An IoT-Based Sag Monitoring System For Overhead Transmission Lines

Mr. P. Muthuponnarasu[1], Banupriya. J[2], Jayasri. S[3], Kaveri. V[4], Oviya. S[5], Sakthi. R[6]
[1]Assistant professor, Dept of Electronics and Communication Engineering
[2, 3, 4, 5, 6]Dept of Electronics and Communication Engineering
[1, 2, 3] Apollo Engineering College

Abstract- *The project focuses on developing a monitoring system for overhead power grids that can detect sagging of extra-high voltage transmission lines in real-time. Such sagging can lead to major blackouts and existing methods for measuring sag have limitations. To overcome these limitations, an IoT-based monitoring system is proposed, which uses an embedded tri-axial accelerometer to detect sagging at different spans of a single circuit. The accelerometer's measurements are converted to accurate sag values. The system also includes an energy monitoring component and a transmission line stand-fall detection system. An Arduino Nano microcontroller is used to implement the system, along with an ADLX335 sensor to detect the position and connection of transmission line stands. The sensor can detect any stand or line falls, and a LORA module sends the data to the central station along with location and stand number information.*

Keywords- Transmission line measurements, Power transmission lines, Temperature measurement, Monitoring, Poles and towers, Mathematical model, Wind speed

I. INTRODUCTION

The term "Internet of Things" (IoT) refers to a recent technological advancement that enables communication and interaction between interconnected devices, as well as between different devices and physical objects. This technology is divided into three layers: perception layer, network layer, and application layer, as illustrated in Figure 1. The perception layer comprises two sub-layers, the first of which is responsible for sensing the physical environment, while the second sub-layer is responsible for data acquisition.

The smart grid is an advanced energy system that utilizes the Internet of Things (IoT) to monitor and manage various intelligent communications in the electrical network. It is considered one of the most significant IoT applications. Ongoing scientific research continues to improve the smart grid by providing it with advanced capabilities such as automation, monitoring, and communication. A transmission line is a conductive wire that is designed to transmit a large amount of energy generated with high voltage from one station to another, based on the difference in voltage levels.

Developing a monitoring system for high voltage transmission lines using IoT technology is an essential project to maintain the safety and reliability of electric power networks. These transmission lines are susceptible to various threats, such as natural disasters (e.g., frost, wind, and hurricanes) or intentional human actions (e.g., theft and destruction). Moreover, transmission lines are often located in remote areas, far from cities and residential regions, making them challenging to monitor and maintain. Therefore, establishing a monitoring system based on IoT is crucial to provide real-time data to the monitoring centre and take necessary actions to prevent disasters and damages.

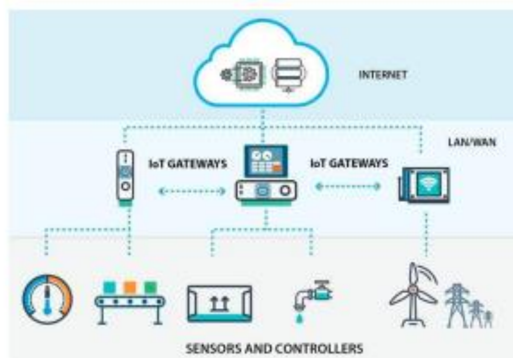

Fig: 1 Internet of Things

II. RELATED WORKS

Navaneetha Krishna R, Niranjan L, and their colleagues proposed a framework for identifying the location of faults in transmission lines based on Ohm's Law. The system is fast, reliable, and cost-effective in identifying the location of faults, which helps in preventing accidents or damage to the equipment. The framework also facilitates the identification of the specific location of the fault, enabling maintenance workers to remove persistent faults and identify areas where faults occur repeatedly, reducing the occurrence of problems and minimizing downtime. The researchers used an Arduino board, introduced an average transmission line resistance of 500 Ω for a distance of 1 km, and added a resistance of 1kΩ for a distance of 2 km. To demonstrate the system's effectiveness, manual error was introduced, and the Arduino attempted to determine the fault distance using its software. The information was sent to the control centre using Wi-Fi (Wireless Fidelity), and the fault location was displayed on the LCD screen [7].

