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An Application of IOT and WSN to Monitor the Temperature of AC Transmission Line

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Abstract

With the increase in demand for power with population, power quality issue is one of the challenging areas which needs utmost attention. It is a known fact that the transmission of power takes place through transmission lines which are bare conductors and are prone to many natural situations, which degrade the quality of power and also leads to sagging of conductors. Variation in temperature is a commonly affecting parameter over these transmission lines and leads to deviation in the power flow affecting ampacity of the conductors and over a period of time leads to unwanted sag. Monitoring the temperature of transmission lines is done continuosly using LM35 temperature sensor and an application of Internet Of Things (IOT) through thingspeak application platform to track the variations. An Wireless Sensor Network (WSN) environment is created to transmit the temperature data from one node to another using NS-2 platform.

Keywords: Sag, Temperature sensor, Internet of Things (IOT), Wireless sensor Network (WSN).

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1. Introduction

Overhead transmission lines are thermally limited to the amount of electrical current it can carry, due to the physical properties of the conductor. In overhead transmission lines, resistance of the conductor is the main reason for losses. When the current in conductor tries to overcome the ohmic resistance of the line, the power is dissipated in the form of heat, leading to increase in temperature of the over head transmission line. One of the major contribution to the sagging is increase in temperature. Increase in the sagging affects the physical property of the conductor. Hence, monitoring the temperature in overhead transmission line plays vital role. LM35 temperature sensor is used for monitoring the temperature and wireless sensor network environment is used to transmit the data of temperature from one node to another using Ns-2 platform.

2. Literature Survey

The temperature sensor DS1820 is used to monitor temperature of transmission lines indoor and outdoor. The maximum current capacity of transmission lines changes with line temperature. However, the maximum current capacity can only be calculated by conductor temperature model [1]. Monitoring of transmission line is required for efficient ampacity. The sag and the conductor temperature are the two parameters defines the ampacity of overhead transmission line [2]. On everyday basis the temperature of the transmission line conductor is typically 5℃ to 15℃ above the air temperature [3]. The temperature of conductor has a very significant impact on the power flow calculations. The power flow model has depicted significant changes with and without temperature considerations. In power flow calculation procedure, the line resistances are assumed to be invariable which does not conform to the actual. Resistance of transmission lines are changed with changes of external environment like temperature and power distribution.[4]. Overhead Transmission line conductor clearance is a key limiting factor. Monitoring the conductor sag can be used for warning purposes to ensure that mandatory clearance limits are not violated [5]. There is a increasing demand for reducing accidents and speeding up diagnosis for overhead transmission line. Some of the significant fault includes sag which poses serious concerns for continuous operation of overhead transmission lines under changing weather conditions [6].

Temperature dependence can be determined as shown in below formula.

$R_{Tc}=R_{T0}[1+\alpha(T_c-T_0)]$ (1)

Where $\alpha = 0.0039$ is the temperature coefficient for aluminum, R_{Tc} and R_{T0} are the resistances at temperatures T_C and T_0 correspondingly. Increase in temperature leads to increase in the length of outstretched conductor. The amountof increase in length is given by

$\Delta L = \alpha T$ (2)

