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 continuously 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).

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 overhead 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°C to 15°C 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 an 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.

\[ R_{T_{c}} = R_{T_{0}}[1 + \alpha(T_{c} - T_{0})] \]  

(1)

Where \( \alpha = 0.0039 \) is the temperature coefficient for aluminum, \( R_{T_{c}} \) and \( R_{T_{0}} \) are the resistances at temperatures \( T_{c} \) and \( T_{0} \) correspondingly. Increase in temperature leads to increase in the length of outstretched conductor. The amount of increase in length is given by

\[ \Delta L = \alpha L \]  

(2)

\( \alpha \) = the coefficient of thermal expansion
\( T \) = the temperature increase in °C
\( S \) = 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.

\[
D = \frac{H}{w}[\cosh\left(\frac{w^2}{H}\right) - 1] \quad (3)
\]

\[
D = \frac{w^2}{L/H} \quad (4)
\]

\[
L = L_0(1 + \alpha T(X - T_0))(1 + \frac{H - H_0}{E_A} + \varepsilon C) \quad (5)
\]

\[
1 + \frac{w^2}{24H^2} = \left(1 + \frac{w^2}{24H^2}\right)(1 + \alpha T(X - T_0))(1 + \frac{H - H_0}{E_A} + \varepsilon C) \quad (6)
\]

Where,

- \(L_0\): Initial length (ft).
- \(H_0\): Stringing (initial) tension (lbs).
- \(T_0\): Stringing temperature (°C)
- \(\varepsilon C\): 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.

4. Practical Implementation

Figure 3 represents the practical implementation of the temperature 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 °C. 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 27°C. 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
6. Conclusion

In a overhead 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 continuously 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.

Acknowledgements.
The authors would like to thank the Management of Vidyavardhaka College of Engineering, affiliated to VTU Mysuru, Karnataka, India for supporting this research work.

References

[1] Song Nie, Yang-chun Cheng, Yuan Dai “Characteristic Analysis of DS18B20 Temperature Sensor in the High-voltage Transmission Lines Dynamic Capacity Increase” Energy and Power Engineering, 2013, pg 557-560.
[2] Nenad Gubeljak, Bojan Banić, Viktor Lovrencic, Matej Kovac, Srete Nikolovski, “Preventing Transmission Line Damage caused by ice with smart on-line conductor monitoring”, International Conference on Smart systems and Technology 2016.
[3] Dale A Douglass, Mohammad Pasha, William Chisholm, “Real-Time Overhead Transmission Line Monitoring for Dynamic Rating”, IEEE Transactions on Power Delivery January 2014.
[4] Lei Luo, Xingong Cheng, Xiju Zong, Wen Wei, Chao Wang, “Research on transmission line losses and carrying current based on temperature power flow model”, 3rd International Conference on Mechanical Engineering and Intelligent Systems (ICMET) 2015.
[5] Satish M. Mahajan, Senior Member, IEEE, and Uma Mahesh Singareddy, “A Real-Time Conductor Sag Measurement System Using a Differential GPS”, IEEE Transaction on Power Delivery, Vol. 27, No. 2, April 2012.
[6] Arsalan Habib Khwaja, Qi Huang, Zeashan Hameed Khan, “Monitoring of overhead transmission lines: A Review from the perspective of contactless technologies” Sensing and Imaging, Article number 24 (2017).
[7] Oluwajobi F. I., Ale O. S. and Aiyarmimuela A, “Effect of Sag on Transmission Line sag incident”, Journal of Emerging Trends in Engineering and Applied Sciences, 2012.
[8] Bishnu P. Bhattarai, Jake P. Gentle, Tim McJunkin, Porter Hill, Kurt S. Myers, Alexander W. Alboud, Rodger Renwick, David Hengst, “Improvement of Transmission Line Ampacity Utilization by Weather-Based Dynamic Line Rating”, IEEE transaction for power delivery, 2018.
[9] Matthew Bartos, Mikhail Chester, Nathan Johnson, Brandon Gorma, Daniel Eisenberg, Igor Linkov, Matthew Bates, “Impacts of rising air temperatures on electric transmission ampacity and peak electricity load in the United State”, Environment Research Letters, Volume 11, IOP Publication Ltd, November 2016.
[10] Ganiyu Adedayo Ajenikoko, Bolarinwa Samson Adeleke, “Effect of temperature change on the resistance of transmission line losses in electrical power network”, International Journal of Renewable Energy Technology Research, Vol. 6, No. 1, January 2017, pp. 1-8.
Rashmi S et al.

