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Retraction

Retracted: Monitoring of Single-Phase Induction Motor through IoT Using ESP32 Module

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Manipulated or compromised peer review

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] A. Shukla, S. P. Shukla, S. T. Chacko, M. K. Mohiddin, and K. A. Fante, "Monitoring of Single-Phase Induction Motor through IoT Using ESP32 Module," *Journal of Sensors*, vol. 2022, Article ID 8933442, 8 pages, 2022.

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Research Article

Monitoring of Single-Phase Induction Motor through IoT Using ESP32 Module

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The condition monitoring of rotating machines for critical applications plays an important role in reducing downtime. With Industry 4.0, the role of IoT in online condition monitoring of electrical machines has gained considerable significance. The main aim of the paper is the use of IoT for online monitoring of motor parameters like current, temperature, vibration, and humidity and observing its online trending using a web server. Data can be accessed in form of graphs and widgets by visiting the web page. The advantage of this project is the real-time monitoring of the motor from any remote area and in case of any abnormality operating personnel can take necessary steps for preventing complete breakdown. The proposed work can help industry people in online monitoring of motors and in the future work can be extended for fault prediction and classification.

1. Introduction

Condition monitoring of motors is very important, and a maintenance schedule is always implemented for every electrical machine. In the proposed work with the use of IoT technology motor parameters like temperature, current, voltage, and vibration can be accessed wirelessly. All these parameters can be analyzed by operator from anywhere and in case of any fault condition alert can be raised. IoT based condition monitoring when joined with machine learning can help in classification and prediction of faults. Electrical motors are work horse for any industry [1, 2]. Electrical motors have to be maintained and monitored on regular basis. Breakdown or faults in such rotating machines can hamper the industry in various ways. Proposed method of monitoring motors can be used for real time parameter monitoring of motors and to generate regular notification in case any parameter shoots up from its regular value [3, 4].

2. Related Work

In reference to various research papers, IoT technology is already being used for data collection and fault prediction of electrical motors. In this method, development boards like Arduino, Nodemcu, and Raspberry-pi are used as processor, and various sensors are interfaced with them for data collection. With the use of Wi-Fi modules, all the parameters can be stored in cloud [1, 5–8]. In reference paper [4], Nodemcu has been used for acquiring motor parameters for traction drive and upload it in cloud.

Other work done in this field is condition monitoring of motors using GSM modules and radio frequency

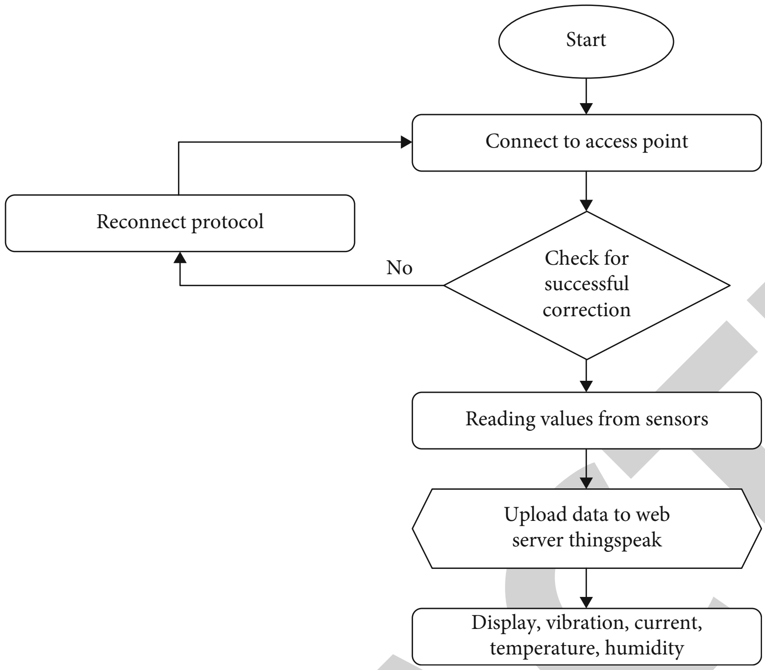

Figure 1: Flowchart showing entire process.

