Development of System for GPS Data Transmission to Web Server for Online over Head Conductor Sag Measurement

Sangeeta Kamboj[1] and Ratna Dahiya[2]

[1] National Institute of Technology, Kurukshetra, Haryana, India
[2] Faculty, National Institute of Technology, Kurukshetra, Haryana, India
http://www.nitkkr.ac.in/

Abstract. This paper describes the design and testing of Web based system for online overhead conductor sag measurement of 11V power distribution line using Global Positioning System (GPS). The paper shows testing results of GPS data transmission from mid span of overhead conductor to substation. Maximum utilization of a power line may be achieved using dynamic rating algorithm for which conductor sag measurement is important. Raw GPS measurements are not so accurate that these are usable for overhead conductor sag evaluation. Further signal processing techniques such as bad data identification/modification, LSPE method and wavelet analysis required to improve accuracy of GPS measurements are discussed in the paper.

Keywords: GPS, LSPE method, Wavelet Analysis, Web Server, Overhead conductor sag, NMEA0183.

1 Introduction

GPS is satellite based radio positioning and navigation system. It provides position in three dimension and time information to users worldwide with twenty four hours a day [2]. It was declared operational for civilian users in December 1993. The developments in applications of GPS over last 10 years have done at higher rate than advancements in realization of GPS constellation. It is maintained by the United States government and every user can freely access this with a GPS receiver. According to W. Wooden, the detailed definition of GPS is "The Navstar GPS is an all-weather, space based navigation system under development by the Department of Defense to satisfy the requirements for the military forces to accurately determine their position, velocity, and time in common reference system, anywhere on or near earth on a continuous basis". A GPS receiver calculates its position by precisely timing the signals sent by GPS satellites. There may be visible more than four satellites but only four satellites are used in position calculation of GPS receiver [3, 9].The application market for vehicular tracking and monitoring, digital video processing, recording and transmission is nowadays considered one of the most promising in the security area [8]. Tracking systems were first developed for the shipping industry because they wanted to determine where each vehicle was at any

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given time. But nowadays Automatic Vehicle Location system has been used which transmit the vehicle location information in real time. Real time vehicular tracking system incorporates a hardware device installed in the vehicle and a remote Tracking server [7]. The ability of GPS Technology to provide time synchronization in order of nanoseconds over wide area has opened up the usage of GPS in electric power systems for its reliable and secure operation [5, 6].

The most concerned issue about GPS application in measurement of overhead conductor sag is its accuracy. There are several factors that affect the accuracy of GPS [4]. Various signal processing techniques such as LSPE method and Wavelet Analysis using Haar wavelet to improve accuracy of GPS measurements are used in the paper. In the paper test system for GPS data transmission to Web Server at 66KV Grid Substation Idgah, sector6, Faridabad has been developed. The testing results of GPS data transmission from mid span of overhead conductor of 11KV Power distribution line, sector 6, Faridabad to substation for sag measurement are also shown in the paper.

2 Description of System

The overhead power distribution line online sag measuring system consists of GPS receiver at mid span of line, leaptop on earth below mid span of overhead conductor, Web Server e.g. at substation and data communication as shown in figure1.

