IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 13, Issue 9, September 2023, ||Series -I|| PP 10-16

Lora Based Wind Turbines Monitoring System

[1]Srinivasulu M,[2]Ambrutha T N, [3]Anusha D N, [4]Divya S, [5]H N Sujana

[1] Assistant professor,Dept of MCA,UBDTCE,Davangere,
EMAIL:sujanahanasi@gmail.com
[2,3,4,5] PG students,Dept of MCA,UBDTCE,Davangere
Received 01 September 2023; Accepted 11 September2023

ABSTRACT
This paper presents a wind turbine parameter monitoring system that uses LoRa technology to monitor the parameters like air temperature, humidity, current, voltage, and light intensity. LoRa which stands for Long Range is a communication protocol that is under the Low Power Wide Area Network(LPWAN) which emphasizes long-range, low-power, low-bit rate wireless technology. The system is designed to provide proto-type data on the current state and to help optimize the performance of wind turbines. The system is based on a wireless network of sensors that are placed on the wind turbines and transmit data to a central server that incorporates the receiver.Upon receiving the data, it undergoes processing and analysis in the ThingSpeak server to gain valuable insights into the performance of the wind turbines. This analysis assists in pinpointing potential areas for enhancement. Additionally, the system incorporates an alert mechanism by the use of the Blynk IoT application server that triggers a notification when any of the parameters exceed their maximum values. This alert system serves as an early warning system, notifying relevant management persons about critical conditions and enabling prompt action to be taken.
Keywords –LoRa WAN, Wind turbine data monitoring, Alert system, Blynk IoT, ThingSpeak.

I. INTRODUCTION

Our increasing dependency on electricity necessitates the development of innovative and sustainable power generation methods to meet the growing energy demands of our modern world. Renewable energy sources like sunlight, wind, water (hydroelectricity, tidal, and wave power), geothermal, and biomass help in the generation of mass production of electricity.The key characteristic of renewable energy is its ability to be replenished naturally and continuously to help in the generation of electricity. This remarkable advancement is done by the various power plants that help in the generation of electricity such as solar power plants, hydropower plants, wind power plants, geothermal power plants, and bioenergy systems,these power plants health needs to be continuously monitored for the better performance so if not continuously monitored the low performance may lead to faults and causing the hazardous situation.

The proposed project is designed with a cost-effective, reliable wireless technology in the wind power plants, this replaces the present use of Optical Fiber Cable(OFC) for performance monitoring of wind turbines by the use of new communication technology called LoRa technology that is a wireless communication technology designed for low-power, long-range transmissions between devices in the Internet of Things (IoT) applications this is based on the low power wide area network (LPWAN) technology designated as Lora WAN to enable devices to communicate over long distances while consuming minimal energy and is based on the Chirp spread spectrum (CSS) modulation.

The designed system comprises two main parts known as the Transmitter and Receiver. All the necessary sensors are connected to the Transmitter module. The Transmitter module interfaces with the ESP32 microcontroller module incorporated with the LoRa transmitter chip. By utilizing the sensors, the Transmitter module reads various parameters and constructs information packets using the LoRa technology. These packets are then securely transmitted to the Receiver. The Receiver module, on the other hand, is connected to the base station. It receives the information packets transmitted by the Transmitter. Upon receiving the packets, the Receiver computes the data and then uploadsall the received information packets to a centralized server. This server allows concerned authorities to monitor and analyse the data from any location without being constrained by physical barriers.

II. LITERATURE SURVEY

A thorough exploration of the existing body of knowledge and previous studies is presented in this section to establish the context for the current research:

