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IOT Based Induction Motor Health Surveillance System by Detecting Vibrations and Monitoring Temperature

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Abstract:

To extend the security, lifetime, and vitality effectiveness of engines, the energetic behavior of the turning shaft must be examined. Shaft vibrations must be checked amid operation in arrange to optimize rotor plan and certify engine execution. Moreover, the energetic behavior of the rotor must be assessed. Shaft vibrations must be measured amid operation in arrange to optimize rotor plan and approve numerical models. Be that as it may, measuring the shaft's vibration amplitude and recurrence may be a troublesome issue for metrology since the shaft turns and noncontact estimations are essential. To fathom this issue, we show a estimation framework comprising of vibration sensor SW-420 and NodeMCU ESP8266 must be mounted on engine. These sensors simultaneously measure the vibrations produced as well as heat produced by motor. Temperature sensor DHT11 is also used to track the heat produced by the motor so that it would not exceed the range given for prolong usage of motor. The NodeMCU ESP8266 connects to a ThingSpeak server through Wi-Fi to transmit the values in real-time the server stores and displays the data on a graphical dashboard, allowing users to monitor vibration and temperature. The project demonstrates the feasibility of low-cost and efficient air quality monitoring using readily available hardware and software tools. The results of the experiments show that the developed motor surveillance can provide accurate and reliable measurements of various amplitude, frequency, celius, thus contributing to environmental sustainability and public health.

Keywords: Vibration Sensor SW-420, NodeMCU ESP8266, Temperature sensor DHT11, Thingspeak , Induction motors.

1. Introduction

Vibration, temperature rise, and noise are the three main factors which affect the normal operation of mechanical equipment [1],[2]. The core and source of these three elements is vibration. Getting affected by the damage and aging of parts and components [3], the vibrations are often produced by equipment in the process of operation. Vibration not only brings noise as well as a rise in temperature, but also aggravates the wear of parts and components, thus reducing the operation efficiency of equipment system. If severe vibrations occur, it will damage the running state of the machine and even shorten its service life. Therefore, real time vibration signal detection is very necessary. It can accurately reflect the structural defects, to evaluate the operation status of equipment in operation [4].

NodeMCU is a microcontroller that provides an easy and reliable way to connect devices to the internet [1]. The SW_420 sensor is a vibration sensor that can detect a wide range of vibrations [1], as well as

DHT11 which is a temperature sensor that can detect wide range of temperature in Celsius/ Fahrenheit [5],[2]. The sensors provide real-time data on the motor status. The research work involves the development of a software system that can read the data from the sensor, process it, and display and store the data.[3]

The implementation of the system involves the selection and calibration of the SW_420 sensor, designing the NodeMCU firmware to read the data from the sensor, and using cloud system to display the real-time data [2],[3],[4]. The system is tested and validated in different vibration conditions to ensure the accuracy and reliability of the data. Overall, the vibration monitoring system using NodeMCU, DHT11 and SW-420 sensor is an effective and efficient way to monitor the motor status in real-time. A on a cloud service [5].

The system can help in identifying the damage caused to the motor. tracking the changes in vibrations in motor over time and providing information to owner to take appropriate actions to safeguard the motor The meter calculates the vibrations in amplitude frequency which is then compared to the given healthy level of the motor.

2. Literature Survey:

The research shows how the SW-420 vibration sensor's performance on vibration tools was analyzed using a fuzzy logic method. The SW-420 is an inexpensive, high-sensitivity vibration sensor that is widely utilized in a range of vibration measuring applications. The paper describes the development of a fuzzy logic model to predict the vibration level of a vibration tool based on the output of the SW-420 vibration sensor. The fuzzy logic model was trained on a set of experimental data that was collected from a variety of vibration tools under different operating conditions.

Research done in 2017 describes how to use the Arduino Uno microcontroller and the DHT11 to measure the temperature and humidity in the environment. The DHT11 sensor is a low-cost, user-friendly sensor that can accurately monitor temperature and humidity. It communicates with the Arduino Uno using a single wire, which makes it simple to connect and use [6].

A study done in Birmingham University discusses the use of the microcontroller on IoT. The NodeMCU is a low-cost, open-source development board that is based on the ESP8266 Wi-Fi chip. It is popular among hobbyists and makers because it is easy to use and has a large community of support. The paper discusses the advantages of using the NodeMCU in IoT applications, including its low cost, small size, low power consumption, and built-in Wi-Fi connectivity. It also provides a review of some of the different ways that the NodeMCU is being used in IoT products, such as in smart home devices, environmental monitoring systems, and industrial automation applications [7].