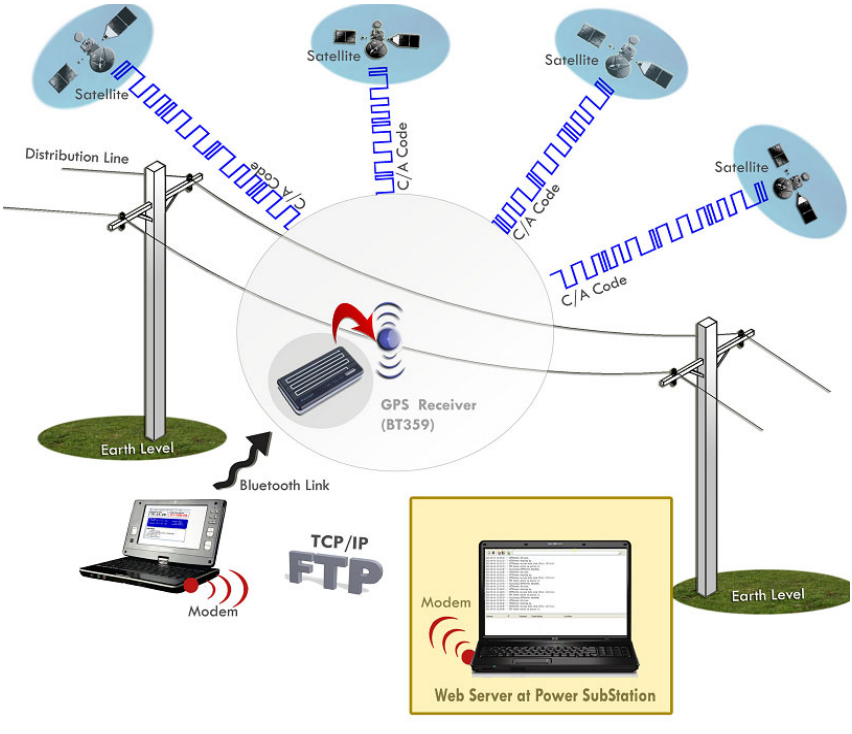

Fig. 1. Conceptual representation of GPS data transmission to Web Server for overhead conductor sag measurement

The GPS receiver BT359 with proper insulation has been hanged at mid span on 11KV power distribution line having span length of 60m. GPS data has been collected for approximately 300s. The lowermost single phase of line section is considered for GPS measurements. Bluetooth link is used to transfer GPS relevant information in standard NMEA0183 sentences from GPS receiver to the leaptop placed on earth where it is processed using GPS software "NMEA/GPS data logger" and gives the information of GPS receiver position in the form of latitude(x), longitude(y) and altitude (z). The Reliance Netconnect modem is installed at leaptop placed on earth for data connection.

At substation, Reliance Netconnect modem has also been installed at personal computer/laptop which is used as data collecting and Web Server system. The communication between GPS based overhead conductor sag measurement system and personal computer/laptop uses the TCP/IP protocol as shown in figure2.

3 11KV Power Distribution Line – Testing

The testing of system as shown in figure1 has been done at 66KV Grid Substation Idgah, sector6, Faridabad, Haryana, India and 11KV power distribution line, sector 6, faridabad is considered for overhead conductor sag measurement. The GPS data logging by NMEA/GPS data logger software in leaptop has been shown in following figure 2. The figure3 shows synchronization of this logged data to Web Server using File Transfer Protocol (FTP).