Purnomo, F.A, Yoeseph, N.M, Yulianto, A, Royan, Y.I, and Safi'ie, M, A. "Development of wind monitoring systems with LoRA technology" This paper deals with a monitoring system, where the air conditions are observed using wireless LoRa (Long Range) technology for data transmission. The setup consists of two LoRa nodes and one LoRa Gateway. The nodes are equipped with two sensors: an anemometer and a BME280 sensor. These sensors collect data on wind speed, air temperature, and humidity. The LoRa nodes transmit the collected data to the LoRa Gateway, which is connected to a Wi-Fi network. The Gateway then forwards the data to a server for further analysis and storage [1].L. Vangelista, "Frequency Shift Chirp Modulation: The LoRa Modulation, "Low Power Wide Area Networks (LPWAN) are becoming increasingly popular in the realm of Internet of Things (IoT) connectivity. Among the LPWAN technologies, LoRaTM has gained significant commercial traction. This paper aims to present a comprehensive mathematical description of the modulation and demodulation processes involved in LoRaTM. The focus is on deriving an optimized receiver with a low-complexity demodulation technique that utilizes the Fast Fourier Transform. Furthermore, the performance of LoRaTM modulation is compared to that of FSK modulation in both an AWGN (Additive White Gaussian Noise) channel and a frequency-selective channel. The results demonstrate the superiority of LoRaTM modulation in the frequency-selective channel [2].A. Augustin, J. Yi, T. Clausen, W. M. Townsley, "A Study of LoRa: Long Range & Low Power Networks for the Internet of Things,"LoRa is a wireless communication framework designed as a long-range, low-power, low-bitrate solution for the Internet of Things (IoT). In this system, end devices utilize LoRa to establish a single wireless hop to communicate with gateway devices. These gateways are connected to the Internet and act as intermediaries, transmitting messages between the end-devices and a central network server [5].

Poornima M Mushi, Vani H U, Varshitha S G, VinuthaCR, RekhaB H, Dr. AnithaG, "IoT Enabled Wind Turbine Data Monitoring System using LoRa" The prototype presented in this proposal utilizes LoRa technology to enable wireless sharing of sensor data, particularly beneficial in applications where machine-to-machine communication and data sharing are critical. The project involves collecting parameters like voltage, current, temperature, and humidity from a wind turbine and transmitting this information to a base station via a LoRa transmitter. Subsequently, the data is sent to a receiver at 433MHz frequency in encoded packets, which are decoded at the receiver and then stored in a database for subsequent analysis and decision-making purposes[6].

A. Zourmand, A. L. Kun Hing, C. Wai Hung and M. AbdulRehman, "Internet of Things (IoT) using LoRa technology, " In recent years, Wireless Sensor Networks (WSN) have witnessed rapid growth and have become a major focus of research in wireless technology. LoRa, a communication technology belonging to the Low Power Wide Area Network (LPWAN) category, has emerged as a promising solution. It is designed to enable long-range communication and exhibits high receiving sensitivity, allowing it to effectively operate even in the presence of noise interference or a high noise floor. Communication range plays a critical role in most IoT systems, and the introduction of LoRa technology opens up new possibilities for improving applications in the Internet of Things (IoT) [3].

Pallayi S. Jagtap, Arvind P. Hatkar, "Smart monitoring and controlling of Wind farms based on WSN," This paper introduces the implementation of a wireless sensor network (WSN) with SCADA (Supervisory Control and Data Acquisition) technology for efficient maintenance. The WSN is designed considering both hardware and software aspects, taking various factors into account. By leveraging wireless communication, the costs of materials such as optical fiber cables and wired communication devices can be significantly reduced [4].

