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Monitoring System for Overhead Power Transmission Lines in Smart Grid System Using Internet of Things

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Abstract: In the traditional systems, detection of the faults in the electric lines is more difficult. Detection of faults takes time more than repairing time. In most cases faults or problems in power transmission lines occur due to environmental disturbance. Advanced monitoring system of overhead transmission lines assists in saving human lives and helps in maintenance planning. Tension and loosening are examples of problems that result in the absence of high quality monitoring system. The objective of this paper is to do continuous monitoring of the atmospheric conditions and the sag status in the power transmission lines. The design consist of a group of sensors (distance sensor, wind speed sensor, pressure sensor and deviation sensor), which are used to monitor the atmospheric conditions, and send the records to main controller. The controllers transmits these measured values through Wi-Fi to the web page and display them in the channel graph. The recorded resulting data can be shown in a digital form at any time by selecting any point in the graph. The system is built up by using internet of things (IoT) monitoring technique and global positioning system (GPS) technology to provide the location and guarantee wide range of covering area of the smart grid. The experimental results include the date, time and value and is shown in graphical form to help the manager to analyze the system faults easily. The obtained results were reliable and correct. The results satisfied the goals of the paper and reveal that the use of IoT monitoring system of the transmission lines enhanced the quality of the service.

Keywords: *Electronic design, Power Transmission, Sensors; WSN; IoT*

1. INTRODUCTION

Energy consumption is increasing every day in particular in the industrial countries. The continuous energy supplies is an important issue whose availability is required to improve the stability of energy[1][2].Transmission lines system is the part of the electric grid network which is responsible of transferring the power from the power station to the end user [3]. Power failure problems in the power transmission lines occurred due to many environment factors such as temperature, strong winds and rain[4]. High temperature caused increasing the length of the line conductor which leads to increasing the sag which is considered very dangerous because it becomes closer to ground and short out when touching together [5]. In the transmission line internet of things (IoT) monitoring system, using of multiple sensors can be applied to overcome these problems in transmission lines. The idea of IoT was first proposed in 1999 in USA. After this date it has been proved useful in many countries [6].

The actual starting of IoT was in 2008 because since that date it became useful widely in many applications. It rapidly spreaded in the wireless sensors networks [7]. In this paper an IoT design for monitoring the transmission lines in smart grid is presented. It aims to provide early detection of faults and contribute in minimizing the power failure problems in smart grid. The system contributes in the country economy by providing continued energy to cover the required needs of industrial sector.

The system based on GPS technology and IoT to provide an efficient monitoring system for covering wide area in the smart grid network. Multiple sensors were used for collecting the Required data from different locations in the grid. All these data are sent through internet and displayed in the monitoring web page.

2. SURVEY OF RELATED WORKS

There is a lot of research work aimed solely in improving the monitoring system of smart grid. Recently there are many published works that attempt to develop an efficient technology for monitoring the power transmission lines. Most of these works are classified in different criteria and are only focused on the temperature parameter and the others add one or more parameters while in the present proposed system many parameters were monitored. The published works in this field are also different in the types of monitoring strategies where some of them used wireless technology such as XBee or GSM technology and some used IoT which provides advanced wireless monitoring system. The proposed system applied IoT monitoring and preferred to display the obtained data in graphic form to provide easy analysis. Abraham et al[8] monitored the current level in the transmission lines wirelessly using ZigBee technology. Javid et al [9] discussed monitoring and controlling design of electric power supply to homes. The system measured the electric power in the transmission lines. Banupriya et al[10] showed wireless monitoring design of temperature in the transmission line where the system used ZigBee technology. Alhebshi et al[11] designed a monitoring system using Arduino microcontroller and the IoT technology to provide wireless monitoring of some parameters related to the power transmission lines. Kaur et al[12] studied in their review paper the requirements of using IoT technology in the smart grid. They overviewed various applications in this field. Hidayatullah eta al [13] discussed the fundamental architecture of IoT in smart grid also discussed the technologies of IoT in smart grid. Ismail et.al [14] showed in his paper a monitoring system to detect such faults, and the control of power switching according to these faults. The system used XBee technology.

3. POWER SYSTEM

Power systems refer to generating power and delivering it to consumers. The first electrical power system was known in 1881 by two electrician in England. It was very simple consisting of two water generator station. It produced power to operate limited number of lambs [15]. Generally the electric power system consists of the following components; generation, transmission and distribution and loads. Grid refers to the transmission system in specific region [16]. Transmission system transfers power from the generation station through the distribution system. The transmission lines transmit the power from the generation station covering long distance to reach the consumers. The standard operating voltage of transmission lines are in the ranges; 66KV, 33KV and 11KV. The customer received 230V per phase. Extra high voltage refers to voltages above 230KV which required high voltage transmission lines while the medium voltage line (MV) usually used in the distribution system in the range of 3.3KV to 33KV. The selection of transmission line voltage depends on the distance and the required transmission power. Distribution network is the part of the power system which connects between the distribution substations and the consumers. The basic component of the distribution system architecture is the step down transformer which is used to step down from high voltage level to lower voltage level. There are many differences between distribution system and the transmission system in terms of magnitudes voltages and topology. The common electrical properties of transmission lines are resistance, capacitance, conductance and inductance [16][17]. The load in the power system can be one of the following: industrial load and commercial load. Commercial and home users consumed small amount of the received power and most of it is used for lighting and heating purpose.