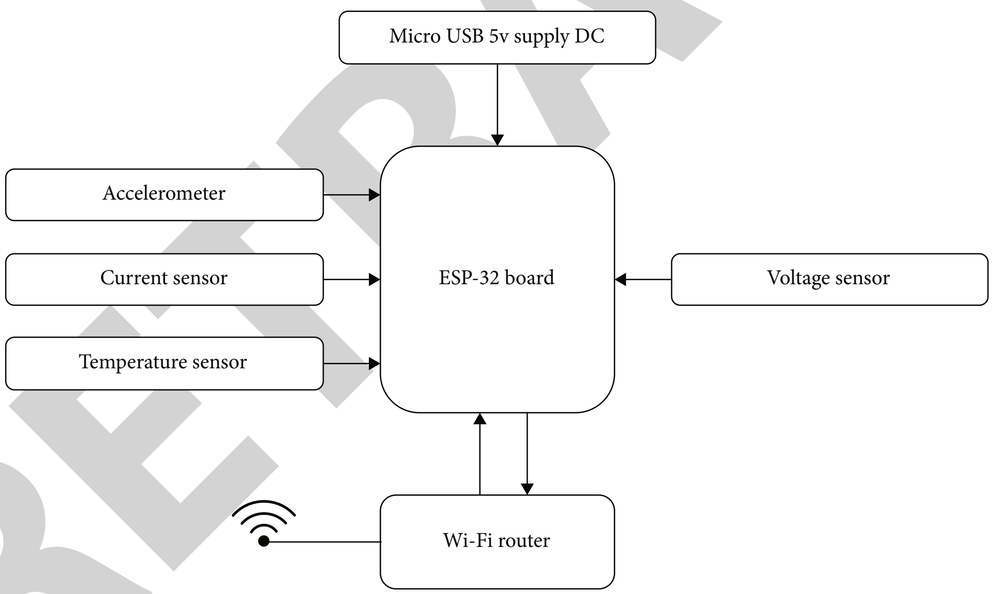

Figure 2: Block diagram of hardware.

Table 1: Motor rating.

Name	Power	Speed	Voltage	Frequency
1PH induction motor	320 W	1350 RPM	220 V	50 Hz

waves [9, 10]. Hardware module consists of printed circuit board, and along with these, sensors, ICs, and processors are mounted. Data collected is sent to control and monitoring room. Hence, operator can go through all the real time data and can take decisions as per requirement [2, 3].

In most of the previous work done, sensors that have been used for parameter collection are ADXL 345, ACS 7212, and LM 35 as acceleration, current, and temperature sensors, respectively [8, 11]. In contrast to it in reference paper [9], piezoelectric transducer is used to collect vibration data for motors and storing it in cloud using Nodemcu.

In reference paper [10], it can be analyzed that after data acquisition, various fault detection methods can be adopted, and it has been concluded that MCSA method is best for fault detection in electrical motors [12, 13]. Motor current signature analysis is a popular predictive maintenance tool

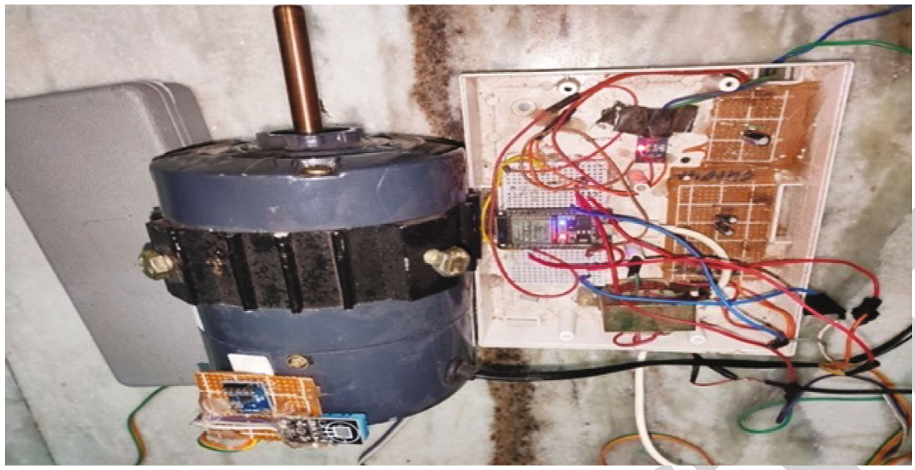

Figure 3: Experimental setup.