III. SYSTEM WORKING

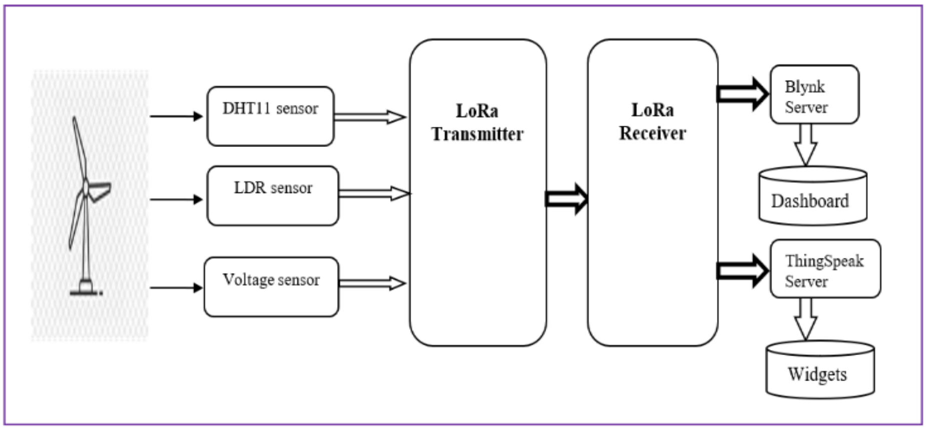


Figure 3.1: System Architecture

The system design, as illustrated in Figure 3.1, has LoRa transmitter and LoRa receiver parts. The transmitter part incorporates various sensors such as the DHT11 sensor, LDR sensor, and Voltage sensor into the LoRa transmitter. These sensors are utilized to obtain crucial parameters from wind turbines. The DHT11 sensor is widely utilized for measuring temperature and humidity. It has a temperature measurement ranging from 0°C to 50°C and can accurately measure humidity within the range of 20% to 90%. The sensor provides a high level of accuracy with temperature measurements having a precision of ±1°C and humidity measurements having a precision of ±1%, the LDR (Light Dependent Resistor) sensor are used to detect and measure light levels by measuring the resistance changes in an LDR sensor, it becomes possible to determine the level of light present in a given environment as the resistance of an LDR decreases as the light intensity increases, and conversely, it increases as the light intensity decreases,and voltage sensor is a device that measures and detects the electrical potential difference between two points, providing information about the voltage level in a circuit or system. These sensors are connected to an ESP32 microcontroller, which acts as the central unit for data acquisition. To transmit the data wirelessly, the ESP32 microcontroller is interfaced with a LoRa transmitter, and that is of a LoRa chip, specifically the LoRa SX1278 operating at a frequency of 433MHz.The LoRa SX1278 is a specific type of wireless communication transceiver module that utilizes Long Range (LoRa) technology and is equipped with the SX1278 chipset. It enables long-range and low-power communication between devices. The SX1278 module is a module that operates in the license-free ISM band and offers excellent range and penetration capabilities, allowing devices to communicate over extended distances while consuming minimal energy.

548On the receiving end, another ESP32 module with the LoRa SX1278 chip is employed to receive the data packets sent by the transmitter. The received data is then forwarded to two servers, namely the Blynk IoT server and the ThingSpeak server these are the IoT platforms. The Blynk IoT server serves as the central hub for receiving, processing, and storing data in the cloud. It is responsible for managing and analyzing the received data, and here it has been set with certain cutoff values on parameters as when certain values exceed their maximum thresholds, it triggers alert notifications. These notifications allow the control room management to be promptly informed, enabling them to take swift actions based on the received alerts. On the other hand, the ThingSpeak server is vital for collecting and storing all the gathered data in the cloud providing real-time monitoring of data. It serves as a repository for the data, facilitating further analysis and visualization, enabling users to gain valuable insights from the collected information. Overall, this system architecture enables the seamless acquisition, wireless transmission, and storage of data from the wind turbines, providing a robust solution for monitoring and analyzing turbine performance.

