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Condition monitoring and control of an Induction motor based on IoT

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Abstract –Induction motors are one of the most widely used motors in the world. They find many applications in domestic and industrial processes. Though electrical machines are considered to be rugged they like any other machines are prone to faults and damage instead of just tripping or repairing in case of faults resulting in higher downtime and lessening reliability predictive maintenance can lead to timely precautions and maintenance avoiding downtime and increasing reliability. This can be done by condition monitoring using various sensors. Also, it is highly desirable to control speed of induction motor remotely avoiding physical controls resulting in power consumption and lesser effort.
The paper proposes a system for condition monitoring of induction motor using various sensors like temperature, humidity, speed, vibration, voltage, current and sensed values or data is sent to cloud and logged in database. Also speed of the motor is controlled remotely using a microcontroller and Wi-Fi module interfaced with it.

***Key Words*:**IoT, induction motor, condition monitoring, control, cloud computing

1.INTRODUCTION

Induction motors are rugged powerful and ubiquitous. They are used in domestic, industrial and automotive sectors widely. They are reliable, economical and can be used in any environmental conditions.

Three phase induction motors are used in drilling machines, agricultural pumps, lifts, cranes etc and single-phase induction motors are used in low power applications. They consume more than half of the total energy generated in the world like any other machine or a device they are prone to faults and defects and it is imperative to find methods to improve efficiency and performance of induction motors.

Faults in induction motors are classified as Internal and external, electrical and mechanical, stator and rotor faults. Variety of faults in induction motors are broken rotor bars, stator winding, faults, phase imperfection, eccentricity etc.

Usually condition of large induction motors is evaluated periodically but due to varying operating and environmental conditions induction motors condition may deteriorate at irregular intervals leading to unexpected breakdowns and higher downtime. Condition monitoring of induction motor can be used for predictive maintenance and thereby enhancing productivity, reduce damages both internal and external and lead to increasing lifetime.

It aims at predicting the schedule of maintenance beforehand by evaluating the motor condition.

The traditional induction motor condition evaluating method involves crew members inspecting and relies on human diagnostics based on temperature, vibration, smell, noise etc. This maylead to false diagnostics and these symptoms are prone to noise for unnecessary sources.

Then for these needs a system to record all the variables like temperature, current, voltage, speed, vibration that can be used to evaluate condition and predict future failures that is minimalistic and easy acceptable.

2. PROPOSED SYSTEM

The proposed system consists of sensors to sense variables like motor voltage, current, ambient humidity, temperature, rotor vibrations, speed and the sensed data using sensors is sent to cloud and visualised in an IoT platform by using a microcontroller and Wi-Fi module. Also system has provision to send control signals to microcontroller to remotely to vary the speed of motor remotely.

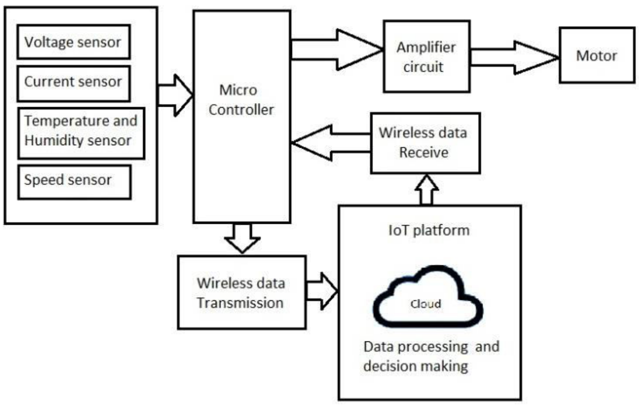

Fig -1: Block Diagram

3.SYSTEM DESIGN

3.1 Sensors

Temperature and humidity sensor

A single sensor module DHT11 is used to measure both temperature and humidity. It is interfaced to microcontroller. Its output either digital or analog value uses resistive humidity measurement component and NTC temperature measurement component. Its operating voltage is 3.3 to 5.5V and consumes 0.3 to 5.5mA. Sends data by serial data transmission has 16-bit resolution.