α = the coefficient of thermal expansion

T = the temperature increase in ℃

S = the span length in meters

An overheating electrical transmission line sagging led to tree sparking causing greatest power failure in the Western United States in 1996. A similar incident is suspected to have caused the recent East Coast blackout [7]. Based on the physical properties of the conductor, Overhead transmission lines (TLs) are thermally limited to the amount of electrical current they can carry. Transmission line current carrying capacity is set to static or seasonally varying values based on a conservative assumption of the environmental conditions (e.g., low wind speed and high ambient air temperature) [8]. The carrying capacity of electric power cables decreases as ambient air temperatures increases. During summer, electricity loads increases due to increased air conditioning usage. Higher ambient air temperatures may strain overhead transmission line by increasing peak electricity load. [9]. In overhead transmission lines, resistance of the conductor is the main reason for losses. When the current in conductor tries to overcome the ohmic resistance of the line, the power is dissipated in the form of heat, which is directly proportional to the square of the r.m.s current flowing through the line [10]. The optical current sensing devices provide wider dynamic range, lower weight, immunity towards electromagnetic interference and improved safety when compared to the heavy electronics for the same operation and this happens mainly due to high intrinsic insulating properties of optical fibers. An optical sensor with fibre bragg gratings(FBG's) which can be used to measure temperature and current of transmission lines accurately [2]. A 9-bus, 3 generator power system to analyse the impact of temperature variation. The authors conclude that approximately 3.5% difference in power flows on the branches were observed. The effect of temperature cannot be neglected especially when the lines are closer to their maximum power handling capabilities according to the authors [11]. The changes in transmission line resistances due to temperature have non-negligible effect on state estimation accuracy. The more accurate allocation of transmission lossess, accurate power flow and network voltage profile is possible only when the state estimation results are accurate for which a more reliable representation of power system is to be considered, line heat balance equation and weather data is utilized [12]. The level of infrastructure utilization and the efficiency of informationization can be improved through IOT as well control over high voltage equipments can be achieved with intelligent decision making and high degree of cognitive with IOT communication among different objects, various entity and virtual body is made possible through the technology of IOT. The redundancy in data can be eliminated from the collected mass of sensed and identified information [13]. An application of IOT connected healthcare to monitor body temperature distribution and heartbeat is proposed by the authors of [14]. Intercommunication between various heterogeneous objects, wearables, sensors and appliances are efficiently enabled through IOT which offers high quality services [15]. A highly federating intelligent application for IOT to distinguish and protect the public data as well as private data without cross reffering the information has been proposed by the authors of [16]. WSN technology can enhance many aspects of present electric power systems, which includes power generation, distribution and utilization. Hence, WSN is an important aspect of electric power system. Typically, wired communication is used for monitoring and diagnosing the electric power system, this kind of communication requires expensive communication cables. Hence, there is a need for wireless monitoring of electric power system [17]. Wireless sensor network has the ability to configure and organize into effective network for communication. Wireless sensor network has the capacity to access data in difficult situations and large geographical area. Wireless sensor network has better flexibility and mobility compared to wired network. [18].

3. Methodology

Methodology includes monitoring the temperature sag of overhead transmission line and block diagram representation for the proposed work.

3.1. Monitoring the temperature sag of overhead transmission line

The overhead transmission lines are constructed with minimum ground clearance and sag template which follows the electricity board specifications as per Indian Electricity rules., 1956, rule77. One of the major contributions to sagging is raise in temperature which has to be monitored regularly for human safety. An illustration of the conductor sag as shown in figure 1 is given an approach to be monitored with the help of temperature sensor LM35 and an equation based sag calculation as given in equations (3), (4), (5) and (6) is done by Atmega AVR Microcontroller.

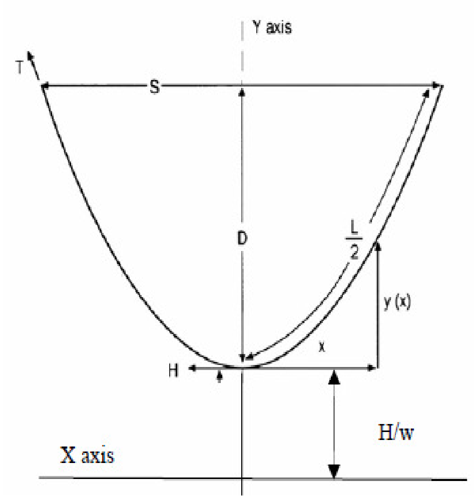

Figure 1. Illustration of conductor sag

D = Sag (m)
S = Span length (m)
L = Line length (m)
H = Horizontal component of tension (N)
T = Total tension (N)
W = Weight per unit length of conductor. (N/m)
x = horizontal distance from lowest point (m)
y(x) = vertical distance from lowest point at x (m)

$$y(x) = \frac{H}{w}\left[\cosh\left(\frac{w.x}{H}\right) - 1\right] \quad (3)$$

$$D = \frac{wS^2}{8.H} \quad (4)$$

$$L = Lo(1 + \alpha_T X(T - To))(1 + \frac{H-Ho}{EA} + \epsilon_c) \quad (5)$$

$$1 + \frac{w^2 l^3}{24H^2} = \left(1 + \frac{w^2 l^3}{24H_0^2}\right)(1 + \alpha_T X(T - To))\left(1 + \frac{H - Ho}{EA} + \epsilon_c\right) \quad (6)$$

Where,
L_0 : Initial length (ft).
 : Length at high-temperature conditions (m).
H_0 : Stringing (initial) tension(lbs).
T_0 : Stringing temperature(°C)
ε_C : plastic deformation of the cable.