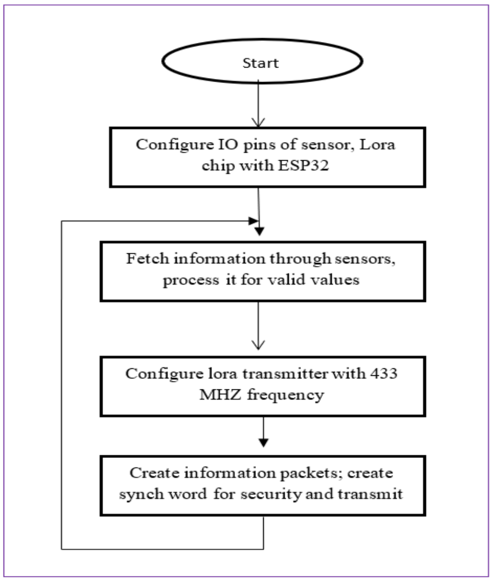


Figure 3.2: Flow chart of Transmitter

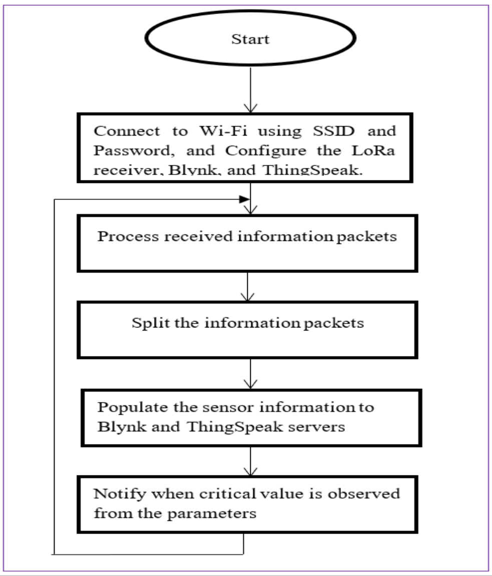


Figure 3.3: Flow chart of Receiver

Starting with the transmitter process as shown in Figure 3.2, the first step is to configure all the input/output pins of the sensor and Lora chip, with the ESP32 ensuring proper communication. After that, the next step involves the set of sensors value with properly defined pins for fetching information from the sensors and processing it to ensure valid values are obtained. Once the sensor data is processed, the Lora transmitter needs to be configured to operate at a frequency of 433MHz in order to transmit data via LoRa. In the fourth step, to transmit data, information packets are created, and a synchronization word is added to enhance security. Finally, these packets, containing valuable data, are transmitted over the Lora network to the receiver.

To begin with the receiver part, initiate the setup process as shown in Figure 3.3. Connect the device to a Wi-Fi network by entering the SSID and password. Configure the LoRa receiver, Blynk IoT, and ThingSpeakfor proper communication. Once connected, the system starts processing the received information packets via LoRa and splits the received information packets into separate individual data elements. The sensor information from the data sets is forwarded to both the Blynk IoT and ThingSpeak servers, allowing for real-time monitoring and data storage. Also Implemented a notification system through Blynk that alerts notifications when critical parameter values are observed, ensuring timely awareness of any significant changes or issues.

IV. WORKING MODEL

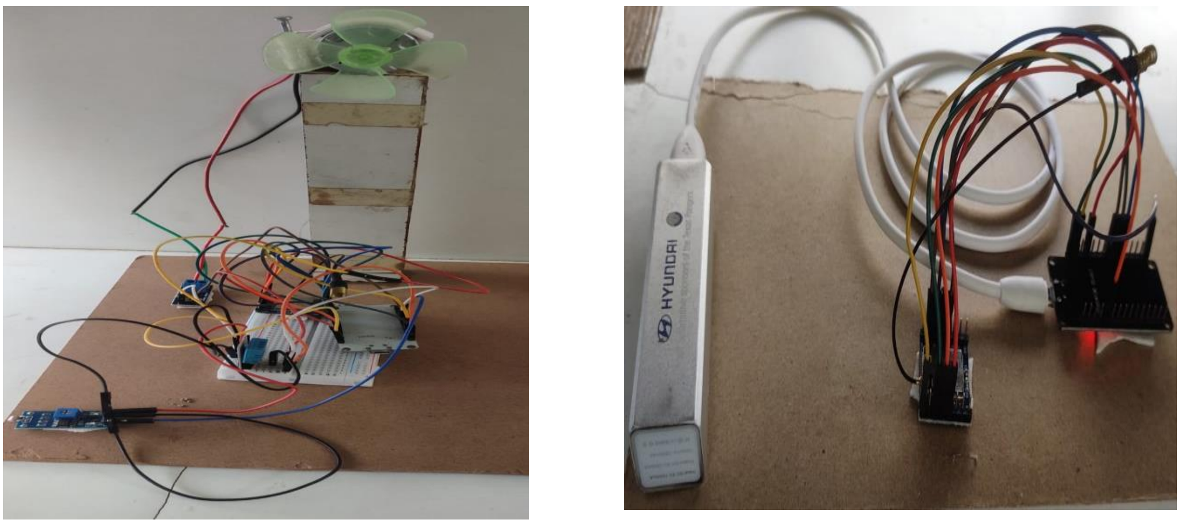


Figure 4: (a) Hardware LoRa Transmitter model and (b) Hardware LoRa Receiver model

Figure 4.1 (a) shows the LoRa transmitter working model which is of LoRa chip and all the sensors interfaced with the ESP32 microcontroller, this gets data from sensors and sends it to the LoRa receiver.
Figure 4.2 (b) shows the LoRa receiver working model which is placed away from the transmitter maximum at a distance of 1 km having an interface of LoRa chip with ESP32 microcontroller which in turn sends the received information packet to the servers.

