Wind Turbine Fault Monitoring System Using MQTT

G Sasikala 1, Yadala Poorna Sai Chandra 2, Nallamilli Siva 3, Avilala Sai Vinesh 4

1 ECE Department, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, India.
2 ECE Department, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, India. Email: yadalapoornasaichandra@gmail.com
3 ECE Department, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, India. Email: aivinesh.avilala@gmail.com.
4 ECE Department, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, India. Email: saivinesh.avilala@gmail.com.

Abstract. Electricity can be generated by many sources in different ways. The one best well-known resource is wind energy. This energy reduces the emission of carbon dioxide and this energy can be produced through wind turbines. The system which is going to be proposed consists of Node MCU, MQTT protocol and sensors like temperature sensor and wind speed sensor are used to detect the faults, which occur in the wind turbine such as temperature in generator and bearing faults respectively. Whenever the value of temperature in the generator exceeds threshold value, then sensor will give the alert. Whenever the sufficient wind speed is detected but the power generation is low with respective to actual energy produced by the turbine, then sensor will alert. These sensors are connected to micro controller unit ESP8266 Wi-Fi module for detection operation and these parameters will be sent to the main location through MQTT by which the client can monitor these detected parameters in a MQTT Client Cloud network through web page and also these parameters can directly send to the user mobile through SMS and Emails.

Keywords—MQTT, Sensors, Node MCU, Monitoring

1. Introduction
The resources like Sunlight and the wind energy are the best natural resources to produce electrical energy. The wind energy is considered as the good source of energy, which is used to rotate the wind turbines in order to produce the current energy. The wind turns 2 or 3 blades around a rotor, which is attached to the main shaft in the turbine, which is used to spins a generator is the one which responsible for creating electricity. Wind turbines are at a risk of fault, because of installation in harsh environment like sea shores, deserts as well as the plains which are far away from the control unit. Due to the hard conditions around the wind turbine, there might be a chance of occurrence of a trouble and sometimes which leads to the power off. In order to stop the occurrence of the trouble it is needed to maintain the fault diagnosis and monitoring devices to screen the execution time status and faults occurred to improve the life time and the efficiency of the wind turbine.
1.1. Problem Identification
Wind turbines are fault inclined, because of their installation in harsh environment like desert, plains aside from that they're complicated gadget, that are placed some distance far away from the manage center. in order that area the threat of fault occurrence and the facet results can be extra, even it ends in electricity off.

1.2. Proposed Solution

The parameters which are required to monitor the wind turbine will be collected by the monitoring system from different parts of the turbine. Based upon the data gathered from turbine the controlling system will compare the data with threshold data which was fed previously and it will alert through the message to the server. The monitoring system consists of various sensors installed at various places of the turbine. The sensors like temperature, humidity, and speed detecting sensor collects the information from the turbine and sends to the MQTT server using ESP8266 NodeMCU.

The micro-controller NODEMCU ESP8266 has ability to perform WIFI related activities hence it is also called as WIFI module. All the ESP models have same type of ESP processor varies only in the type of breakout board used. The board of ESP8266-01 has only two gpio pins whereas ESP-12 has 16 GPIO pins many devices surrounding cannot be connected to internet directly on its own. So, ESP8266 module enables these devices to connect with internet and makes to communicate and make them as IOT devices. This is low cost; small module and it is really simply and easy to use.

In our proposed model we are using NODEMCU ESP8266 and sensors like temperature, humidity and speed sensors. These sensors are situated in and out of the turbine which are used to monitor the temperature and humidity. The IR speed sensor senses the speed of the air. These data will be sends to the WIFI module. The code will be written in the Arduino IDE, here we will select the board as NODEMCU ESP8266 then we will connect the hardware component of ESP8266 through USB cable to the port of pc the compiled code will be dumped in the ESP8266, the resultant output will be seen in the serial monitor. The WIFI module is connected to the server through the MQTT protocol. The all data will be sends to the server and the output will be monitored with the live graphs.

Internet of Things devices have been a part of our daily lives. From smart homes, smart bulbs and other house hold appliances; the developers are including this technology to create a network of connected devices that make the daily life a little easier. All these been made possible for the easy communication. There are many ways to communicate among devices, one of the ways is using single protocol commonly used is MQTT. MQTT is known as machine-to-machine protocol designed for ease and low weight publish/subscribe message transportation.

| Table 1. Supervisory and Control Data Acquisition Data Set |
|------------------------------------------------------------|
| Time Stamp | Wind Speed(m/s) | Generator Temperature (℃) |
|-------------|-----------------|----------------------------|
| 2018-10-01 00:10:00 | 4.94 | 64.653 |
| 2018-10-01 00:20:00 | 5.361 | 64.632 |
| 2018-10-01 00:30:00 | 5.01 | 61.16 |

These values are the average different parameter values of wind turbine which is shown on Table 1. Whenever the sensor values exceed the above values a message will be sent to the receiver through E-mail or an SMS [6].

