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IOT-Based Industrial Motor Speed Control using Pid and MQTT

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ABSTRACT: Electric motors are very important for factories, automation, conveyor belts, and other mechanical production processes. Industrial motors keep working all the time in factories, which makes production more efficient. But there are some problems that could make an industrial motor not work as well as it should. Some of these problems are speed problems, overheating, overcurrent, and electrical faults. Problems like the ones listed above can cause unexpected breakdowns and system failures, high costs for repairs and maintenance, and lower production efficiency. In this case, you need to control the motor's speed and find any mistakes that may have happened.

This paper proposes a solution based on IOT which includes a PID controller and MQTT protocol. The key idea behind the proposed system is to constantly monitor motors operation, control their speed and avoid any potential risk.

The design involves an 8051 microcontroller, which forms the major control unit in the system. The microcontroller controls the motor speed and analyses all the information obtained from different sensors. A current sensor is employed to monitor the motor current, helping the system monitor overload condition or any other abnormal current usage. Also, an LM35 temperature sensor is employed to monitor the temperatures of the motor.

In order to control the speed of the motor, a PID controller is integrated into the system. The PID control method is a continuous feedback system that constantly checks foe any deviation between the desired speed and the actual speed. It ensures constant motor speed with minimal variation. A motor driver system has been incorporated to link the control system and the motor.

A MAX232 interface connects a GSM module to the system for remote monitoring and communication. The MQTT protocol, which is commonly used in IoT apps for fast and reliable data transfer, sends information about how well the motor works to a cloud platform. When something goes wrong, like overheating or too much current, the system turns on a relay protection mechanism and a buzzer to let the operator know so that more damage doesn't happen.

The proposed system makes industry more reliable by using IoT-based communication to watch motors in real time, control their speed intelligently, and find problems early.

KEY WORD: Cloud Monitoring, GSM Communication, Industrial Automation, Internet of Things (IoT), PID Controller, MQTT Protocol, Motor Speed Control, and Fault Detection are some of the most important words

I. Introduction

Electric motors are really important in factories and plants. They are used a lot in manufacturing for moving things on conveyors pumping systems, compressors, robots and other machines that help with work. It is very important that these electric motors work well all the time so that factories can keep running and do not have to stop work. Sometimes these motors have problems like getting too hot too much electricity wearing out and not running at the right speed. If we do not find out about these problems quickly the motors can get damaged factories can shut down. It can cost a lot of money to fix them. So it is very important to make a system that can watch and control these motors to prevent problems.

Nowadays we have something called the Internet of Things that helps machines talk to the internet and send information about what they're doing. Many factories are using this to watch their machines and get information, about how they're working. This makes it easier to check the machines look at the information and even find problems before they get serious. The Internet of Things helps people who work in factories to always keep an eye on their machines and find out if there are any problems. This way the machines are more reliable and safe to use.

With advancements in the field of Internet of Things, various industries have started deploying intelligent monitoring methods that enable machines to interact with the cloud and generate real-time data about their operations. The usage of IoT makes it easier to perform monitoring, analyze data, and even identify problems early on, making equipment more reliable and safe for use. IoT-based solutions help industry professionals to constantly monitor their equipment and be informed of any problems in time.

Besides monitoring, another crucial feature of industrial automation is the precise control of the speed of motor drives. Effective control allows one to manage machine's operations better and achieve higher productivity. One of the popular types of control methods used in this situation is called PID control. PID control stands for proportional–integral–derivative control, and its main function lies in comparing the required speed of the drive to its current state.

The current project discusses the design of an IoT based industrial motor monitoring system and controlling its speed by the implementation of PID control along with real-time communication using the MQTT protocol. The suggested system utilizes 8051microcontroller as the CPU which acquires data through various types of sensors like current sensors and temperature sensors. The system keeps analyzing the values of the parameters and if any fault is found, then the system activates relay protection as well as sends a warning message to the user via the use of GSM technology. Moreover, the performance data about the motor can also be sent to cloud systems for remote operation purposes.

The main purpose of conducting the suggested research is the development of an intelligent and effective motor monitoring system which will have a capability to control motor speed and prevent motor fault at the initial stage along with provision of real-time information to the operator.