V. RESULTS

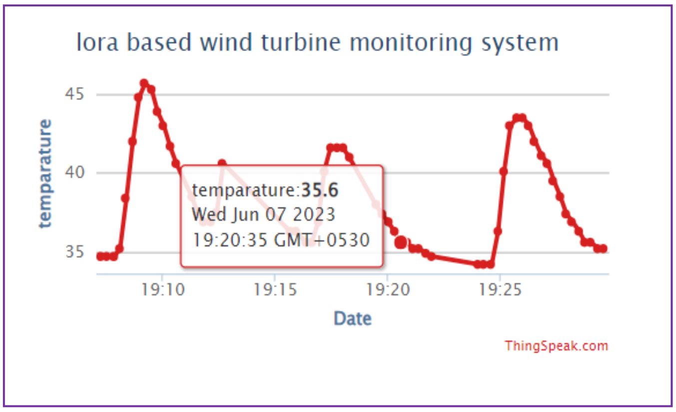


Figure 5.1: Temperature sensor value in ThingSpeak server

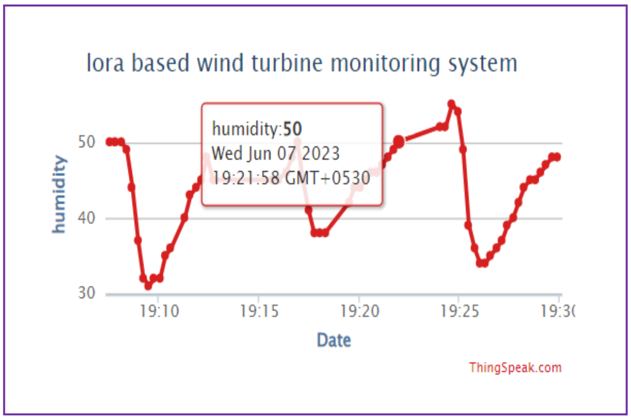
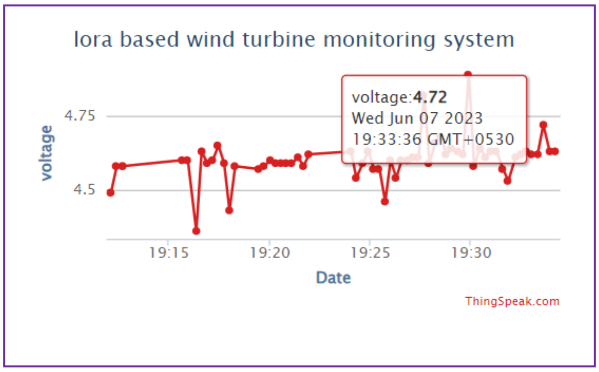


Figure 5.2: Humidity sensor value in Thing Speak server



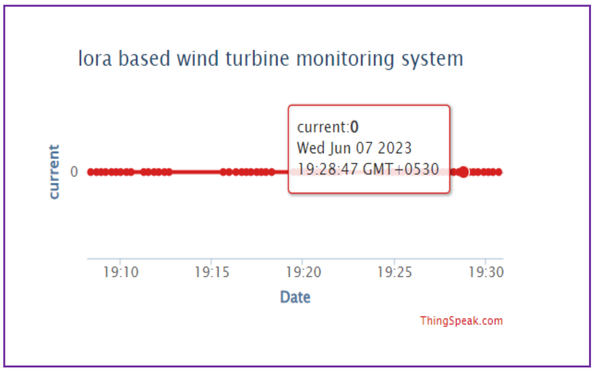


Figure 5.3: Voltage sensor value in Thing Speak server   Figure 5.4: Current value in Thing Speak server