Methodology

Fig 1 illustrates the block diagram of the system that is specified by four main blocks; the sensors, control unit, GPS module and the Wi-Fi transmission.

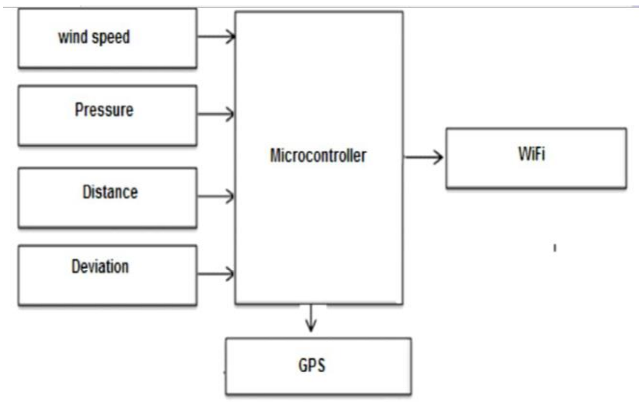

Fig.1. Block Diagram

In this system we use four sensors; wind speed sensor, pressure sensor, distance sensor, and deviation sensor. The controller units used Arduino responsible of connecting these sensors and processed the collected data then send it wirelessly through internet. The Wi-Fi transmitter and receiver are used to connect the circuit and the website wirelessly.

The electronic circuit is shown in Fig.2. All the sensors measure the physical values continuously, and send it to the Arduino unit. The Arduino provides real time comparison of the obtained values from the sensors with the normal conditions. The Arduino send these readings to the transmitter, and the transmitter sends it to the receiver. At the receiver side the obtained results are shown in website channel. The GPS were used to specify the location of the site. The system results of each sensor are shown in the web page l in a graphic form.

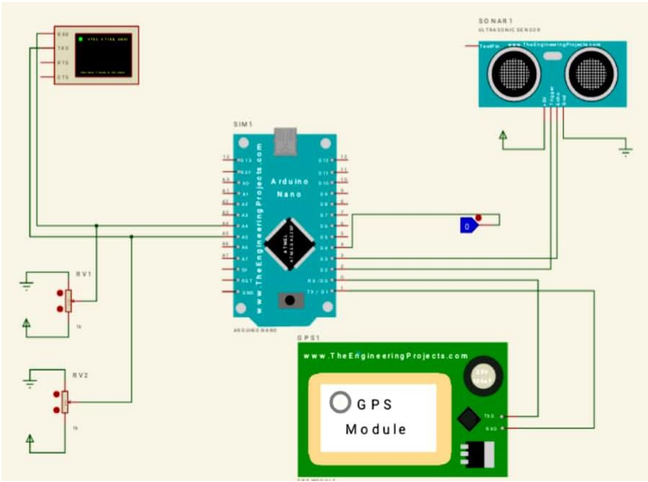

Fig.2. Circuit schematic

Fig 3 depicts a prototype model design of the system which shows the appropriate positions of the sensors. This model was used for the experimental test.

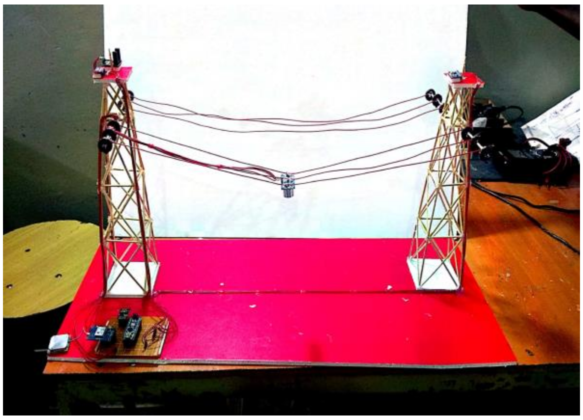

Fig.3. Design model

An ultrasonic sensor is used to detect the distance of the sag in the system. The basic principle of this sensor is based on the following formula:

$$\text{Distance} = V \times T \quad (1)$$

Where:

V: is the velocity of sound (340M/S)

T: is the high level of the time.