3.2. Block Diagram Representation

The block representation for sag calculation with increase in temperature is shown in figure 2 and its practical implementation is shown in figure 3 which works according to the flowchart shown in figure 4. The program is written in programmers notepad using Embedded C and is transferred to the microcontroller using AVR Dude. The USB based programmer for the AVR is USBasp.

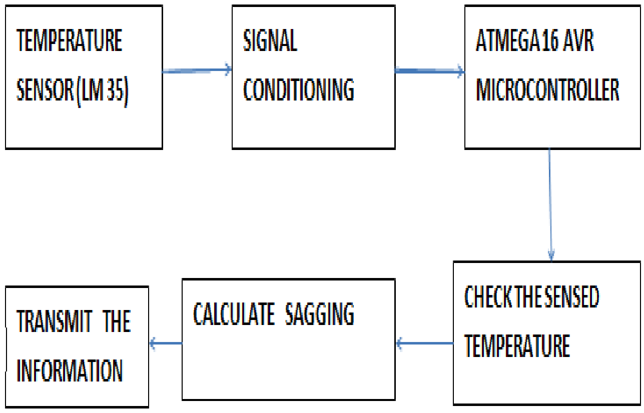

Figure 2. Block diagram representation

4. Practical Implementation

Figure 3 represents the practical implementation of the temperature sensor node.

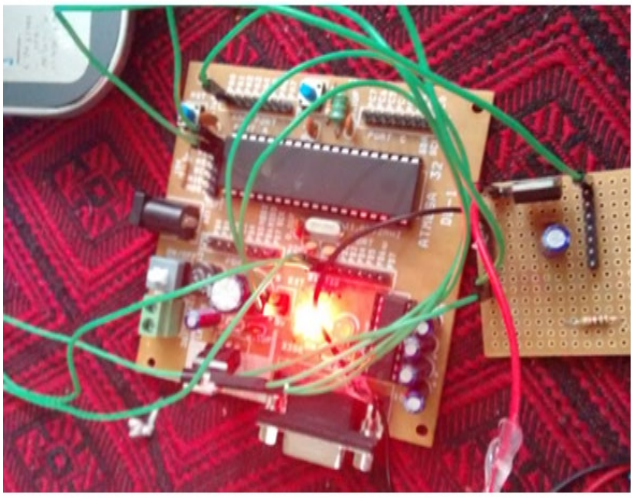

Figure 3. Practical implementation of the sensor node

4.1. Flowchart representation

The Figure 4 represents the flowchart representation for the proposed paper.

4.2. Internet of Things

The information regarding the transmission line temperature and sagging of the line is transmitted using internet of things. Here things is the temperature sensor and the application platform for internet of things is thingspeak which include real time data collection, data processing etc.

5. Results

Teraterminal is an emulator where the actual temperature and amount of sagging is displayed. CP2102 transmitter is connected between microcontroller and Teraterminal serial port. Figure 5 shows Teraterm display on screen and figure 7 shows Thingspeak application platform. It can be observed that the display showing 034054 for a 33KV line where 34 represents the amount of sagging in cm and 54 represents the temperature in ºc. The output is also observed on LCD for sagging information and on LED's for temperature as shown in figure 6. 00100111 on LED's represent the temperature of 27ºC. Figure 8 represents the variation in temperature and figure 9 represents the sagging variation.

