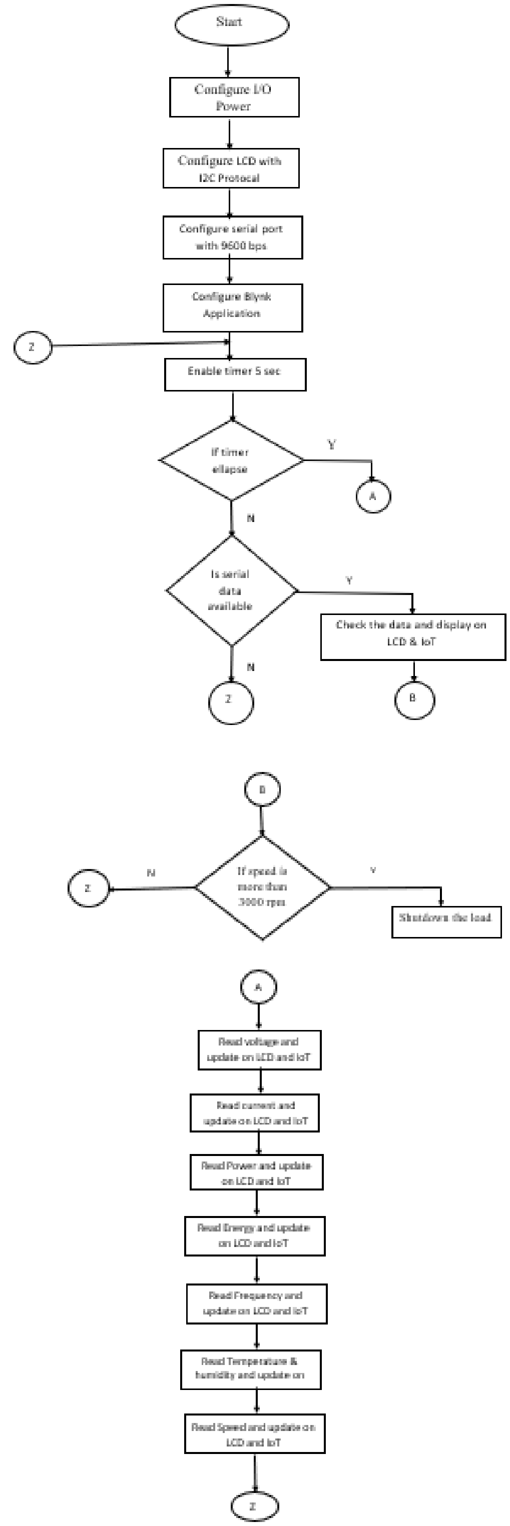

Fig. 7. Flow chart of the proposed system

5. Conclusion

In this paper the concept of Internet of Things for early detection and monitoring of motor system failures remotely. The system has the ability to combine various sensed parameters in real time and improve accurate detection of different faults occur in motor. The monitoring of the motor system presents the measurement of different parameters namely vibration of the motor, temperature, speed, surrounding humidity, supply voltage and motor current. Thus, compared to other conventional methods this system has more number of fields which enables alarm, alert messages and quick controlling. The concept of IoT is presented here for remote monitoring and controlling the motor. By using visual basics, the data received from the controller node represent by graphically. The data is also displayed serially. The work is updated to extra fields for precious control. The application of the system is needed today for every electrical system (i. e EV vehicle and automation of industries where greater safety is needed). The system has the specific advantage less maintenance, easy and quick controlling and accessing of data remotely. Experimental results confirm the feasibility of the implementation of the system.

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