The research paper by Wong C. discusses how to use ThingSpeak, a cloud based analytics platform, and MATLAB, a numerical computing environment, to develop a sensing and monitoring system for the Internet of Things (IoT) [8].

The research paper describes a wireless temperature and humidity monitoring system that is based on the Arduino Uno microcontroller. The system uses a DHT11 temperature and humidity sensor to measure the temperature and humidity of the environment, and then transmits the data wirelessly to a receiver using an nRF24L01 wireless transceiver module. The receiver can then display the temperature and humidity data on an LCD display [9].

The paper by D. Z. Li, W. Wang, and F. Ismail proposes a new technique for monitoring the health of induction motors by detecting faults in the motor's bearings and rotor bars. The technique is based on the analysis of the motor's current spectrum. The authors of the paper tested the spectrum synch technique on an induction motor with a bearing failure and an induction motor with a broken rotor bar. The results showed that the spectrum synch technique was able to accurately identify the faults in the motors [10].

Some research papers discusses the use of CITs to extract knowledge from motor health condition data. CITs are a type of decision tree that is well-suited for handling noisy and incomplete data, which is often the case with motor health condition data. The paper also presents a case study of how CITs were used to extract knowledge from motor health condition data in a real-world setting. The case study shows how CITs were used to develop a diagnostic model for identifying motor failures [11].

The research paper based on eccentricity of induction motor discusses the use of vibration monitoring to detect gap in air eccentricity in huge induction motors. Airgap eccentricity is a misalignment between the rotor and stator of an induction motor, which can cause a variety of problems, including increased vibration, noise, and heat generation. If not detected and corrected, airgap eccentricity can lead to motor failure [12].

Recent research on Stator current and motor efficiency as indicators for different types of bearing faults in induction motors" discusses the use of efficiency of motor to detect different types of bearing faults in induction motors. Bearing faults are the most common type of fault in induction motors, and they can lead to premature failure of the motor. The paper describes how bearing faults can cause changes in the stator current and motor efficiency of an induction motor [13].

The field of Acoustic-excitation optical coherence vibrometer (AE-OCV) for real-time microstructure vibration measurement and modal analysis" discusses a new method for measuring the vibration and modal parameters of microstructures. The method uses acoustic excitation to excite the microstructures and then uses optical coherence vibrometer (OCV) to measure the vibration. OCV is a non-contact optical measurement technique that can be used to measure the vibration of surfaces with a high degree of accuracy. OCV works by measuring the phase difference between two optical beams that are reflected from the surface of the object being measured. The phase difference is proportional to the displacement of the surface [14].

Investigations into Interferometric Sensor System for Blade Vibration Measurement proposes a new interferometric sensor system for blade vibration measurement in turbomachine applications. The system uses four laser Doppler sensors to measure the in-plane velocity and the out-of-plane position of the blade tips. This information can then be used to calculate the vibration amplitude and frequency of the blades [15].

To address the challenge of Research Progress of Mechanical Vibration Sensors" discusses the recent progress in the development of mechanical vibration sensors. Mechanical vibration sensors are used to measure the vibration of objects, and they are widely used in a variety of applications, such as industrial monitoring, condition monitoring, and structural health monitoring. The paper reviews the different types of mechanical vibration sensors, including piezoelectric sensors, capacitive sensors, and strain sensors. It also discusses the advantages and disadvantages of each type of sensor [16].

A recent study discusses the use of slope, humidity, and vibration sensors to monitor landslides. Landslides are a major natural hazard that can cause significant damage to property and infrastructure. Early detection of landslides is essential for preventing loss of life and property. The paper describes the different types of slopes, humidity, and vibration sensors that can be used for landslide monitoring. Slope sensors measure the movement of the ground, humidity sensors measure the moisture content of the soil, and vibration sensors measure the vibrations caused by the movement of the ground [17].

Findings from recent research suggest that discusses a method for predicting the electromagnetic vibration sources of permanent magnet synchronous motors (PMSMs) based on analytical magnetic field calculations. PMSMs are a type of electric motor that is widely used in a variety of applications, such as electric vehicles, industrial automation, and aerospace. PMSMs are known for their high efficiency, high power density, and low noise. However, PMSMs can also be susceptible to vibration, which can lead to noise, reduced performance, and even failure [18].