II. Existing work

Numerous studies have examined alternative techniques that can be utilized in the monitoring and control of industrial motors through automated and IoT-based solutions. Various researchers have examined methods for integrating monitoring systems, which use sensors to capture relevant parameters such as current, temperature, and vibration measurements, in order to detect any unusual conditions that affect motor operation. With the recent advancements in the Internet of Things, monitoring systems have become more effective in collecting data and detecting faults within the motor and its components.

Recent advancements in the Internet of Things have enabled remote monitoring of machines, thereby enhancing their operational efficiency. The adoption of IoT-based monitoring systems allows industrial motors to send real-time data to the cloud-based platform. Operators can monitor machines while working from distant places without physically visiting the location

where the machines are installed. MQTT protocol is commonly applied in this process due to its effectiveness in data transmission processes.

Intelligent control algorithms for the regulation of motor speed and system stability were also applied in some research works. Various control methods can be used to achieve the best possible results, but among these methods, the PID controller is most commonly used because of its efficiency in closed-loop control and its reliability and simplicity. Systems that use PID controllers regulate the motor's input signal depending on the difference between the required and real speeds.

IoT and machine learning techniques are usually combined in some research papers to predict faults and diagnose them accurately. Despite their effectiveness, they may need a lot of computing power and complicated computations to work properly. A simpler system, which uses only sensors and an embedded controller, can be applied to achieve the same purpose, without increasing the system complexity and costs.

From the available literature studies, this study proposes an IoT-based motor monitoring and control system that involves sensor-based monitoring, PID speed control, GSM-based alarm system, and cloud computing-based information transfer. This research work emphasizes the need for early fault detection and real-time monitoring along with speed stabilization of motors without a complex and expensive system design.

III.Proposed Method

In essence, this system has been designed to provide intelligent monitoring, speed control, and failure detection of industrial motors using sensor monitoring, embedded control, and IoT communication technologies. The main components that make up this system include an 8051 microcontroller, current sensor, LM35 temperature sensor, motor drive, DC motor, GSM module, relay, buzzer, and communication via the cloud server. Through these devices, it becomes possible to regulate the performance of the motor while also monitoring any anomaly.

The central element in this system is the microcontroller, responsible for performing different functions such as data collection and analysis. The current sensor will measure the electrical current used by the motor. This measurement is vital since high and low amounts of current can indicate different anomalies such as overloading, short circuits, or failures within the motor itself. In addition, there will be an LM35 temperature sensor used to measure the temperature of the motor during its operation. High temperatures are usually an indicator of either mechanical strain, faulty insulation, or overloading

A control algorithm using the PID controller is utilized for stable and precise motor speed regulation. In the PID control method, an error between the setpoint speed of the motor and the speed of the motor is calculated, and then control signals for regulating the motor drive are generated based on the result.

Control signals are generated in the motor drive to control the power delivered to the DC motor. With changes in the load condition, it is possible to regulate the speed of the motor efficiently through the adjustment of the control signals.

For remote monitoring purposes, the use of MQTT protocol enables effective transmission of the operational data to the server on the cloud. The MQTT protocol is commonly used in the IoT application due to its efficiency in communication among the device and servers. Thus, essential information including the current of the motor, temperature, and motor status is remotely monitored.

Furthermore a GSM module is part of the system to send warnings when something goes wrong. If there are temperature readings or higher than normal current usage the microcontroller will switch off the motor and a buzzer will sound to alert the person in charge. The microcontroller will also send a text message to the user about the problem.

The system we suggest includes monitoring with sensors a PID controller, a connection and GSM notifications. This makes it a strong and affordable way to monitor, control and find faults in motors. It helps keep an eye on the motor and catches issues early. The system is good, for use.

IV. COMPONENTS

Hardware Components

• 8051 Microcontroller. This is the brain of the system. It gets signals from sensors figures out what they mean. Then tells the motor and other parts what to do.

• DC Motor. This is the motor that does the work. We can check how well it is doing and control how fast it goes all the time.