The power system can be divided into three parts, power generation, transmission, and distribution. The transmission network is a crucial component of the power system since it links the supply and demand sides. In comparison to other parts of the power system, the transmission and distribution network experiences higher losses. Currently, the electric power infrastructure is vulnerable to various natural and malicious physical events that can negatively impact the overall performance and stability of the system. Any fault in the transmission network can impede the supply of power to the consumer. Therefore, it is crucial to rapidly identify and resolve any issues in the transmission network.

The transmission network is a critical component of the power system, as it connects the supply and demand sides. However, the transmission and distribution networks are associated with high power loss. Moreover, the power infrastructure is vulnerable to various natural and malicious physical events, which can have a significant impact on the system's overall performance and stability. Thus, it is essential to identify and clear any faults in the transmission network quickly to avoid disruption of power supply to the consumers.

To achieve this, there is a need to upgrade the traditional transmission line system with a high-performance data communication network that supports future operational requirements such as real-time monitoring and control, which are essential for a smart grid integration. Many electric power transmission companies have traditionally relied on circuit indicators to detect faulty sections of their transmission lines. However, this method can be expensive and time-consuming, especially when using sensors, breakers, and other communication lines. Despite these efforts, there are still challenges in accurately identifying the specific location of these faults.

While fault indicator technology has improved the ability to locate persistent faults in transmission lines, the current process for identifying faults is still time-consuming and labour-intensive. Technical and inspection teams must physically monitor and inspect the equipment for long hours to identify the faulty components of their transmission lines, and then manually clear the fault. This process requires significant human effort and can lead to delays in restoring power.

Monitoring transmission lines using remote sensors is a solution to several challenges such as real-time awareness, faster issue localization, accurate fault identification, condition-based maintenance, and cost reduction. These applications require a reliable and cost-effective network architecture that can deliver a massive amount of data in a timely manner. Xihai Zhang, Yan Zhao, and their team proposed a system for monitoring the inclination of electric power transmission towers using Low Power Wide Area Network (LPWAN) and Narrowband Internet of Things (NB-IoT) technologies. The system addresses the challenges of high energy consumption, long-distance, and high cost. The sub-nodes of the system include a tilt sensor (ADLX335) and a LORA Module, while the main node includes an NB-IoT. The tilt sensor collects data, which is then relayed through multiple hops using the LORA Module to the Cloud Platform via NB-IoT. When the threshold for tower inclination is exceeded, the Cloud Platform sends an alert message to the administrators through email and mobile terminal, and a short message is displayed on the Cloud interface [34].

III. SYSTEM DESIGN

The current system used for monitoring transmission line position aims to prevent short circuits. It calculates the line temperature and sag value by utilizing wind speed, ambient temperature, line current data, and sunshine information at a span. However, obtaining these parameters with high accuracy in real-time can be challenging. To address this issue, an IOT-based information communication system could be implemented.

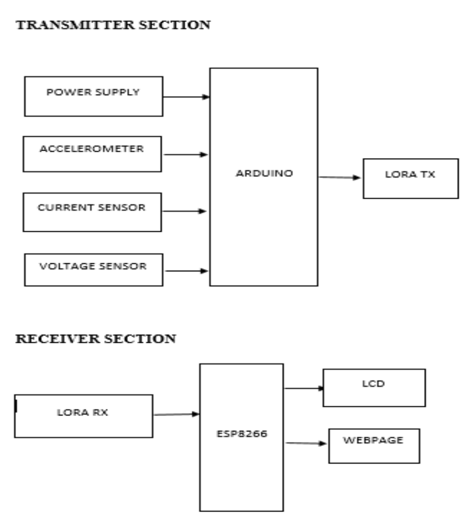

Figure 2:- BLOCK DIAGRAM

Figure 2 illustrates the two main sections of this project: the transmission section and the receiver section.

MODULE1:-MONITORING MOVEMENTS

Accelerometers can play a crucial role in monitoring the sag of overhead transmission lines. By measuring the acceleration caused by the movement of the conductors due to sag, an accelerometer sensor can provide information about the sag level of the transmission line. The accelerometer sensor can be installed at a specific point along the line, and its readings can be used to determine the sag level.