Evidence supports the claim that the importance of measuring the natural frequency of pipe vibration for vortex flowmeters. Vortex flowmeters are a type of flowmeter that measures the flow rate of a fluid by detecting the shedding of vortices from a bluff body. The frequency of vortex shedding is proportional to the flow rate of the fluid. However, pipe vibration can interfere with the vortex shedding process and affect the accuracy of vortex flowmeters. Therefore, it is important to measure the natural frequency of pipe vibration and design the vortex flowmeter to avoid resonance [19].

The research discusses the development of a low-cost system for measuring the force and vibration of sports shoes. The system uses two types of sensors: the FSR-402 force sensor and the SW-420 vibration sensor. The FSR-402 is a force-sensitive resistor that changes its resistance when it is subjected to pressure. The SW-420 is a vibration sensor that detects the movement of the object it is attached to. The system is designed to be attached to a sports shoe and worn by a human subject. The force sensor is attached to the bottom of the shoe, and the vibration sensor is attached to the upper part of the shoe [20].

The research on Analysis of the Vibration Magnitude of an Induction Motor discusses the relationship between the number of broken bars in an induction motor and the magnitude of the vibration. The paper presents an analytical equation that relates the two variables and validates the equation with numerical and experimental investigations. The paper finds that the magnitude of the vibration increases quadratically with the number of broken bars. This means that the vibration magnitude doubles when the number of broken bars doubles. The paper also finds that the frequency components of the vibration that are of interest are in the range of two to four times the value of the supply frequency [21].

The research paper on Dempster–Shafer theory in fault diagnosis of induction motors using vibration and current signals discusses the use of Dempster-Shafer theory (DST) to improve the accuracy of fault diagnosis in induction motors using vibration and current signals. DST is a mathematical theory of evidence that can be used to combine evidence from multiple sources to make a more informed decision. The paper describes a fault diagnosis system for induction motors that uses DST to combine evidence from vibration and current signals. The system first extracts feature from the vibration and current signals. These features are then used to train classifiers for each type of fault. The outputs of the classifiers are then combined using DST to make a final diagnosis .

The research paper "Bearing fault model for induction motor with externally induced vibration" investigates the relationship between vibration and current in induction motors operated under external vibrations. The paper proposes a bearing fault model that considers the effects of externally induced vibration. The paper describes two approaches for modeling the relationship between vibration and current in induction motors: the airgap variation model and the torque perturbation model. The airgap variation model is because bearing faults can cause changes in the airgap between the rotor and stator of the motor. These changes in the airgap can cause changes in the vibration and current of the motor.It also discusses two algorithms for estimating the running speed and bearing defect frequencies of an induction motor from vibration data. The first algorithm is based on the fundamental frequency of the motor, which is proportional to the running speed of the motor. The second algorithm is based on the characteristic frequencies of the bearings, which are related to the bearing geometry and the number of rolling elements [22].

The research paper on fault diagonistics discusses a method for learning features from vibration signals for induction motor fault diagnosis. The method uses a deep belief network (DBN) to learn features from vibration signals. A DBN is a type of artificial neural network that is well-suited for learning complex patterns from data. The paper describes how the DBN is trained to learn features from vibration signals. The DBN is trained on a set of labeled vibration signals, where the labels indicate the fault type. The DBN learns features from the vibration signals that are discriminative of the different fault types. Once the DBN is trained, it can be used to extract features from new vibration signals. The extracted features can then be used to classify the new vibration signals into different fault types.

The research paper "Vibration analysis of an induction motor" discusses the use of vibration analysis to diagnose faults in induction motors. Induction motors are the most common type of electric motor used in industry, and they are susceptible to a variety of faults, including bearing wear, rotor imbalance, and misalignment. Vibration analysis can be used to detect these faults at an early stage, which can help to prevent motor failure and extend the life of the motor.

3. Requirements:

Hardware-

- Node MCU: NodeMCU is an open-source development board based on the ESP8266 Wi-Fi module that provides a simple way to connect IoT devices to the internet.

- SW-420: The SW-420 vibration sensor is a small, low-cost sensor that can be used to detect vibrations in a variety of applications. It is a normally closed switch, meaning that it is closed when there is no vibration and opens when vibration is detected. The sensor has a sensitivity adjustment potentiometer that can be used to set the threshold at which the sensor triggers

- DHT-11 : The DHT11 is an cheap computerized temperature and stickiness sensor. It measures the encompassing discuss with a capacitive stickiness sensor and a thermistor and yields a computerized flag by means of the information stick (no analog input pins are required). It is straightforward to function, be that as it may capturing information requires exact timing.