Fig. 2. Logging of GPS data

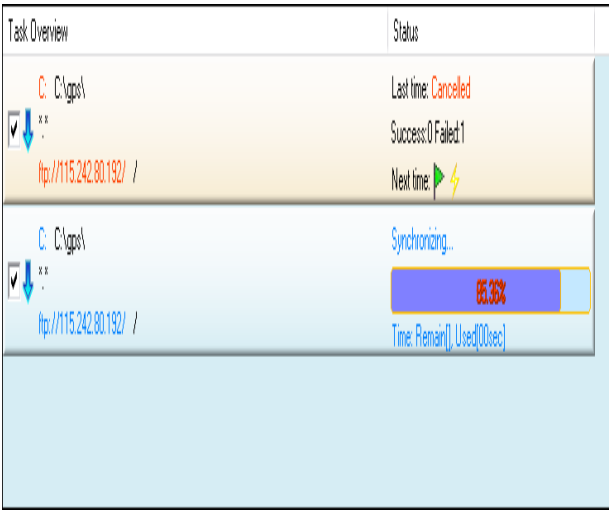

Fig. 3. Message Window showing GPS data Synchronization

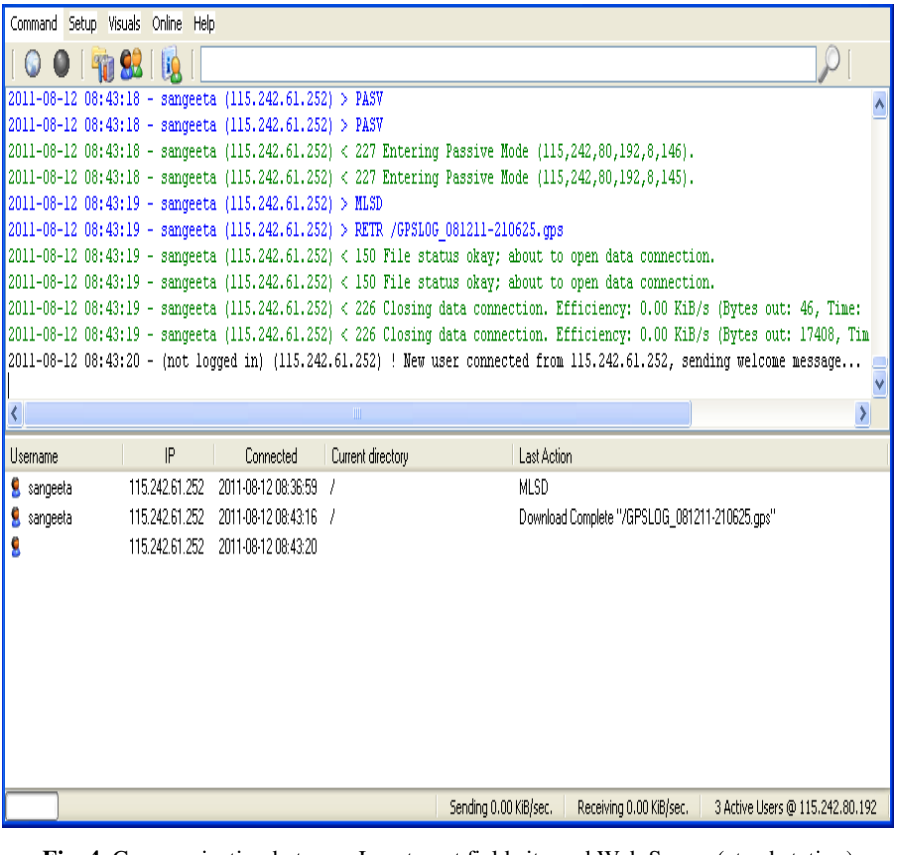

Fig. 4. Communication between Leaptop at field site and Web Server (at substation)

The GPS data from Leaptop placed on earth below mid span of overhead conductor of 11KV power distribution line has been transmitted to Web Server e.g. at 66KV Grid Substation Idgah, sector6, Faridabad, Haryana, India as can be seen from figure4.

4 Results and Discussion

At substation after collecting GPS data for some period of time, a module has been developed in MATLAB programming environment to process only raw GPS altitude data to obtain best estimate of GPS altitude data for particular time instance [9]. The altitude information is important for sag measurement. The Altitude obtained by GPS receiver is above mean sea level. It is required to take measurements with GPS at 2-3 places to improve accuracy of GPS measurements. The GPS measurements have been taken at mid span and its nearby places. An average of approximately 300 readings has been taken at each place. From these GPS altitude measurements taken at three places, more accurate measurements are used as controlled data in the LSPE method considered to obtain best estimate of raw GPS altitude measurements at mid span.

The figures 5, 6 & 7 show raw GPS altitude measurements taken at mid span and its nearby places (10cm towards right and 20cm towards left). The deviation of raw GPS altitude measurements from actual altitude is error in these raw GPS altitude measurements which can be seen in following figures 5, 6 & 7.

The error in raw GPS altitude measurements at mid span has been reduced using LSPE method and further reduced using Haar wavelet at level nine as can be seen in figure 8 [9]. Furthermore accuracy of GPS altitude measurements is more important to evaluate sag of power distribution line. The GPS altitude measurements obtained from Haar wavelet is closely matches to actual altitude as compared to those obtained from LSPE method. It can be seen from figure8. The wavelet analysis technique may be used to process raw GPS altitude measurements directly rather than estimated GPS altitude measurements resulting from LSPE method as can be seen from figure9.