Additionally, the accelerometer sensor can provide information about the vibration of the conductors due to wind or other external factors. This information can be used to detect potential issues, such as fatigue or damage to the conductors, and take preventative action before a failure occurs. Overall, the use of accelerometer sensors in sag monitoring systems can improve the safety and reliability of overhead transmission lines.

MODULE 2:- CURRENT AND VOLTAGE SENSOR

While an accelerometer sensor is primarily used to monitor sag in overhead transmission lines, current and voltage sensors also play an essential role in the sag monitoring system.

The current sensor measures the electric current flowing through the transmission line, which helps to calculate the line's sag accurately. By measuring the current, the system can determine the tension on the line and, consequently, its sag.

Similarly, the voltage sensor is used to measure the voltage level of the transmission line. The voltage level is also used to calculate the sag accurately. By measuring the voltage level, the sag monitoring system can determine the actual sag of the line and alert operators if it is outside of the acceptable range.

Thus, all three types of sensors, including the accelerometer, current, and voltage sensors, work together to accurately monitor and calculate the sag in overhead transmission lines.

MODULE 3: LORA TRANSMISSION

Lora (Long Range) is a low power wide area network (LPWAN) protocol used for long-range communication between devices. It operates on unlicensed frequencies, making it a cost-effective solution for many IoT applications. LoRa enables long-range communication with low power consumption, making it ideal for remote monitoring and control. It can transmit data over several kilometres with a low data rate, and its modulation technique provides a high level of interference immunity. LoRa technology is used in various applications such as smart cities, agriculture, asset tracking, and more.

Sag Monitoring System for Overhead Transmission Lines using Accelerometer Sensor, the data collected by the accelerometer sensor is transmitted using the LoRa (Long Range) technology. LoRa is a low-power wide-area network (LPWAN) technology that enables long-range communication with low power consumption, making it suitable for remote sensing and monitoring applications such as sag monitoring of transmission lines. LoRa can transmit data over distances of several kilometers with minimal power consumption, making it an ideal choice for transmitting data from remote sensors placed on transmission lines.

MODULE 4:- DATA DISPLAY

The LORA receiver receives data from the Sag Monitoring System for Overhead Transmission Lines and displays it on a 16x2 display.

MODULE 5:- IOT

The ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capability. It can be used as a Wi-Fi module for microcontroller-based projects, such as sending data received from the Sag Monitoring System to the cloud. With the help of ESP8266, the received data can be transmitted over the internet to the cloud server for storage and further analysis.

IV. HARDWARE DESCRIPTION

ADLX335

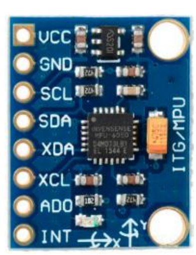

Figure 3:- ACCELEREMOTER SENSOR

Figure 3 displays the accelerometer sensor. ADLX335 is a well-known device used for motion tracking, which integrates a 3-axis gyroscope and a 3-axis accelerometer on a single chip. Its small size, high accuracy, and low power consumption make it a popular choice for many applications, such as gaming controllers, drones, and robotics. The ADLX335is capable of measuring acceleration, angular velocity, and temperature, and outputs digital signals using the I2C protocol. Furthermore, it has additional features like programmable interrupts, motion detection, and tap detection, which increase its versatility and applicability in various domains.

CURRENT SENSOR

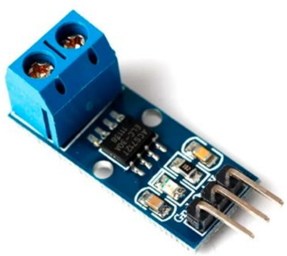

Figure 4:- CURRENTSENSOR

Figure 4 displays the current sensor ACS712 is a popular current sensor that can measure both AC and DC currents. It works based on the Hall Effect, which produces a voltage proportional to the magnetic field generated by the current flowing through a conductor. The ACS712 has a high accuracy, low noise, and low offset voltage, making it suitable for use in various applications, including power supplies, motor control, and energy metering. It provides analog output that is proportional to the measured current and can be easily interfaced with microcontrollers such as Arduino. The ACS712 comes in different variants that can measure different current ranges, from a few amps to tens of amps, making it a versatile sensor for different current measurement applications.

