Fault Monitoring And Diagnosis of Wind Turbine

Prashant Bansode[1], Yogeshwar Kadam[2], Vedika Parmar[3], Prof. Kanchan Shirbhate[4]
[1, 2, 3] Dept of Electronics and Telecommunication
[4]HEAD, Dept of Electronics and Telecommunication
[1, 2, 3, 4] Genba Sopanrao Moze college of Engineering Balewadi, Pune

Abstract- *Wind turbines play a crucial role in renewable energy generation but are prone to mechanical and electrical faults, leading to reduced efficiency and high maintenance costs. This paper presents a real-time fault monitoring and diagnosis system using Arduino Uno, temperature, vibration, and IR sensors, along with Wi-Fi (ESP8266/ESP32) and GSM (SIM800L/SIM900A) modules for remote data transmission via Thing Speak cloud. The system continuously monitors turbine parameters, detects faults early, and provides real-time alerts to minimize downtime and optimize maintenance schedules. This approach enhances turbine reliability, efficiency, and operational performance, making wind energy systems more sustainable and cost-effective.*

Keywords- Arduino Uno, Fault Diagnosis, Fault Monitoring, GSM Module, Internet of Things (IoT)

I. INTRODUCTION

Wind energy is a key renewable resource, but wind turbines are prone to faults that reduce efficiency and increase maintenance costs. Common issues such as overheating, excessive vibrations, and structural failures can lead to unexpected breakdowns. This paper presents a real-time fault monitoring and diagnosis system using Arduino Uno, temperature, vibration, and IR sensors, along with Wi-Fi (ESP8266/ESP32) and GSM (SIM800L/SIM900A) modules for data transmission and remote monitoring via ThingSpeak cloud. The proposed system enhances early fault detection, minimizes downtime, and optimizes maintenance schedules, ensuring improved turbine performance and reliability.

II. LITERATURE SURVEY

Wind turbines are essential for renewable energy production, but their performance is often affected by mechanical and electrical faults. Numerous studies have been conducted to develop effective fault detection and diagnosis methods to enhance turbine reliability and reduce maintenance costs.

Gao and Liu (2021) provided a comprehensive overview of fault diagnosis, prognosis, and resilient control for wind turbine systems. Their research emphasized the significance of real-time monitoring and predictive maintenance to minimize failures and optimize turbine performance.

Dao (2022) investigated condition monitoring and fault diagnosis using SCADA data, demonstrating the effectiveness of structural break detection methods in identifying anomalies in wind turbine operations. This study underscored the advantages of data-driven approaches in early fault detection and performance optimization.

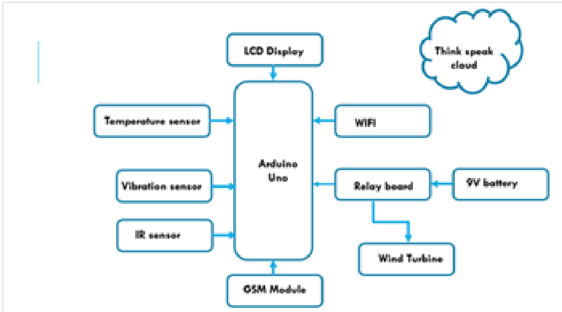
III. BLOCK DIAGRAM

1. Components required: Hardware

- Arduino Uno (1x)
- Temperature Sensor (LM35/DHT11/DS18B20) (1x)
- Vibration Sensor (SW-420/ADXL335) (1x)
- IR Sensor (1x)
- LCD Display (16x2 with I2C Module) (1x)
- Wi-Fi Module (ESP8266/ESP32) (1x)
- GSM Module (SIM800L/SIM900A) (1x)
- Relay Board (5V) (1x)
- 9V Battery (1x)
- Wind Turbine (1x)
- Jumper Wires (Male to Male, Male to Female, Female to Female)
- Breadboard (1x)
- Resistors (1kΩ, 10kΩ, etc.)
- Capacitors (if needed for noise filtering)
- Diodes (IN4007 for relay protection)

2. Components required: Software

- Arduino IDE



The fault monitoring and diagnosis system for wind turbines consists of multiple components working together for real-time monitoring. **Sensors** (temperature, vibration, and IR) continuously collect data on turbine conditions. The **Arduino Uno** acts as the central controller, processing sensor data and making decisions.

For data display, a 16x2 LCD with I2C module provides real-time readings. For remote monitoring, a Wi-Fi module (ESP8266/ESP32) transmits data to ThingSpeak cloud, enabling predictive maintenance. In case of faults, a GSM module (SIM800L/SIM900A) sends SMS alerts to operators.