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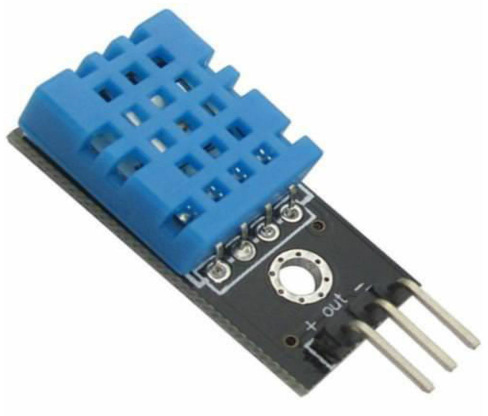

Fig -2: Temperature and Humidity

SW-420 vibration sensor

The module has a comparator to compare the vibration need with the threshold and a potent meter to adjust sensitivity of the sensor outputs digital output logic low when vibration is below threshold and logic high otherwise. It operates at voltage of 3.3 to 5V. It also has an onboard LED to indicate if the value is above threshold. It is interfaced to the microcontroller serially.

Fig -3: SW-420 vibration sensor

IR speed sensor

Put near rotor bar to find speed in RPS. It has groove coupler sensor; width of groove is 5mm. whenever the slot is obstructed the sensor outputs high value and if an obstructed it outputs digital low. It also has onboard LED which turns on and off based on whether slot is obstructed or not. Works in the voltage range 3.3 to 5V. It has onboard LM393 comparator.

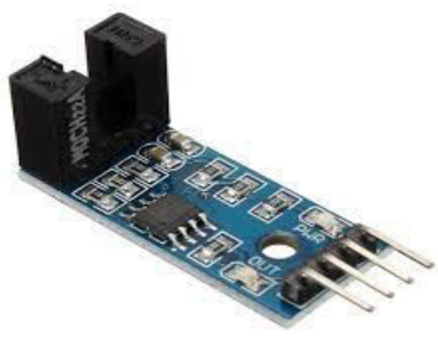

Fig -4: IR speed sensor

ACS 712 current sensor

The device has a precise, linear hall sensor circuit with a copper conduction path. Applied current flows through this see conduction path and generates magnetic field and it is sensed by a hall IC integrated in the device and their converts into proportion voltage. It needs 4.5 to 5.5V and 10 to 13mA. It has 66 to 185mV/A output sensitivity.

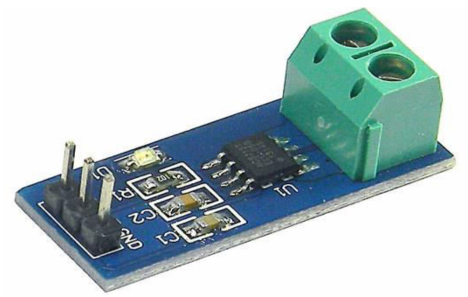

Fig -5: ACS 721 current sensor

ZMPT 101 voltage sensor

It is based on ZMPT101B voltage transformers can measure up to 250V AC voltage. It has multi turn trim pot for adjusting analog output. It operates at voltage of 5 to 30V.

Fig -6: ZMPT 101B voltage sensor

3.2 Wireless data transmission

The variable values sensed by the sensors are initially read by microcontroller and then are sent to cloud by connecting to the internet using ESP 8266 Wi-Fi module. It embeds L106 32-bit RISC microprocessor core based on tensilica microcontroller. It has 32KB each for RAM and instruction cache. It has 16 GPIO pins and supports I2C, SPI and UART serial communication standards. It has also PWM capability. The core runs at 80MHz. It also has 64KB ROM. It can access internet by connecting to Wi-Fi using SSID and password of router. It provides Wi-Fi capability to microcontrollers. It uses TCP/UDP protocol to communicate with server or client. Using AT commands, we can communicate with ESP 8266 module and control data sending and receiving. It uses on 3.3V. It has two SMD LED indicators for power and data transmission.

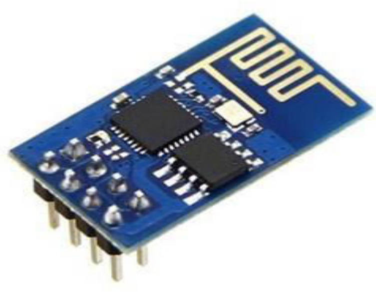

Fig -7: ESP 8266 Wi-Fi module

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3.3 Data logging

Data from sensors is sent to IoT platform Thingspeak for logging and insulation. Thingspeak is an open IoT platform with MATLAB analytic. It is used to collected data and data is stored in database. The data collected is also visualised in custom format. It also provides applications to trigger a reaction based on data. To send and visualise data within the platform we need to enter a channel and each channel has 8 fields to represent 8 different variables.