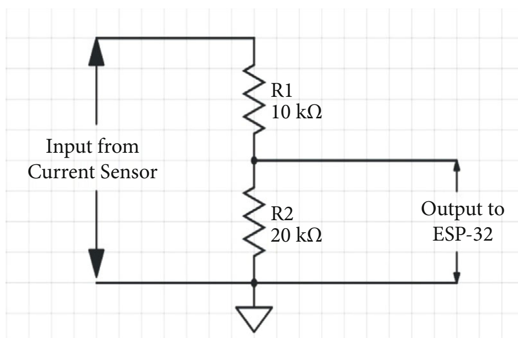

Figure 4: Signal conditioning circuit for 5-volt reference to 3.3 volt.

for electrical motors, and it mainly uses current spectrum for analysis [14, 15].

3. Proposed Work

In the proposed work, ESP32 board is used as processor. Sensors used for collecting parameters are DHT 11, ACS 712, and ADXL 345. Data collected from various sensors are uploaded to cloud using THINGSPEAK platform. All the live data of parameters can be seen using IoT platform inform of graphs and widgets [16, 17]. Assembled hardware has been used with a single-phase induction motor, and results were discussed for it. Figure 1 explains the flowchart for entire process in the proposed work. When the supply is given to ESP32 board, it connects with the access point [18, 19]. The sensors connected to motors start delivering signals to GPIO pins of ESP32 board. As real time data gets uploaded to cloud operator in the field can monitor current, vibration, temperature, and humidity of motor from any part of world with only requirement of internet in laptop or smart phone [20, 21].

Operating personnel working on the motor can monitor the data in real time. In case, any of the parameter magnitude crosses the limit [22, 23]. Operator can start the shutdown process which will prevent the machine from having complete breakdown. With things, speak cloud platform limits can be set for each field [24]. If in any abnormal condition the parameter value of motor increases and breaches the set limit then an alert or notification can be sent to operator. Such protocol can play very important role for protection of motors [25, 26].

Prediction of faults and its classification of industrial machines can also be possible. The real time data from motors can be given to trained artificial neural network, and the output of the ANN model will be the prediction of fault and its type [27]. If the fault is of incipient stage, machine can be scheduled for maintenance. In future, the proposed work can be expanded for having fault prediction and its classification for various motors.

4. Block Diagram of Hardware

Figure 2 shows the block diagram which explains the interconnections between the sensors and processor. Block diagram also elaborates the type of sensor and data which has to be collected from motor. The ESP32 module is powered with a 5 V 2A adapter.

4.1. Development Boards and Sensors

4.1.1. ESP32. ESP32 is a series of low-cost, low-power system on a chip microcontroller with integrated Wi-Fi and dual-mode Bluetooth [28]. The ESP32 board has 15 ADC pins, and each pin has 12-bit resolution with range from 0 to 4095.

4.1.2. Current Sensor. A hall effect current sensor called the ACS712 is used to measure current. It is both cost-effective and provides a precise solution for AC and DC current detection. Its output sensitivity ranges from 66 to 185 mV/A. A hall effect current sensor called the ACS712 is used to measure current [29]. It is both cost-effective and provides a precise solution for AC and DC current detection. Its output sensitivity ranges from 66 to 185 mV/A.