[11] Valentina cerchi and Matthew knudson, “Study of effects of temperature dependent electric power transmission line models on estimation of transfer capabilities”, 11th international conference on Applications of Electrical and Computer Engineering, March 2012, pp 64-69.

[12] Marija Bockarjova, Goran Andersson, “Transmission line conductor dependent temperature impact on state estimation accuracy”, IEEE Lausanne Power Tech July 2007.

[13] Ye Cai, Xiao-Qin Huang, and Jie He, “High voltage equipment monitoring system based on IOT”, International Conference on Wireless Communications and Applications, 2011, pp 44-57.

[14] Taiyang Wu, Fan Wu, Jean-michel redouté, and Mehmet rastı yuæ, “An Autonomous Wireless Body Area Network implementation Towards IoT Connected Healthcare Applications”, IEEE, Body Area Networks, 16 June 2017.

[15] Anderson Augusto Simiscuka, Cristina Hava Muntean, Gabriel-Miro Muntean, “A Networking Scheme for an Internet of Things Integration Platform”, IEEE International Conference on Communications Workshops (ICC Workshops), 21-25 May 2017.

[16] Chi-Sheng Shih, Ching-Chi Chuang and Hsin-Yuan Yeh, “Federating Public and Private Intelligent Services for IoT Applications”, 13th International Wireless Communications and Mobile Computing Conference (IWCMC), 26-30 June 2017.

[17] Vebbi C. Gungor, Bin Lu, and Gerhard P. Hancke, “Opportunities and Challenges of Wireless Sensor Networks in Smart Grid”, IEEE transactions on industrial electronics, vol. 57, october 2010.

[18] Katarzyna Mazur, MichałWydra, Bogdan Kaiezopolski, “Secure and Time-Aware Communication of Wireless Sensors Monitoring Overhead Transmission Lines”. Sensors, 11 July 2017.

Dr. Rashmi S received her Bachelor of Engineering in Electrical and Electronics Engineering from National Institute of Engineering, Mysore, affiliated to Visvesvaraya Technological University, Belgaum, Karnataka, and obtained her Master’s Degree in the area of VLSI design and Embedded systems from Sri Jayachamarajendra College of Engineering, Mysore, affiliated to Visvesvaraya Technological University, Belgaum, Karnataka. She completed her Ph.D under the guidance of Dr. Shankaraiah in the area pertaining to WSN application to Power systems. Her research interests include Embedded systems, VLSI and Power Engineering. She has 6 Conference and 8 International journal publications to her credit. She is also the life member of ISTE and IETE. At present she is working as Associate Professor in the Department of Electrical and Electronics Engineering at Vidyavardhaka College of Engineering, Mysuru, Karnataka, India.

Dr. Shankaraiah received his B.E. degree in Electronics and Communication Engineering from Mysore University, Mysore, affiliated to Visvesvaraya Technological University, Belgaum, Karnataka. He completed his M.E degree in Digital Electronics and Communication Systems from Mysores University in 1997. He completed Ph.D. under the guidance of Prof. P. Venkataram, Dept. of ECE, IISc., Bangalore. He has Investigated a transactions based QoS, Resource management schemes for mobile communications environment. He has more than 20 years of teaching experience in Engineering. He has published more than 20 papers in national and international journals and conferences. He is a reviewer and chair for many conferences. His research interest includes bandwidth management, Quality of Service (QoS) management, topology management, and Energy management. He is a student member of IEEE and life member of India Society for Technical Education (LMISTE). He is presently working as Professor in the Department of E&C at Sri Jayachamarajendra College of Engineering, Mysuru, Karnataka, India.

Pooja H K. received the Bachelor of Engineering degree in Electrical and Electronics Engineering from Shridevi Institute of Engineering & Technology affiliated to VTU, Karnataka, India, and the Master of Technology degree in Power Electronics from Oxford college of Engineering affiliated to VTU. Currently working as Assistant Professor in the Department of Electrical and Electronics Engineering at Vidyavardhaka College of Engineering, Mysuru, Karnataka, India.

Upanya M. received the Bachelor of Engineering degree in Electrical and Electronics engineering from Cambridge Institute of Technology, Bangalore, affiliated to VTU, Karnataka, India, and M.E in Control and Instrumentation from University Visvesvaraya college of Engineering (UVCE), affiliated to Bangalore university. Currently working as Assistant Professor in the department of Electrical and Electronics Engineering at Vidyavardhaka College of Engineering, Mysuru, Karnataka, India.

EAI Endorsed Transactions
on Smart Cities
06 2020 - 07 2020 | Volume 4 | Issue 11 | e4