• Motor Driver Circuit. This part connects the motor to the microcontroller. It makes the signal from the microcontroller stronger so the motor can use it. This way the motor gets the power it needs.

• Current Sensor. This sensor checks how electricity the motor is using. If it is using much that means something is wrong like the motor is overloaded.

• Temperature Sensor (LM35). This sensor checks the temperature of the motor all the time. If the motor gets too hot the system thinks that something might be wrong.

• Voltage Regulator. This part makes sure all the electronic parts get the amount of voltage. This way they do not get damaged if the voltage changes.

• GSM Module. This part lets the system send messages to the user without using any wires. If something goes wrong with the motor it sends a message to the user.

• MAX232 Interface. This part changes the signal from the microcontroller so it can be sent to the GSM module. This way the signal is strong enough to be sent

• Relay Module. This part is like a safety switch. If the system thinks something is wrong it can turn off the motor to prevent any damage.

• Buzzer. This part makes a noise if something is wrong, with the motor. This way the user knows that they need to check the motor.

Software Implementation

• **Embedded C Language** – The program code controlling various functions of the control unit is written using Embedded C programming language.

• **MQTT Protocol** – A simple communication protocol employed for relaying motor parameter information between the hardware component and the cloud server.

• **Cloud Monitoring Interface** – A graphical interface providing access to data about the motor's operating parameters such as its speed and temperature.

V. BLOCK DIAGRAM

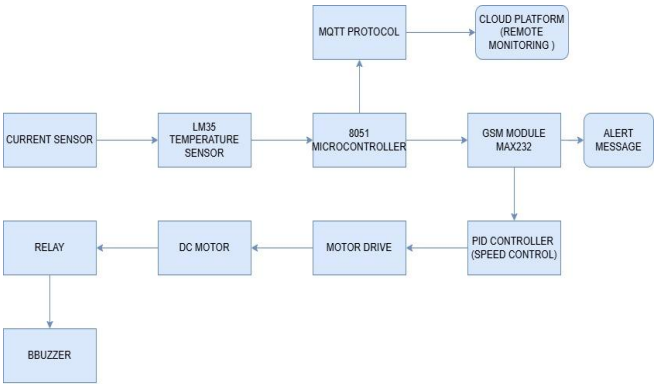

Fig: 1 BLOCK DIAGRAM

The designed system runs on the basis of the 8051 microcontroller that functions as the main controller and controls all functions in the system. The controller obtains the real-time input data from the current sensor and the LM35 temperature sensor. The current sensor detects the level of current taken by the motor, whereas the temperature sensor monitors the temperature of the motor in order to find out if there is any overheating.

After collecting the sensor input data, the controller analyzes the motor performance based on the collected data in order to decide if the operation of the motor is at safe levels. The PID control strategy is applied to ensure that the motor is running at constant and steady speeds. The controller continuously compares the required speed with the actual motor performance.

The control signal goes to the motor driver circuit. This circuit makes sure the power sent to the DC motor is controlled. If the system finds something like high currents or temperatures it triggers the relay protection circuit. This circuit turns off the motor. The buzzer then makes alerts. For monitoring data, about the motors condition is sent through the GSM module. The data is sent to the cloud using MQTT. This way users can check the motors performance from anywhere.

VI. System Architecture

1. System Architecture of the proposed project

In an effort to incorporate the sensing, control, communication, and monitoring functionalities into an intelligent motor operation, control, supervision, and management system, the system architecture involves sensors, processing, control, communication, and cloud-based monitoring modules. These components work

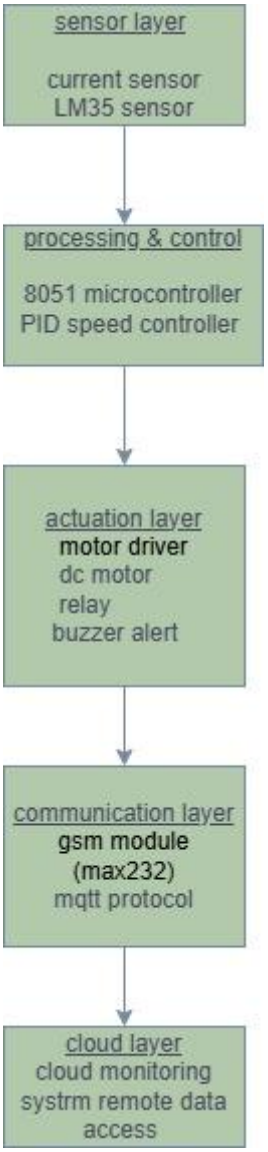

Fig:2 System Architecture

seamlessly together to facilitate proper motor operations, failure detection, and control in an effort to guarantee high reliability.