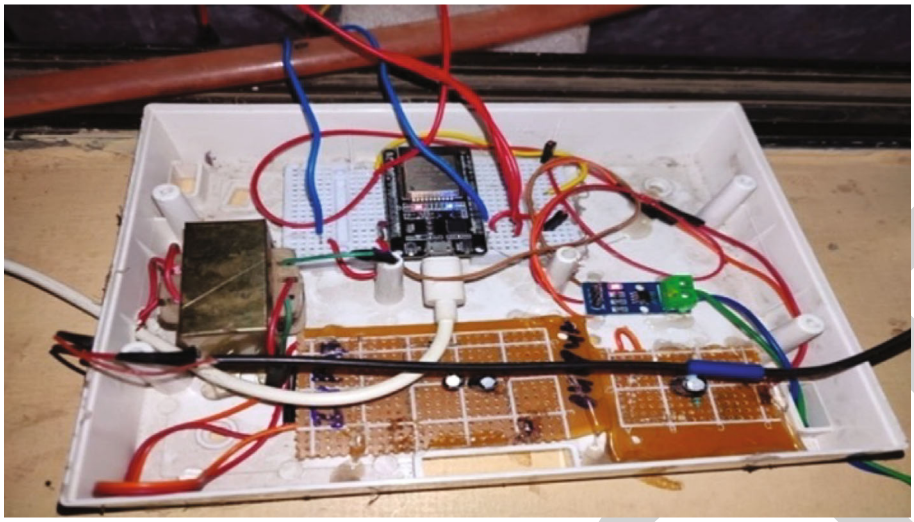

Figure 5: Assembled circuit.

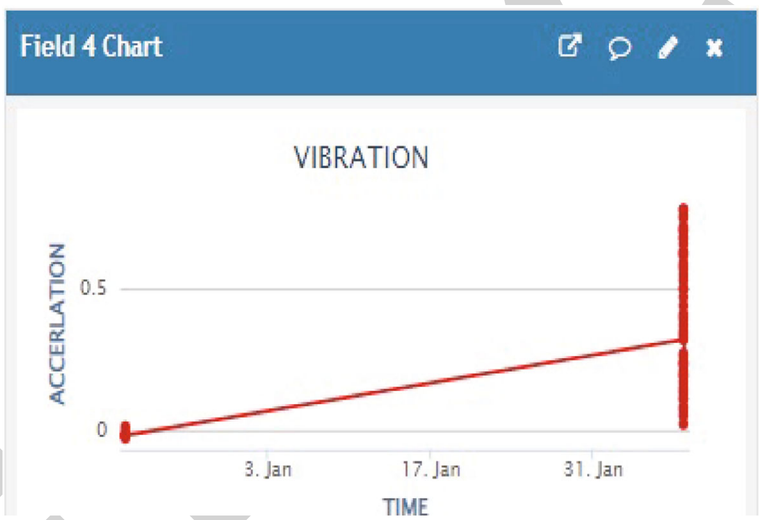

Figure 6: Vibration graph of motor.

4.1.3. Vibration Sensor. The vibration sensor or accelerometer utilized is the ADXL 335, a tiny, thin, low-power, three-axis accelerometer with signal-conditioned voltage outputs. It has a 3 g range and measures full scale acceleration. Both static and dynamic accelerations are measured. This is where the dynamic acceleration caused by motion, shock, or vibrations is monitored. Different bandwidths for three axes can be chosen depending on the application [30]. The X and Y axes have bandwidths ranging from 0.5 Hz to 1600 Hz, while the Z axis has bandwidths ranging from 0.5 Hz to 550 Hz. It displays three values for each of the three axes that represent motor vibrations. Vibrations are measured based on the values acquired in three axes.

4.1.4. Voltage Sensor. A voltage sensing circuit measures the voltage and creates an output voltage that meets the Wi-Fi board's requirements. A 230 V/12 V potential transformer is employed, and the output is converted to DC via a rectifier when needed. The rectifier output is rippled out using a capacitor [31]. The output remains high enough to be transmitted to the microcontroller. As a result, a potential divider circuit is utilized to obtain the requisite voltage of 5 V, which is then fed into the ESP32.

4.1.5. Temperature Sensor. The DHT11 is a temperature and humidity sensor that is widely used. The sensor includes a dedicated NTC for temperature measurement and an 8-bit microprocessor for serial data output of temperature and humidity values.