2
2. Literature Review

In this paper the research is carried out with the sensor issue in a Wind Turbine model with fault tolerant control [1]. Which is utilized to permits boundaries of the regulator to be reconfigured in agreement mistake information acquired online from sensors to improve the dependability and by and large execution of the framework when a blunder experience. The essential part is planned by sliding mode observer based fault detection filter to create a lingering sign to assess flaw. Fault detection filter is intended to amplify affectability shortcoming

The author proposed a 3-stage philosophy for discovery and disconnection of detecting component deficiencies, i.e., SHORT issue, CONSTANT flaw, and NOISE issue, in WSN-based turbine CMS [2]. The proposed sensor flaw location and seclusion incredibly will expand the exactness and dependability of wind turbine CMSs. Information gathered from wind turbines in the field are utilized to assess the viability of the proposed strategy.

This paper presents 2 novel methodologies arranged to the plan of flaw open minded control plans for solid guideline of generator twist in a breeze turbine that can be influenced by both model vulnerabilities and actuator issues in its generator/converter [3]. The essential methodology depends on fluffy model reference versatile control in which a fluffy deduction component is utilized for boundary variation with no information on the possible shortcomings in the framework. The optional methodology misuses fluffy displaying and recognizable proof approach to build up a coordinated model-based shortcoming recognition and finding, and a programmed signal amendment instrument is utilized to enjoy issues in the framework dependent on online information of analyzed issues.

To identify the wind turbine [4] and to change the fault components three types of curve are used such that power curve, blade curve, rotor curve.

This paper proposes a little example Wind Turbine flaw location technique with the manufactured deficiency information utilizing generative ill-disposed nets [5]. basically, in view of past information, an unpleasant shortcoming information age measure is created to change the typical information to the harsh deficiency information. Optionally, a harsh flaw information purifier is created by GANs to make the unpleasant issue information more acquainted with the genuine shortcoming information.

The author [7] suggested here MQTT protocol for both way communication between the console and robot. The work is carried out with cloud platform, control and tracking system

Publisher subscriber is a one such protocol used in surveillance IOT. A scheme to stream a lot of data from publisher to subscriber using an IoT device that is microcontroller NodeMCU 8266 using two different protocol, there are MQTT and CoAP [8]. The NodeMCU will act as responder or publisher and can act as subscriber or sending request to get data from publisher. By the experiment, we can see that the differences in accuracy, time spend and the convenience from using Message Queuing Telemetry Transport (MQTT) and CoAP schemes.

In the midtowns, underground links are utilized rather than of overhead transmission lines. It is difficult to go through the particular spot of the shortcomings [9]. we have utilized IOT based generally method with Google information base for the issue discovery with the assistance of Node MCU Module with transformer and utilized Google information base to checking the situation with transformers.
3. Methodology

3.1. Proposed Methodology
When the simulation process gets started, initially the IR sensor checks for the speed of the blades, if the speed of air is high, then after sometimes it checks again, else if the speed of air is low, the temperature sensor senses the temperature. The detected temperature from sensor installed inside the generator will send the temperature value with the help of ESP8266 and through MQTT to the MQTT server. The range of the temperature is shown in the format of graph for every interval of time or whenever the values exceed the triggered values the receiver will be given with an alert through an Email or an SMS to their mobile.

![Flow Chart](image)

Figure 1. Flow Chart
By using above Figure 1 a circuit is designed and simulated code is written in the Arduino IDE.

3.2. Proposed Model
The proposed model for fault monitoring in wind turbine system using MQTT has been demonstrated using the block diagram figure 2 as follows.
Figure 2. Block Diagram

Figure 2 describes about the block diagram of our proposed model. Firstly, from the wind turbine the faults are detected by the various types of sensors of different parameters. The sensors are connected to the NODEMCU ESP8266. The data which is published in the Node MCU transmitted to the MQTT server. From the MQTT server will be sent as an Email or an SMS.

4. Methodology

4.1. DHT 11 Sensor
It is a temperature and humidity based sensing module as shown in Figure 3 to give digital output. This module can be connected to any micro-controller. The suitable one is Arduino and Raspberry. With that we can find amount air present in surroundings.

Figure 3. DHT11 Sensor

4.2. Node MCU ESP8266
This is user-friendly very low cost WIFI module, which develops a simple TCP (Transmission control protocol)/IP (Internet Protocol) connection and can easily be interfaced with micro controllers via Serial Port. Normally it is used in IOT cloud based Wi Fi device with the operating range of 3 to 3.6 volts. ESP8266 WIFI module can easily be interfaced with micro controller’s board (Arduino UNO) via Serial Port as shown in Figure 4.

Figure 4. Node MCU ESP8266
4.2.1. Features of NODEMCU

- 32-bit micro-controller SOC works at 80 MHz having antenna switches, power amplifier, digital peripheral interfaces, low noise receive amplifier, power management module and with filter capability.
- It comprises of 64 Kilo Bytes of boot Read just Memory, 80 KB client information RAM and 32 KB guidance RAM.