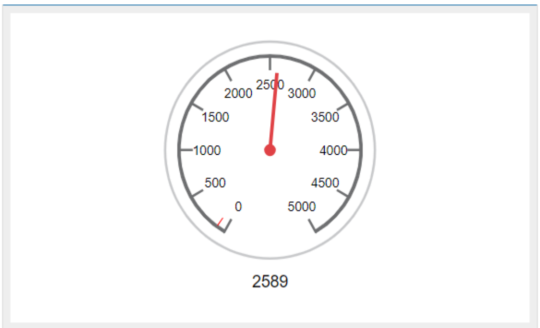
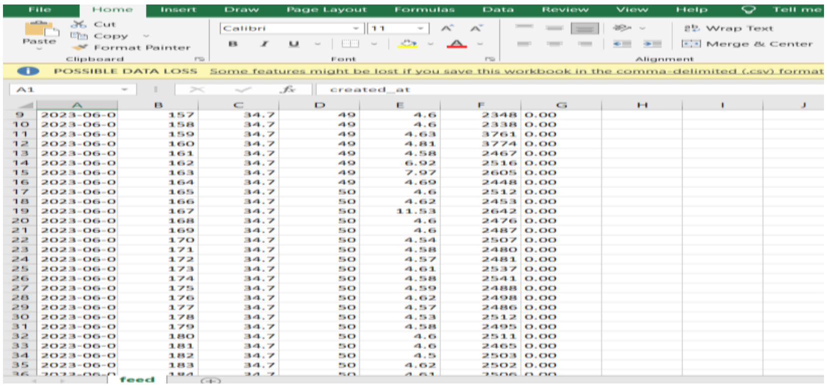


Figure 5.5: Value of Light intensity in Thing Speak server

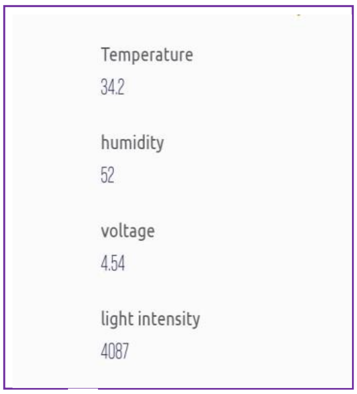
Here from these figures, we can observe the all-following parameters:
Figure 5.1 shows the temperature sensor data, ranging in degrees Celsius. It provides information about the temperature levels in surrounding environments that are recorded by the sensor.
Figure 5.2 shows the humidity sensor data; this gives intuition into the levels of humidity in the environment. It helps monitor the moisture content in the surrounding environment.
Figure 5.3 represents the voltage sensor data, which oscillates based on the rotations of the gear motor supporting the wind blades. This data helps in monitoring of the motor performance of wind turbines.
Figure 5.4 shows the current data of the motor, this is calculated using the voltage sensor data and a given resistance of the voltage sensor. It provides information about the electrical current flowing in the motor.
Figure 5.5 shows the LDR sensor value, this represents the intensity levels of light captured by the sensor. It allows to collect the values for monitoring changes in light levels in the environment.



	A	B	C	D	E	F	G
9	2023-06-0	157	34.7	49	4.6	2348	0.00
10	2023-06-0	158	34.7	49	4.6	2338	0.00
11	2023-06-0	159	34.7	49	4.63	3761	0.00
12	2023-06-0	160	34.7	49	4.81	3774	0.00
13	2023-06-0	161	34.7	49	4.58	2467	0.00
14	2023-06-0	162	34.7	49	6.92	2516	0.00
15	2023-06-0	163	34.7	49	7.97	2605	0.00
16	2023-06-0	164	34.7	49	4.69	2448	0.00
17	2023-06-0	165	34.7	50	4.6	2512	0.00
18	2023-06-0	166	34.7	50	4.62	2453	0.00
19	2023-06-0	167	34.7	50	11.53	2642	0.00
20	2023-06-0	168	34.7	50	4.6	2476	0.00
21	2023-06-0	169	34.7	50	4.6	2487	0.00
22	2023-06-0	170	34.7	50	4.54	2507	0.00
23	2023-06-0	171	34.7	50	4.58	2480	0.00
24	2023-06-0	172	34.7	50	4.57	2481	0.00
25	2023-06-0	173	34.7	50	4.61	2537	0.00
26	2023-06-0	174	34.7	50	4.58	2541	0.00
27	2023-06-0	175	34.7	50	4.59	2488	0.00
28	2023-06-0	176	34.7	50	4.62	2498	0.00
29	2023-06-0	177	34.7	50	4.57	2486	0.00
30	2023-06-0	178	34.7	50	4.53	2512	0.00
31	2023-06-0	179	34.7	50	4.58	2495	0.00
32	2023-06-0	180	34.7	50	4.6	2511	0.00
33	2023-06-0	181	34.7	50	4.6	2465	0.00
34	2023-06-0	182	34.7	50	4.5	2503	0.00
35	2023-06-0	183	34.7	50	4.62	2502	0.00

Figure 5.6: Database of all the parameter's previous records.
Figure 5.6 shows the Database of all the parameter's previous records.