The data sent to various fields using commands which in turn are send to ESP8266 by microcontroller can be visualised in the form of graphs with time on X-axis and sent data on Y-axis. Data is stored in CSV files which can be imported or accessed from any other website or application.

The sensor values are stored in the form of key value pairs. The data can also be viewed in mobile application of the IoT platform.

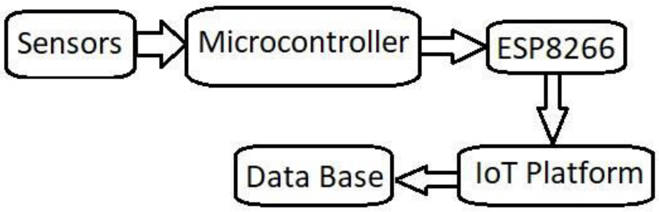

Fig -8: Data flow

3.4 Induction motor control

Induction motor is controlled using node MCU and thingspeak IoT platform development board is an open source platform. It has onboard ESP8266 and a single analog pin. It also has eight digital pins on its board, supports serial communication protocols like UART, SPI, I2C etc. It can be used along with arduino IDE to develop IoT applications.

To control induction motor, we create a separate channel in thingspeak and we can manually enter data into the channel using write APIURL provided for each channel. The value can be from 0 to 1024. The value updated in IoT channel is read by using node MCU. The value read is converted into corresponding output voltage that is supplied to motor. Since the node MCU can generate maximum of only 3.3 the control signals are amplified up to 10v using op-Amp and op-Amp is then controlled to motor. The speed of motor depends on the voltage outputted by node MCU which in turn depends on the valued entered into the channel

Fig -9: node MCU

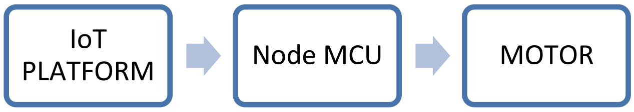

Fig -10: motor control using node MCU

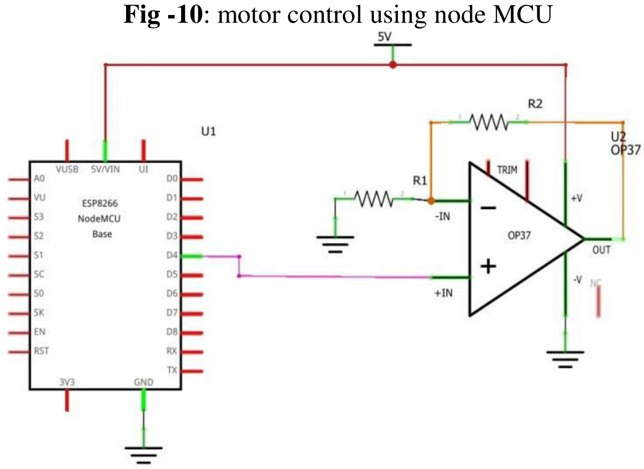

Fig -11: motor control circuit

3.5 Microcontroller

Arduino Uno development board is used in the system. It has an onboard ATmega328 microcontroller IC that has features like timers, counters, interrupts, PWM, I/O pins and based on a 16MHz clock. It has 14 digital I/O pins and 6 analog pins and has a resolution of 10 bits. It also has an on-chip ADC. The GPIO pins come with rating between 20 to 40mA.

It is programmed using Arduino IDE which uses C and C++ languages for creating programs. It is a cross platform software application and converts code into text file using hexadecimal encoding and loaded into board. It has many inbuilt libraries for seamless coding.

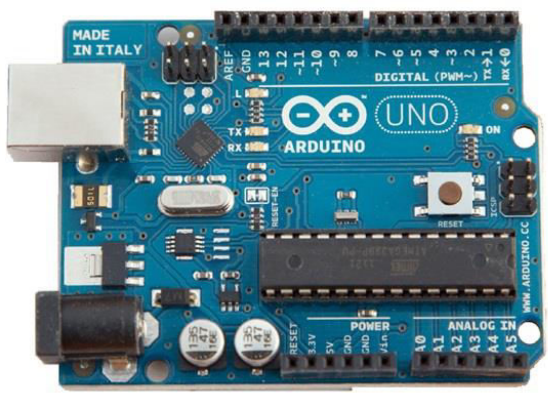

Fig -12: Arduino Uno

4. RESULTS

Data has been collected from the sensors and send to cloud successfully. The values are visualized in the IoT platform in graphical format. Motor is being controlled successfully and speed is varied wirelessly.