A tachometer senor is used in measuring the wind speed. This sensor consists of a number of rotating discs. The operating principle of the tachometer in generating an electrical signal depends on the amount of the rotating air speed.

The operation algorithm of the monitoring system is shown in Fig.4. The algorithm starts by gathering data of pressure, distance, wind speed and deviation by the appropriate sensors. Then the Arduino unit transmits these data through Wi-Fi technology. These cases will be displayed in the web page (stable, low and high).

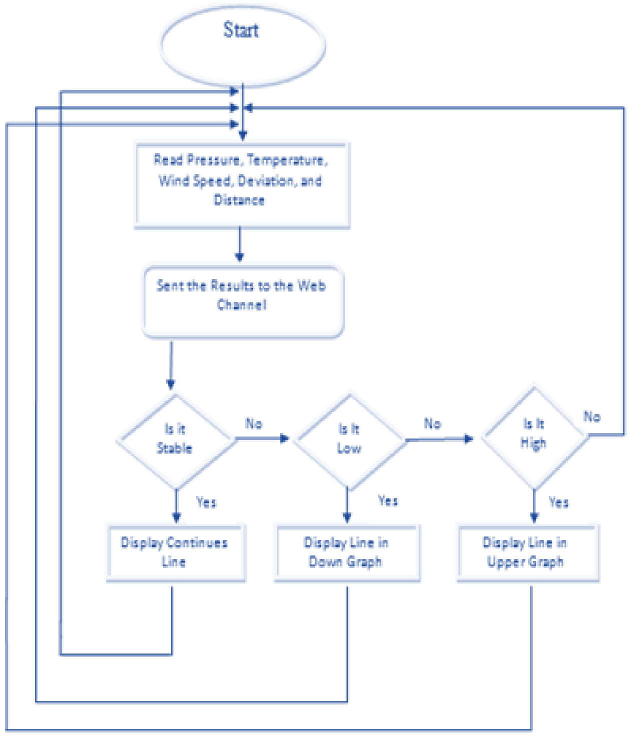

Fig.4. Algorithm

To access the IoT system, three steps are required to be followed by the manager of the system.

Step1. In this step user must insert the correct E-mail and password, the system uses the E-mail address as user name., the user of the system is required to insert the correct password to continue into the next step.

Step2: After entering the correct E-mail and password the user log in to the main interface page, as shown in Fig. 5.

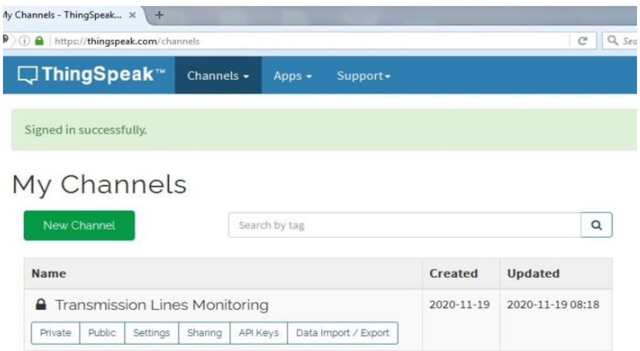

Fig.5. Main page

Step3: The user can select the channel button to display the instantaneous state of each channel, as shown in Fig..6

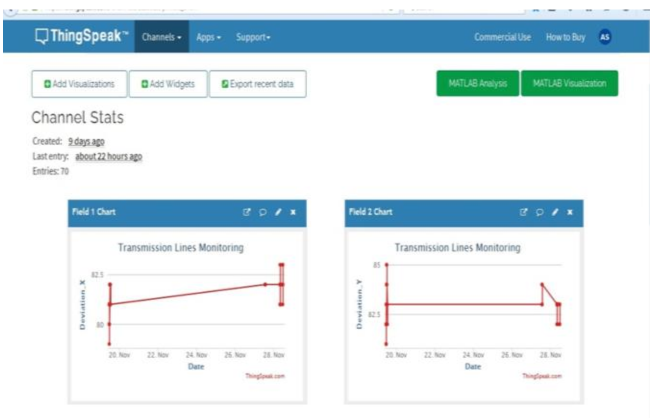

Fig.6. Channels Screen

By completing the previous steps successfully the user will be able to obtain real time monitoring of all the sensors in the required field.

4. Experimental Results And Discussions

The experimental test evaluates the operation of the system by monitoring the gathering of data from the sensors. The result of each sensor is shown in graphic form.

A. Deviation Sensor Result

The deviation sensor is used to monitor the towers slope in the normal case which is often within the range of 80 cm for x and y axis. If the sensor read a stable value, the display in the graph is continuous line. If the sensor reads a low value, the display in the graph is a lower line. If the sensor reads high value, the display result in the graph is an upper line. The deviation result of x and y axis were shown in Fig.7 and Fig 8 respectively.