4.1.6. Single Phase Induction Motor. A single-phase squirrel cage induction motor for testing purposes and its rating is shown in Table 1.

4.2. Technology Used. In this research, the Internet of Things technology (IoT) is used to monitor an induction motor. In IoT (Internet of Things), the Internet of Things (IoT) is a network of smart devices and things that are equipped with

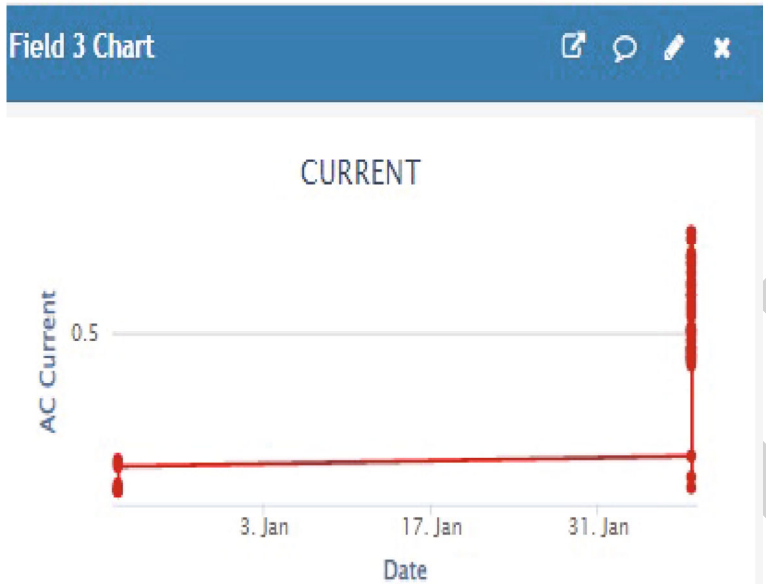

Figure 7: Current intake graph of motor.

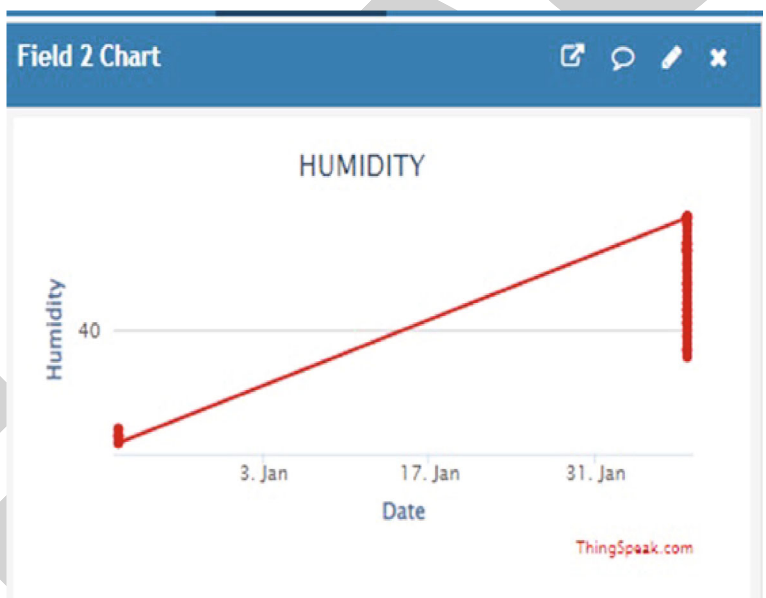

Figure 8: Humidity graph of motor.

various sensors and network to gather and transmit data. In IoT/cloud platform, the IoT platform is the heart of the Internet of Things architecture, as it connects the physical and virtual worlds, allowing items to communicate with one another [32]. Thing speak is a cloud platform by Math Works. It has been used as the IoT platform in this research. It generates graphical displays for data uploaded to the platform by devices in real time. Thing speak is frequently used for prototyping and proof of concept IoT applications.