4.3. Arduino IDE

- It is an open-source gadgets stage dependent on simple to utilize equipment and programming.
- This board is flexible runs on Mac, Windows, and Linux and able to access all type of inputs and as well as all type of outputs.
- It provides several development tools like, IDE (Integrated Development environment).
- In the Arduino 1.8.13 we can convert the any language code into hexadecimal code for uploading into Arduino.

The Figure 5 shows the output of the code where that Sketch uses 279972 bytes (29 percent) of program storage space. Maximum is 958448 bytes. Global variables use 27804 bytes (33 percent) of dynamic memory, leaving 54116 bytes for local variables. Maximum is 81920 bytes.

![Figure 5. Arduino Simulation](image)

4.4. Adafruit IO

It is a cloud administration free open source tool that simply implies to run it for you and you don’t need to oversee it. This will connect to projects to many web services like Android SMS, E-Mail, RSS feeds, weather services, etc

5. Results and Discussion

5.1. Arduino Output

The simulated ESP8266 output is shown in Figure 6 using Arduino IDE. When the codes of sensors which are being used in the hardware were dumped into the Arduino IDE and after the successfully compilation, the codes are uploaded to the ESP8266 and the sensors will detect the parameters which will be sent to the receiver through MQTT protocol.
5.2. **Server Output**

The Figure 7 shows the results of the sensors used in the hardware in the MQTT server.

5.3. **Message Output**

Figure 8 shows the output of the Wind Turbine whenever the temperature exceeds the threshold value a message will be sent to phone.
5.4. E-Mail Output

The Figure 9 shows the results of the monitoring system through E-mails whenever the temperature exceeds the threshold level.
5.5. Wind Turbine Model Output
The Figure 10 shows the output in the wind Turbine consists of sensor and anemometer to check the speed of the air.

![Wind Turbine Model](image)

**Figure 10. Wind Turbine Model**

6. Conclusion
In Wind turbines there is a possibility of fault occurrence which is explained in problem statement. So, the chance of fault occurrence will be more, even it may lead to power off. The proposing remote monitoring system will detect the faults occurred in the turbine and sends using ESP8266 through the MQTT to receiver.

References
[1] “Active Fault Tolerance Control For Sensor Fault Problem in Wind Turbine Using SMO with LMI Approach”, Nuralif Mardiyah, Novendra, Setyawan, Bella Retno and Zulfatman Has Department of Electrical Engineering, University of Muhammadiyah Malang, Indonesia, Proceeding of EECSI 2018, Malang – Indonesia.
[2] 2017-PSEC-0784, Aziz Altaf Khuwaja, “Sensor Fault Detection and Isolation for a Wireless Sensor Network-Based Remote Wind Turbine Condition Monitoring System”, by Yayu Peng Student Member, IEEE Power and Energy Systems Lab Department of ECE, University of Nebraska-Lincoln Lincoln, NE 68588-0511 USA.
[3] IEEE Transactions on Control Systems Technology “Wind Turbine Fault Diagnosis and Fault-Tolerant Torque Load Control Against Actuator Faults” by Hamed Badihi, Student Member, IEEE, Youmin Zhang, Senior Member, IEEE, and Henry Hong.
[4] A Survey of “Wind Turbine Control Monitoring and Fault Detection on Wind Energy” by M.Kokila Research Scholar Department of Computer Science Ayya Nadar Janaki Ammal College, Sivakasi.
[5] IEEE Transactions on Industrial Informatics, VOL. 15, NO. 7, JULY 2019, “A Small-Sample Wind Turbine Fault Detection Method With Synthetic Fault Data Using Generative Adversarial Nets” by inhai Liu , Member, IEEE, Fuming Qu , Student Member, IEEE, Xiaowei Hong , and Huaguang Zhang , Fellow, IEEE.
[6] Research Article, “Wind Fleet Generator Fault Detection via SCADA Alarms and Autoencoders” by Mattia Beretta, Juan Jos’e C’ardena2, Cosmin Koch 2 and Jordi Cusid’o, Published on 3 December 2020.
[7] “Study of using MQTT Cloud Platform for Remotely Control Robot and GPS Tracking” by Nut Aroon, Department of Computer Engineering School of Engineering, BangkokUniversity Pathumthani, Thailand.
[8] “he Use and Performance of MQTT and CoAP as Internet of Things Application Protocol using NodeMCU ESP8266 ” by, Sandy Suryo Prayogo, Yulisdin Mukhlis, dept of Electrical
Engineering, Gunadarma University, Jakarta, Indonesia.

[9] “IOT Based Fault Detection of Underground Cables through Node MCU Module”, by Laxmi Goswami, Vinay Anand, Department of EE, Sanskriti University, Uttar Pradesh, India.