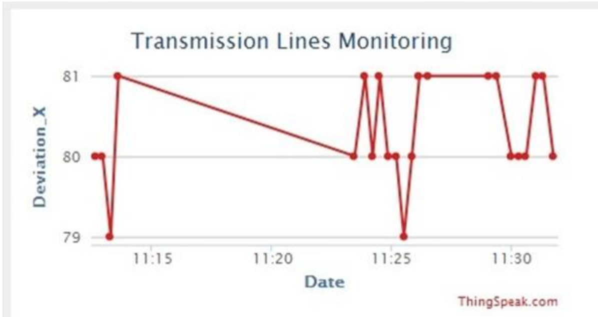

Fig.7. Deviation in X axis

Fig.8. Deviation in y axis

B. Wind Speed Sensor Result

The level of wind speed from 1400 to 1500 km/h is considered normal range. The graphic results obtained from the wind sensor are shown in Fig. 9. When the sensor measure a stable value, the display in the graph is shown as continuous line. When the sensor measure a low level, the display in the graph shows lower line. In the case of high value, the display result in the graph channel appears as upper line.

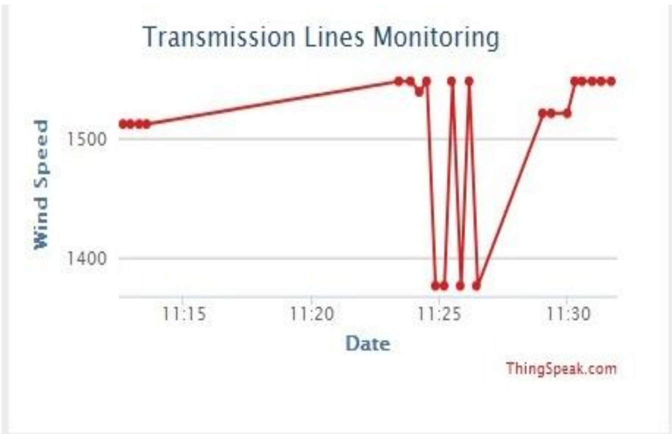

Fig.9. Wind speed Results

C. Sag Results

In this experiment the normal distance of the sagging is 10 cm. The results of the sagging were recorded by the ultrasonic sensor. The experimental results of the sag are shown in Fig.10.

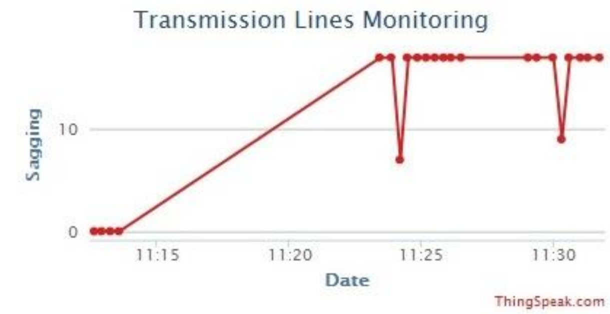

Fig.10. Sagging Results

D. Pressure Sensor Result

The normal atmospheric pressure is 100kPa. The results of the pressure sensor are shown in Fig.11. When the sensor measured a stable value, the display in the graph is continuous line. If the sensor read a low value, the display in the graph is shown as lower line. When the received data from the sensor is high, the display results in the graph channel is shown as an upper line.

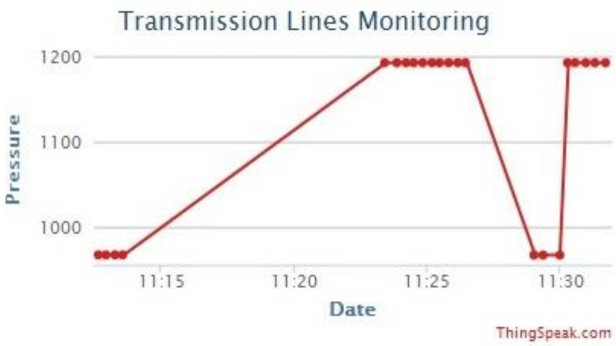

Fig.11. Pressure Results

The gathered data from the sensors can be shown in digital form at any point in the graph as shown in Fig.12.

Fig.12. Digital Results

The digital data included the reading value of the sensor, the date of reading and the time of reading the value.

5. Conclusion

This paper presented an IoT monitoring system for power transmission system. The basic structure of the design consists of group of sensors, Arduino unit and GPS module. The gathering results from the sensors displayed in internet website. The system aimed to use modern technology to provide high quality service in the smart grid. This goal is achieved by providing continuous energy to users which is required to avoid power failure problems. The system was practically tested and the obtained results were analyzed. The overall results of the experiments for all sensors reveal that the system is helpful and provides easy real time monitoring of the smart grid.

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