Software-

- Arduino IDE -Arduino IDE is an open-source software used for writing and uploading code to microcontroller boards like NodeMCU. It was used in this project for coding the NodeMCU to read and process data from the MQ135 sensor, as well as for calibrating and testing the sensor.

- C++ Language -C++ is the programming language used in the Arduino IDE to write code for the microcontroller. It is a high-level language that is easy to learn and widely used in embedded systems programming.

- ThingSpeak -ThingSpeak is an IoT analytics platform that allows users to collect, store, and analyse data from IoT devices. In this project, ThingSpeak was used to store the air quality data obtained from the MQ135 sensor, and to display the data in real-time using customizable graphs and charts. The data was also made accessible through a publicly accessible URL.

4. Methodology/Experimental

Working:

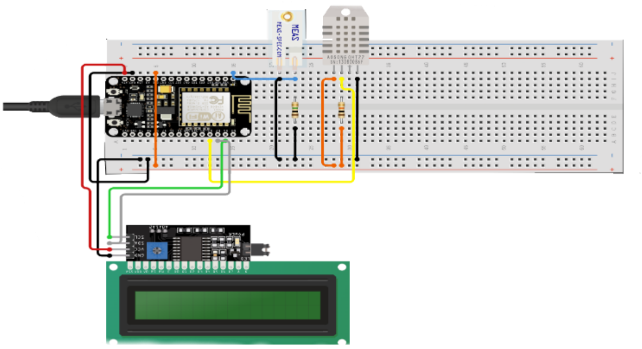

Figure 1 – Circuit diagram

Figure 1 explains the actual circuit diagram of model which we are going to use. This diagram gives you an idea to how and where to connect the pins to each component. In this circuit micro USB cord is used as a connecter for power supply.

The SW-420 vibration sensor is a mechanical switch that is activated by vibration. It has a small metal ball inside that is held in place by a spring. When the sensor is vibrated, the metal ball moves and triggers the switch. This causes the output signal of the sensor to go high.

The sensor has a sensitivity adjustment potentiometer that can be used to set the threshold at which the sensor triggers. This means that you can adjust the sensor to be sensitive to vibration.

Connect the SW-420 vibration sensor to a microcontroller or other electronic device using two wires: one for power and one for the sensor output as shown in Figure 1. Write a program on your microcontroller to read the data from the sensor. When the sensor detects vibration, the output signal will go high. You can then use this signal to trigger an alarm, send a notification, or perform some other action.

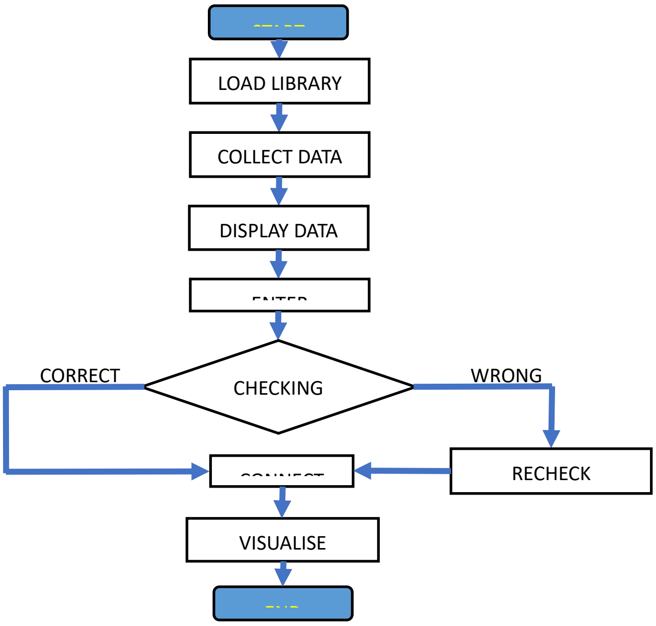

Figure 2 – Flow Chart

Figure 2 – Flow Chart shows us complete logic of project. The DHT11 temperature and humidity sensor works by using a capacitive humidity sensor and a thermistor to measure the surrounding air.

The capacitive humidity sensor is made of two metal electrodes with a moisture-holding substrate in between. As the humidity rises, the substrate absorbs water vapor, which increases the capacitance between the electrodes.

The thermistor is a type of resistor whose resistance changes with temperature. As the temperature rises, the resistance of the thermistor decreases.