2. Sensing

For efficient and reliable operation and monitoring, the proposed system adopts sensors including a current sensor and an LM35 temperature sensor for measuring various parameters. Current sensor measures the motor current, thus helping detect any malfunctioning of the motor and/or any overload or electrical problems. LM35 temperature sensor measures the temperature of the motor to detect overloading temperatures that may affect motor efficiency.

3. Processing & Control

The sensor measurements from various sources are relayed to the microcontroller for processing. The 8051 Microcontroller is used as the main controller for processing the information. In terms of control, a PID Controller approach is adopted, whereby the controller constantly monitors and regulates motor operation through the use of PID algorithm that compares the desired speed and actual speed and controls the system accordingly.

The control signal produced from the microcontroller will be fed into the motor driver circuit, which helps control the amount of power fed to the DC motor. In the event of any abnormality detected by the controller such as high levels of current or temperature, relay protection will be initiated to shut down the motor operation. Also, the buzzer will emit an alarm sound.

4. Communication & cloud

Remote monitoring of the motor operation and communication is enabled using a GSM module to transmit the status of the motor to the cloud using MQTT.

VII. Results and Discussion

The control system we designed was tested to see if it could control the motor speed track how the motor was working and find any problems quickly.

We set up the experiment by connecting the DC motor to a control circuit that had sensors, a microcontroller, devices to communicate with parts and a motor driver.

The control system collected data like the motors temperature and the microcontroller analyzed it right away to see if the motor was working properly.

The sensors helped us keep an eye on the motors temperature status.

A current sensor measured how much current the motor used to see if it was overloaded or had another issue.

The LM35 temperature sensor checked the motors temperature to help us understand its status.

The 8051 Microcontroller processed data from the sensors. Was the main part of the control system that made decisions.

The microcontroller used data, from the sensor and the LM35 temperature sensor to check the motors operation.

The control system and the 8051 Microcontroller worked together to regulate the motor speed and detect any irregularity.

Speed control for the motor was accomplished by using PID Controller technology. Here, the PID control logic compared the required speed of the motor with its present operating condition and made necessary adjustments. With the help of closed-loop feedback control strategy, smooth operation was ensured for the motor irrespective of any variation in load. Thus, the motor could perform effectively without having speed variations.

Moreover, another significant aspect observed during testing is the ability of the proposed design to detect any faults. When any abnormal condition related to current or temperature level of the motor was found, the controller would trigger a relay protection circuit to halt motor operation. Meanwhile, a notification message was sent via GSM module while at the same time, information was shared with the cloud server using MQTT protocol.

Thus, the results obtained from experiments prove that the proposed concept can be applied in practice for motor speed control, fault detection, and monitoring.

VIII. Conclusion

In this project, a study has been conducted regarding the creation of an advanced intelligent monitoring and control system for industrial motors that uses sensors, embedded systems, and IoT technology. In the proposed design, sensors along with the microcontroller-based control unit are used to monitor the running state of the motor. Using parameters like motor current and temperature, the monitoring system will detect any abnormality and protect the motor from damage.

The motor speed control system is really good because it uses a PID Controller approach. This PID Controller helps the system adjust the signal it sends to the motor driver all the time. The motor works well even when the load changes.

The system also has a GSM communication system. It is connected to the cloud using the MQTT protocol. This means people can check the motor parameters as they happen and get notifications away if something goes wrong. Using these technologies will make planning better. Reduce unexpected problems, with the system.

In conclusion this system is a way to monitor industrial motors control their speed and find faults with the motor. The motor speed control system is practical. It works well.

IX. References

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