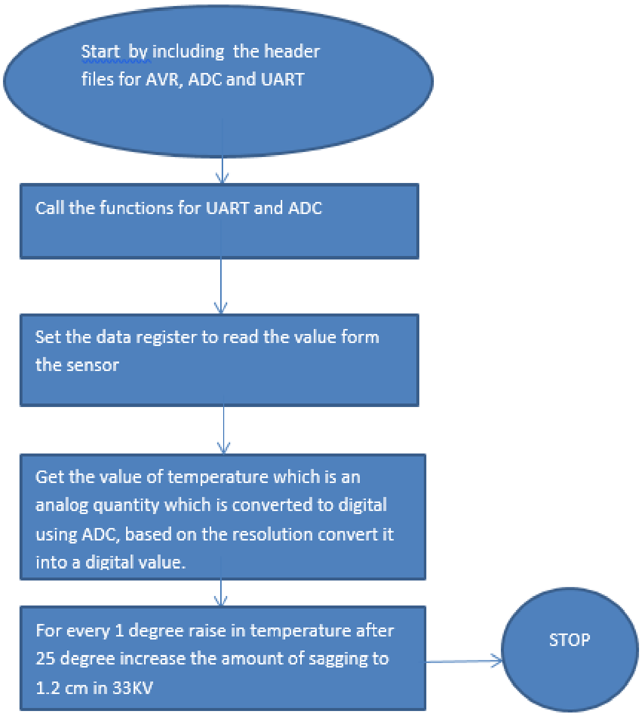

Figure 4. Flowchart representation

Figure 5. Tera Term showing the sagging with temperature

Figure 6. LCD showing the sagging and LEDs the temperature

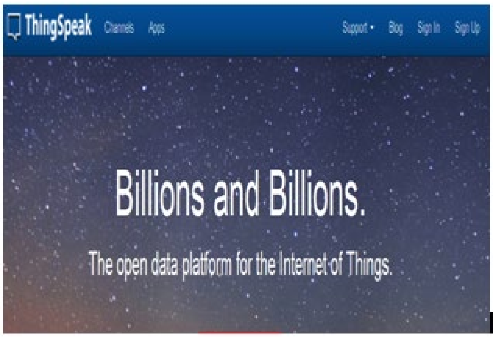

Figure 7. ThingSpeak application platform

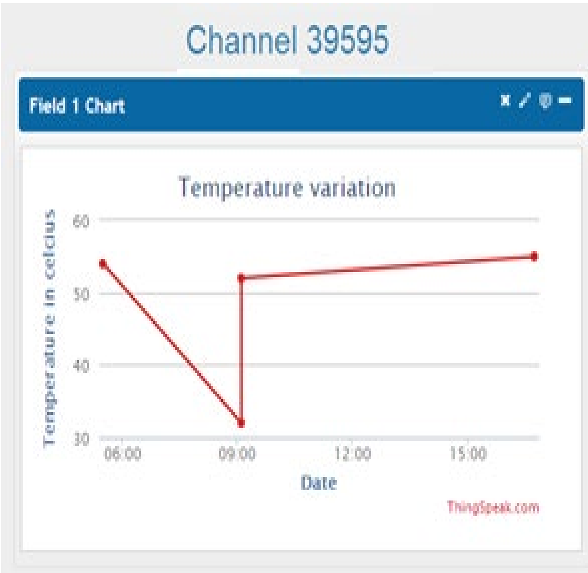

Figure 8. Graph representing temperature variation

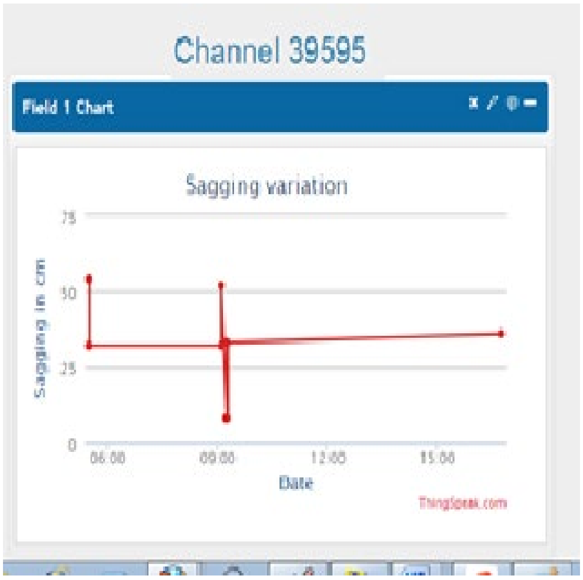

Figure 9. Graph representing sagging variation

6. Conclusion

In a over head transmission line, variation in temperature leads to deviation in power flow. The current carrying capacity of the conductor is also affected by variation in temperature, over a period of time leads to unwanted sag. Monitoring the temperature of transmission lines is done continuosly using LM35 temperature sensor and an application of IOT through thingspeak application platform to track the variations. WSN environment is created to transmit the temperature data from one node to another using NS-2 platform.

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