These parameters provide valuable information for monitoring and analyzing various aspects such as temperature.



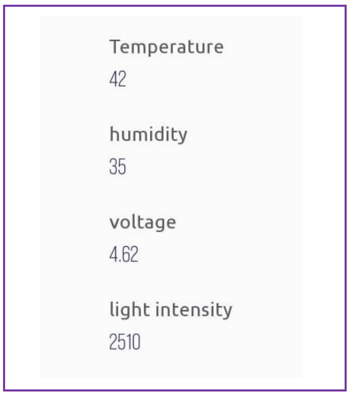


Figure 5.7 (a): Blynk IoT Application notification on the parameters.
Figure 5.7 (b): Blynk IoT Application notification on the parameters with the temperature value getting above the cutoff.

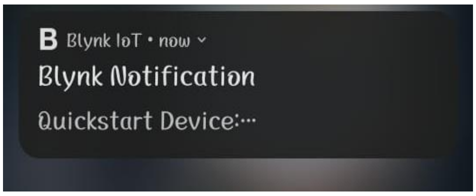


Figure 5.8(a): Blynk IoT Application Android system notification on

Figure 5.8(b): Blynk IoT Application notification on the temperature value the temperature value getting above the cutoff triggering an alert system. going above the cutoff value triggering an alert system.Along with the analyzing and processing of the sensor data from ThingSpeak, the prototype design implements the Blynk IoT Application server to trigger an alert system for alerting on the critical condition of wind turbine performance with any disturbances in the parameters. Figures 5.7 (a) and (b) display all the sensor values obtained from the system showing the real-time data monitoring. If the temperature condition around the wind turbines exceeds the cutoff value, it leads to the triggering of an alert notification sending notification to the respected mobile server, as depicted in Figures 5.8 (a) and (b). This notification is sent to the respective team for prompt action to address the issue effectively.

VI. CONCLUSION

The proposed project is highly beneficial for wind power plants. It utilizes sensors to fetch parameters of the wind turbines, which are then transmitted using LoRa communication technology known for its low power consumption and long-range capabilities. The collected data is examined using ThingSpeak, enabling the identification of patterns and trends. This analysis facilitates the detection of inefficiencies or areas where wind turbine performance can be optimized. Furthermore, the Blynk IoT application is employed in conjunction with critical condition monitoring. It sends alert notifications to the concerned authority, allowing them to access the data and make informed decisions promptly. Thus, enhancing the overall functionality and effectiveness of the wind turbines. As a result, energy production and operational efficiency are improved significantly.

REFERENCES

[1]. Purnomo, F.A., Yoeseph, N.M., Yulianto, A., Royan, Y.I. and Safi'ie, M.A., 2022, February. Development of wind monitoring systems with LoRA technology. In *IOP* Conference Series: Earth and Environmental Science (Vol. 989, No. 1, p. 012011). IOP Publishing.

[2]. L. Vangelista, "Frequency Shift Chirp Modulation: The LoRa Modulation," in IEEE Signal Processing Letters, vol. 24, no. 12, pp. 1818-1821, Dec. 2017, doi: 10.1109/LSP.2017.2762960

[3]. A. Zourmand, A. L. Kun Hing, C. Wai Hung and M. AbdulRehman, "Internet of Things (IoT) using LoRa technology," 2019 IEEE International Conference on Automatic Control and Intelligent Systems (I2CACIS), Selangor, Malaysia, 2019, pp. 324-330.

[4]. P. S. Jagtap and A. P. Hatkar, "Smart monitoring and controlling of wind farms based on WSN," 2016 1st India International Conference on Information Processing (IICIP*)*, Delhi, India, 2016, pp. 1-5, doi: 10.1109/IICIP.2016.7975359

[5]. A. Augustin, J. Yi, T. Clausen, W. M. Townsley, ―A Study of LoRa: Long Range & Low Power Networks for the Internet of Things, Sensors (Switzerland), Vol.16, pp.1-18, September 2016.

[6]. Poornima M Mushi, Vani H U, Varshitha S G, VinuthaCR, RekhaB H, Dr. AnithaG,"IoT Enabled Wind Turbine Data Monitoring System using LoRa",Volume 4 , Issue 7, July 2022 , Page No : 1338-1341, doi: 10.35629/5252-040713381341