VOLTAGE SENSOR

Figure 5:- VOLTAGESENSOR

A voltage sensor is a type of sensor that is used to measure the voltage level of an electrical circuit. It is commonly used in electronic applications such as power supplies, battery monitoring systems, and voltage regulators. A voltage sensor typically works by converting the voltage signal into a proportional analog or digital output signal that can be processed by a microcontroller or other electronic device. There are different types of voltage sensors available in the market, such as resistive, capacitive, and magnetic sensors. The selection of a voltage sensor depends on the specific application requirements such as voltage range, accuracy, and response time.

BRIDGE RECTIFIER

Figure 6:- BRIDGE RECTIFIER

A bridge rectifier is an electronic component that converts alternating current (AC) to direct current (DC). It consists of four diodes arranged in a bridge configuration, hence the name "bridge rectifier". When an AC voltage is applied to the input terminals of the bridge rectifier, the diodes conduct in a way that allows current to flow in only one direction, resulting in a DC voltage at the output terminals. Bridge rectifiers are commonly used in power supplies and electronic circuits where a stable DC voltage is required.

ARDUINO UNO

Figure 7:- ARDUINO UNO

The Arduino Uno is a microcontroller board based on the ATmega328P microcontroller. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, and a power jack. The board is programmable using the Arduino Software (IDE), which is a cross-platform development environment that allows users to write, compile, and upload code to the board. The Arduino Uno is widely used in various electronic projects due to its ease of use and low cost.

LORA MODULE

Figure 8:- LORA

The LORA module is a wireless communication module that uses LORA technology to transmit data over long distances with low power consumption. It operates at a frequency range of 868 MHz or 915 MHz and can transmit data up to a distance of several kilometres, making it suitable for applications such as remote monitoring and control systems. The LORA module uses a spread spectrum modulation technique that provides robust communication even in noisy environments. It also has a low data rate, which reduces power consumption and allows for long battery life. The LORA module can be integrated with various microcontrollers and single-board computers, making it a popular choice for IoT applications.

ESP8266

Figure 9:- ESP8266

ESP8266 is a low-cost, Wi-Fi enabled microcontroller module that is widely used for IoT applications. It is developed by Espressif Systems and is designed to be integrated into embedded systems. The module comes with built-in Wi-Fi connectivity, making it easy to connect to the internet and other devices on a network. It has a small form factor and can be easily programmed using the Arduino IDE or other programming languages. The ESP8266 module is commonly used for home automation, sensor monitoring, and other IoT applications.

V. RESULTS

The study on IoT-based Sag Monitoring Systems for Overhead Transmission Lines suggests that such systems offer real-time monitoring of sag with high accuracy and reliability. They also facilitate the early detection of sag, improve operational efficiency, enhance safety, and can be cost-effective compared to traditional methods of sag monitoring. These systems have the potential to enhance the performance and reliability of power transmission systems, while reducing maintenance costs and minimizing downtime.

Figure 10:- Prototype module

Storing the monitoring data in a database allows for further processing and analysis, which can lead to the development of useful services, such as determining the optimal placement of sensors and reconstructing the temperature distribution of an entire power grid. The implementation of IoT-based sag monitoring systems provides a reliable and real-time monitoring solution for overhead transmission lines, ensuring the proper tension in the conductors and promoting safe and reliable operations. This technology has the potential to transform the traditional approach to monitoring and managing overhead transmission lines for utilities. With continuous advancements in IoT technology and data analytics, the system can become even more efficient and effective in ensuring a safe and reliable power delivery.

VI. CONCLUSION

In conclusion, the implementation of IoT-based Sag Monitoring Systems for Overhead Transmission Lines offers a promising solution for ensuring safe and reliable power delivery. The use of sensors such as accelerometers and voltage sensors enable real-time monitoring of sag, which is crucial for maintaining proper tension in conductors. These systems provide accurate and reliable monitoring of sag, increase operational efficiency, enhance safety, and can be cost-effective compared to traditional methods. Moreover, the monitoring data can be analysed to generate useful information and services, such as optimal sensor placement and reconstruction of line temperature distribution for the entire power grid. As IoT technology and data analytics continue to advance, these systems have the potential to revolutionize the way utilities monitor and manage overhead transmission lines, ultimately improving the overall performance and reliability of power transmission systems while reducing maintenance costs and minimizing downtime.

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