To measure the temperature and humidity, the DHT11 sensor sends out a pulse signal. The microcontroller then measures the time it takes for the sensor to respond. The response time is proportional to the humidity, and the resistance of the thermistor is proportional to the temperature.

As shown in Figure 2 – Flow Chart once the NodeMCU board reads the values from the SW-420, DHT11 sensor, it establishes a Wi-Fi connection with the ThingSpeak server using the Wi-Fi credentials. Then, using an API key provided by ThingSpeak, the NodeMCU sends the data to the field.

The ThingSpeak server receives the data and plots it on a real-time graph, which can be accessed via the ThingSpeak website or mobile application. This allows users to monitor the air pollution levels in their area and take necessary measures to improve air quality.

5. Results

Figure 3 – Temp vs Time graph

The Figure 3 shows that the temperature is lowest at around 6am, and then gradually increases throughout the day. The highest temperature of the day is reached around 6pm, and then the temperature gradually decreases again until the early morning hours.

The Figure 3 – Temp vs Time graph also shows that the temperature fluctuates throughout the day, even though the overall trend is upward. This is because there are several factors that affect the temperature, such as the amount of sunlight, the wind speed, and the humidity.

- 6am-12pm: The temperature gradually increases during this period, as the sun rises, and the air warms up.
- 12pm-6pm: The temperature reaches its peak during this period, as the sun is at its highest point in the sky.
- 6pm-12am: The temperature gradually decreases during this period, as the sun sets and the air cools down.
- 12am-6am: The temperature reaches its lowest point during this period, as the sun is below the horizon and the air is at its coolest.

Figure 4 – Vibration graph

Figure 4 shows the vibration of a device over time. The x-axis represents time in seconds, and the y-axis represents vibration amplitude in arbitrary units. The frequency of the vibration is the number of cycles that occur per second. The frequency of the vibration is calculated by dividing the period by 1. In this case, the frequency of the vibration is about 5 Hz.

The Figure 4 shows a sinusoidal vibration, which is a type of vibration that repeats itself at regular intervals. The period of vibration is the amount of time it takes for one complete cycle of vibration to occur. In this case, the period of the vibration is about 0.2 seconds. The amplitude of the vibration is the maximum displacement of the device from its equilibrium position. The amplitude of the vibration is represented by the height of the peaks on the graph. In this case, the amplitude of the vibration is about 2 arbitrary units. The graph also shows that the vibration is damped, which means that the amplitude of the vibration gradually decreases over time. This is because of the friction between the device and the surface it is vibrating on.

Overall, the graph shows that the device vibrates at a frequency of 5 Hz with an amplitude of 2 arbitrary units. The vibration is damped, which means that the amplitude of the vibration will gradually decrease over time.

Here are some potential applications of this type of vibration:

- Vibration motors: Vibration motors are used in a variety of devices, such as cell phones, pagers, and video game controllers. Vibration motors work by creating a sinusoidal vibration, which is felt by the user as a buzz or rumble.
- Ultrasonic cleaning:
- Ultrasonic cleaning is a process that uses high-frequency sound waves to clean objects. Ultrasonic cleaning is often used to clean delicate objects, such as jewelry and medical instruments.
- Vibration analysis: Vibration analysis is a technique that is used to diagnose problems with machinery and other equipment. Vibration analysis works by measuring the vibration of the equipment and comparing it to known values.

6. Conclusions

In conclusion, the system can monitor the motor's condition in real time, which allows users to detect faults early and take corrective action to prevent motor failure. The system can be monitored from remote locations, which is especially useful for applications where the motors are in inaccessible or hazardous areas. The system can be used to predict when a motor is likely to fail, which allows users to schedule maintenance accordingly. Overall, the IoT-based system for monitoring the health of induction motors by detecting vibrations and monitoring temperature is a promising technology that can help users to improve the reliability and efficiency of their motors.

The system can monitor the motor's condition in real time, which allows users to detect faults early and take corrective action to prevent motor failure. This can lead to significant cost savings, as it can help to avoid expensive downtime and repairs. The system can be monitored from remote locations, which is especially useful for applications where the motors are in inaccessible or hazardous areas. This can improve worker safety and reduce the need for costly on-site inspections. The system can be used to predict when a motor is likely to fail, which allows users to schedule maintenance accordingly. This can help to extend the life of the motor and reduce the risk of unexpected failures. Overall, the IoT-based system for monitoring the health of induction motors is a valuable tool that can help users to improve the reliability, efficiency, and safety of their operations.

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