5. Experimental Setup and Assembly

Figure 3 shows the experimental set up developed in this research work. The goal of real time monitoring of 1-pH induction motor is done by continuously monitoring the parameters with the use of different sensors [25]. Current sensor ACS 712, ADXL acceleration sensor, DHT 11 temperature sensor, and voltage sensor circuit are used to sense parameters RMS current, vibration, temperature, and voltage, respectively. All the data sensed will be in accordance with the instruction coded to ESP32 module.

The ESP32 module has fifteen ADC pins, and it can sense voltage between 0 volt to 3.3 volt. Corresponding to this range value can be assigned between zero to 4095. The analog input has 12-bit resolution. The data collected can be analyzed and stored in cloud using ESP32 module [17]. There are various general purpose input output pins in ESP32 module which can be used for reading and writing

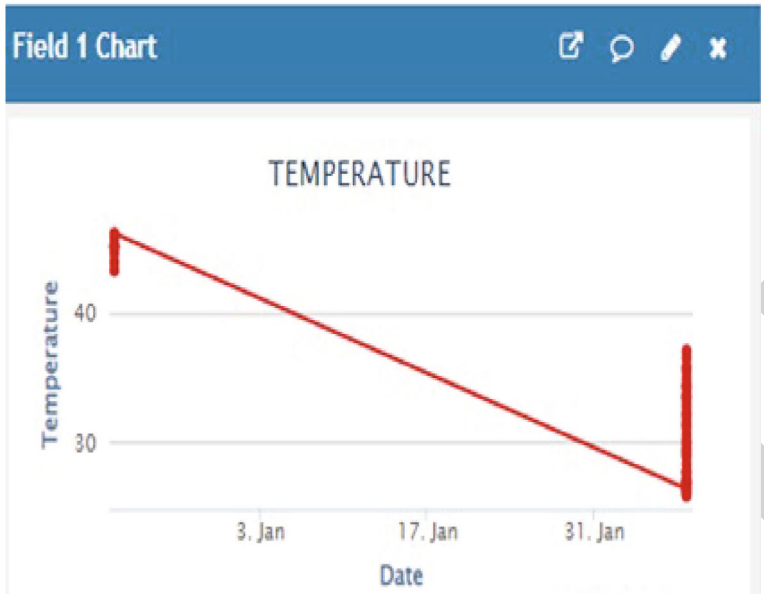

Figure 9: Temperature graph of motor body.

data. For storing the data in things speak platform account is to be created, and a new channel is generated. Number of fields has to be chosen proportional to the number of parameters under monitoring. Each field is being given with its own parameter and then it can be visualized using various graphical forms. In this work, parameters of healthy motor and abnormal motor have been shown and compared. User with this system can visit things speak website and can monitor the motor anytime from anywhere [18, 19]. In case of any abnormal operation, emergency protocol can be implemented and motor can be turned off [22]. Hence, such systems can improve the longevity and reliability of rotating machines.

6. Formula Used for Data Sampling

6.1. Sampling of AC Current Data. AC current withdrawn from induction motor is sensed using hall effect current sensor. The output voltage coming from sensor is converted to voltage under 3.3 volts. Signal conditioning circuit for the reference voltage conversion is shown in Figure 4.This is done because the reference voltage for ESP32 for reading analog values is 3.3 volt only. As mentioned, ESP32 is a 12-bit ADC hence scale for resolution is kept from 0 to 4095. ACS 712 05B module has sensitivity of around 185 mV. The formula used for calculation of RMS current is mentioned below.

$$I_{\mathrm{RMS}} = \sqrt{\frac{(I_{\mathrm{SUM}}/\text{Measurement Count})}{4095 \times (3.3/0.185)}}\,\text{Amps}. \quad (1)$$

6.2. Sampling of Vibration Data. ADXL 335 GY-61 sensor is used to detect vibration in motor. Initially, the sensor is calibrated, and the error is subtracted from the expression of main equation. The GY-61 sensor used in this work has a sensitivity of 330 mV per G. The formula used for calculation of acceleration is given below.

$$\text{Acceleration} = \left\{\frac{((\text{sensor output} \times 3.23)/4095 - 1.47)}{0.33}\right\} \text{M/S}^2. \quad (2)$$

6.3. Sampling of Temperature and Humidity Data. The instruction code uploaded to ESP32 uses DHT 11 library for getting data values and for updating it in regular intervals. DHT-11 sensor provides temperature and humidity data using its data output pin [11]. The single wire two-way communications are used for data retrieval process.