Fig -13: Temperature and humidity values

Fig -14: Voltage and Current values

Fig -15: Speed values

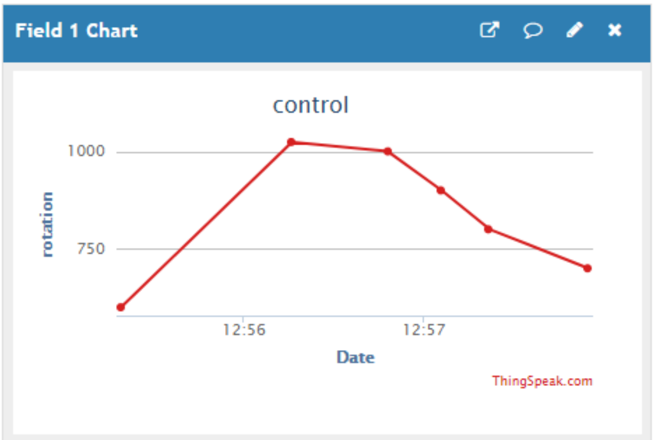

Fig -16: Speed Control through thingspeak

Table -1: Sensor Values

Temperature	Humidity	Voltage	Current	Speed
29.8	61	228.72	0.22	1458
28.7	62	227.84	0.23	1389
30.1	59	236.621	0.25	1247
31.4	56	227.84	0.33	1064
30.9	54	228.72	0.38	873

5. CONCLUSION

By using the proposed system, the variables like temperature, humidity, voltage, current, speed etc. upon which motor performance and depends, can be monitored remotely. It prevents any external noises from influencing the decision making and data can also be logged for reference in the future.

We can improve the system by automating of motor on or off depending on sensor values and also, we could feed data collected to prediction algorithms to predict future outages and maintenance schedules.

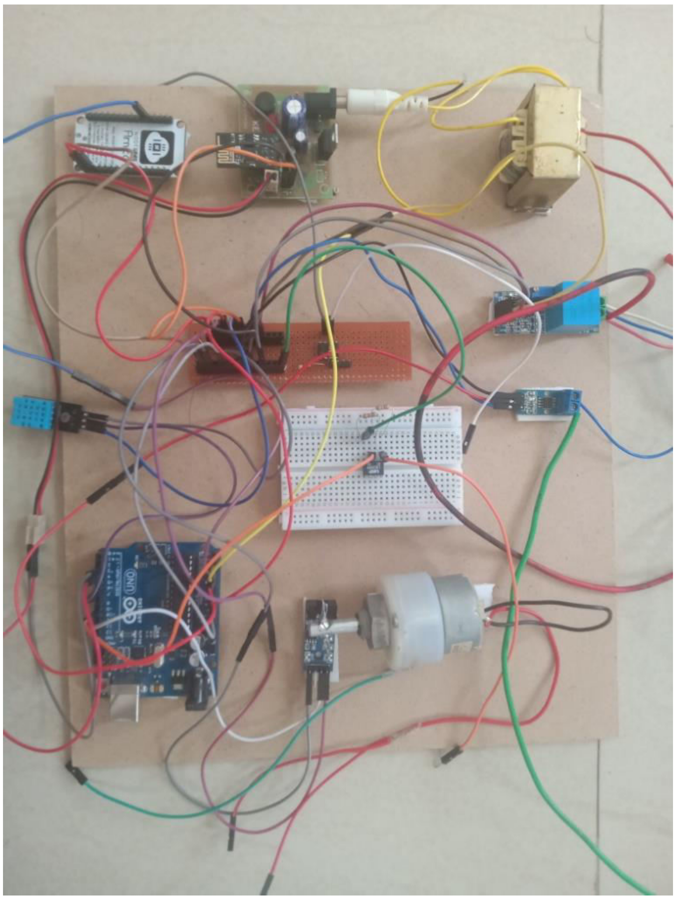

Fig -17: Practical setup

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