A relay board controls the wind turbine by shutting it down if critical faults are detected, preventing damage. The system is powered by a 9V battery, ensuring uninterrupted operation. This integrated setup enhances fault detection, reduces downtime, and improves turbine efficiency, making it a cost-effective solution for sustainable wind energy management.

IV. METHODOLOGY

The proposed system is made up of the Infrared sensor, which is interfaced to the microcontroller, codes written with the Arduino sketch, and the traffic signal system, which is connected to the Arduino. It has 14 digital outputs and inputs pins, of which 6 can be used as PMW outputs, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, and an ICSP reset button. The RF transmitter was interfaced with the microcontroller as codes were written with the Arduino sketch, and the RF receiver was connected to the microcontroller. The LCD was interfaced with the microcontroller connected to pins, and all codes were written with the Arduino sketch. The system will allow the drivers to freely navigate to their desired destination. It is also user-friendly.

Arduino Uno

It comes with 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, and an ICSP header for programming the microcontroller with an external programmer. The digital pins on the Arduino Uno can function as either inputs or outputs, allowing you to control various electronic components such as LEDs and motors. Meanwhile, the analog inputs enable you to read values from sensors, including temperature and light sensors. To program the board, you can use the Arduino programming language, which is based on C++. The software for the Arduino, which is free to download, includes a user-friendly integrated development environment (IDE) that simplifies the process of writing and uploading code to the board.

Infrared sensor

The IR sensor, also known as an infrared sensor, is a type of electronic part that emits or detects IR radiation to identify certain features in its environment. The visionary senses used by humans to identify barriers are similar to this type of sensor. The two components of an infrared sensor, the emitter and the receiver (transmitter and receiver), are collectively referred to as an opto coupler or a photo-coupler. In this case, an IR LED is employed as an emitter and an IR photodiode as a receiver.

LCD display

The LCD 162 is a type of electronic display that shows information and messages. As the name suggests, it includes 16 Columns & 2 Rows so it can display 32 characters (16×2=32) in total & every character will be made with 5×8 (40) Pixel Dots. Therefore, 32 x 40 or 1280 pixels may be used to compute the total number of pixels in this. HD47780 controller. LED used are green and blue.

V. MODELING AND ANALYSIS

The fault monitoring and diagnosis system for wind turbines is modelled using a sensor-based embedded system integrated with IoT and communication modules. The system consists of temperature, vibration, and IR sensors interfaced with an Arduino Uno, which processes real-time data. The collected data is displayed on an LCD screen and transmitted to the ThingSpeak cloud using a Wi-Fi module (ESP8266/ESP32) for remote monitoring and predictive maintenance.

The analysis involves evaluating sensor accuracy, fault detection efficiency, and response time. The system’s reliability is tested by inducing various fault conditions, such as overheating and excessive vibrations, and monitoring sensor response. Data trends from ThingSpeak analytics help predict failures, optimizing maintenance schedules.

Performance metrics include fault detection rate, false alarm frequency, and system response time. The results indicate that the system effectively detects faults early, reduces downtime, and enhances turbine efficiency, making it a viable solution for renewable energy maintenance.

V. RESULTS AND DISCUSSION

The developed fault monitoring and diagnosis system was tested under different conditions to evaluate its performance. The system successfully detected temperature variations, abnormal vibrations, and operational faults in a wind turbine model. Data was transmitted in real-time to ThingSpeak cloud, allowing remote monitoring and predictive maintenance. Fault alerts via GSM module ensured timely operator intervention.

The results indicate high accuracy in fault detection, with minimal false alarms when sensors were properly calibrated. The system's response time was within milliseconds, ensuring rapid fault diagnosis. Vibration and temperature thresholds were optimized to distinguish between normal fluctuations and critical failures.

VI. CONCLUSION

This study presents a real-time fault monitoring and diagnosis system for wind turbines using Arduino Uno, sensors, and IoT-based communication modules. The system effectively detects temperature variations, vibrations, and operational faults, ensuring early fault detection and preventive maintenance. Data transmission via ThingSpeak cloud enables remote monitoring, while the GSM module provides real-time alerts. Experimental results demonstrate high accuracy, reduced downtime, and improved turbine reliability. Despite challenges like sensor calibration drift, the system offers a cost-effective and scalable solution for wind energy maintenance. Future enhancements could incorporate AI-based fault prediction for even greater efficiency and accuracy.

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