6.4. Sampling of Voltage Data. The output of voltage sensor circuit is given to ESP32 module. The ESP32 module reads the output from sensor within the scale of resolution from 0 to 4095, and the reference voltage is 3.3 volt. The transformer converts 240 V to 12 V, and the secondary is connected to arrangement of rectifier with zener diode. Five-volt logic across zener diode is reduced to proportional 3.3 V, and the logic is given to ESP32 module ADC pin [9]. As the single-phase supply varies, the logic level to ESP32 module also changes in reference to 3.3 V. As per the formula given in the code single phase voltage gets recorded and stored in cloud IoT platform.

7. Experimental Results

Figures 3 and 5 show the entire assembled circuit set up. The developed code is uploaded to module. Sensors are interfaced to ESP32 board. Once the module is powered up, it gets connected to internet, and sensors start accumulating the data. All the data is sent to things speak IoT platform and user can monitor the parameters with the help of graphs and widgets. From Figures 4–8, various graphs are shown below, and the parameters that can be monitored are current, temperature, humidity, vibration, and power. From the graphs, it can assessed that x axis comprises of date, and y axis comprises of the magnitude of the parameter. When the system turns on, the dark red dotted points on the graph show present value of the parameter. The straight-line which traces with in the various dates shows the changes by comparing the present-day status with the last period when system was turned on. Hence, it should not be concluded that graphs are linear in nature. The present value of parameter can be seen by tracing the latest entry of red dark dot and by double clicking with in it the graphical display becomes more dynamic as it shows minute by minute entry of data from the sensors.

With all these parameters, any threshold limit can be set and if the set limit for any required parameter is crossed then notification or alert can be sent to the operator using IoT platform. Therefore, it can be assessed that such systems can be used for real time monitoring of various electrical machines.

ADXL sensor is used for retrieving vibration data from motor. Sensor is placed on top of the motor body and as soon as motor starts values from the sensor can be seen on graph. ADXL sensor measures acceleration in x, y, and z -axis in g unit. From the graph Figure 6, motor had present vibration value of 0.71M/S^2.

Single phase induction motor current data is retrieved from current sensor ACS 712. From the graph Figure 7, current magnitude is approximately one ampere. The ACS 712 sensor has an output error percentage of around ±1.5%.

Temperature and humidity data are taken from DHT 11 sensor which has been mounted on motor body. As the motor started temperature value started increasing, this happens as winding of the motors starts heating up with the safety insulation point. After a certain point temperature of the motor body reaches a saturation value of around thirty-nine-degree Celsius (Figure 9), DHT 11 humidity sensor can measure from twenty percent to eighty percent range with accuracy of five percent.

8. Conclusion

In this paper, a single-phase induction motor has been monitored in real time environment. All the important parameters can be visualized using things peak platform. Any deviation of parameter can be seen by operating personnel, and necessary action can be taken for improving longevity of motor. In future, such methods can be used for data acquisition from industrial motors, and at the same time, all the data set can be given to ANN model for fault prediction and classification. Processor such as raspberry pi can be used for data collection and running ANN algorithm. ANN is used for achieving fault prediction and classification. The proposed research mainly contributes in collection of important motor parameters and provides means of its monitoring through cloud platforms. The proposed research also contributes in planning effective maintenance schedule of motors. The developed IoT based method is very effective in having real time monitoring of motors.

Acronyms

IoT: Internet of Things
MCSA: Motor Current Signature Analysis
ANN: Artificial neural network
RMS: Root mean square
DHT: Digital temperature and humidity sensor.

Data Availability

All data used to support the findings of this study are included in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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