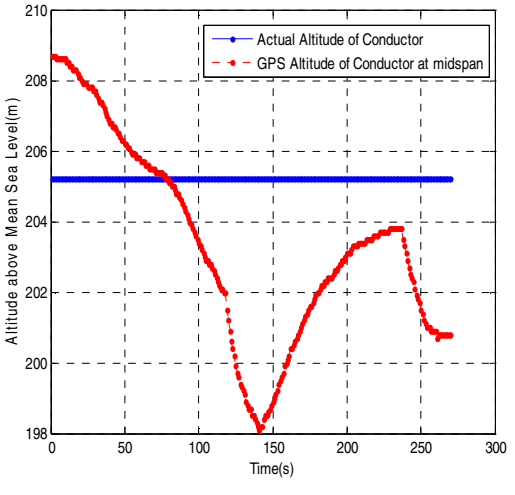

Fig. 5. Raw GPS altitude measurements at mid span

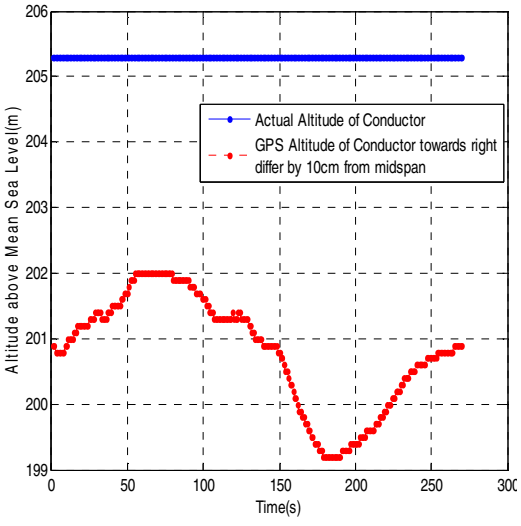

Fig. 6. Raw GPS altitude measurements towards right differ by 10cm from mid span

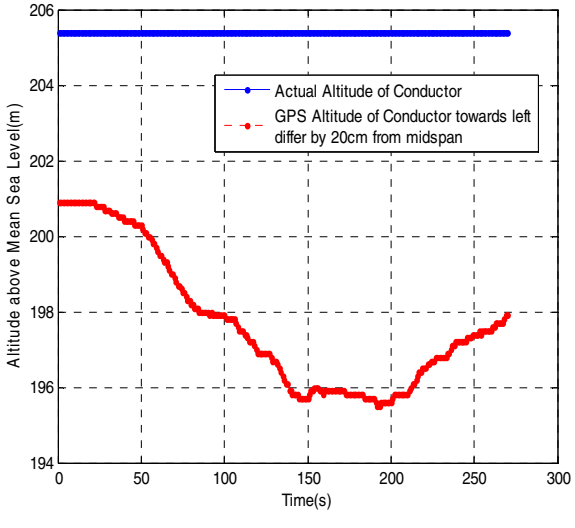

Fig. 7. Raw GPS altitude measurements towards left differ by 20cm from mid span

The accuracy of observed GPS altitude measurements has not been improved to such extent as improved using Haar wavelet to estimated GPS altitude measurements resulting from LSPE method as can be seen from figure9.

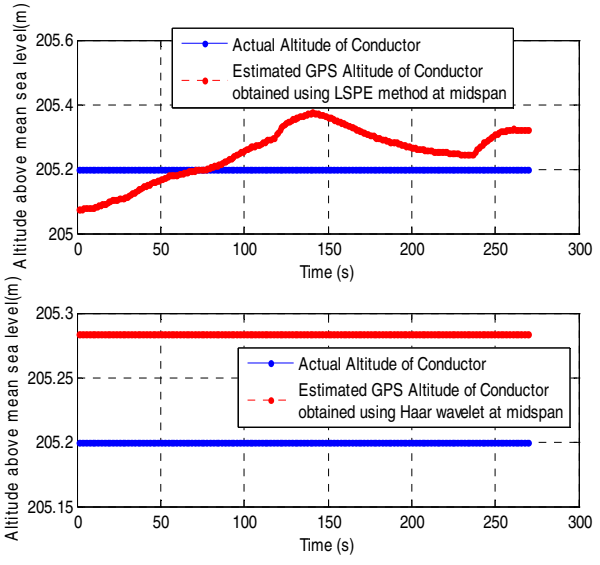

Fig. 8. Comparison of Estimated GPS altitude measurements resulting from LSPE method and further using Haar wavelet with actual altitude of conductor at mid span

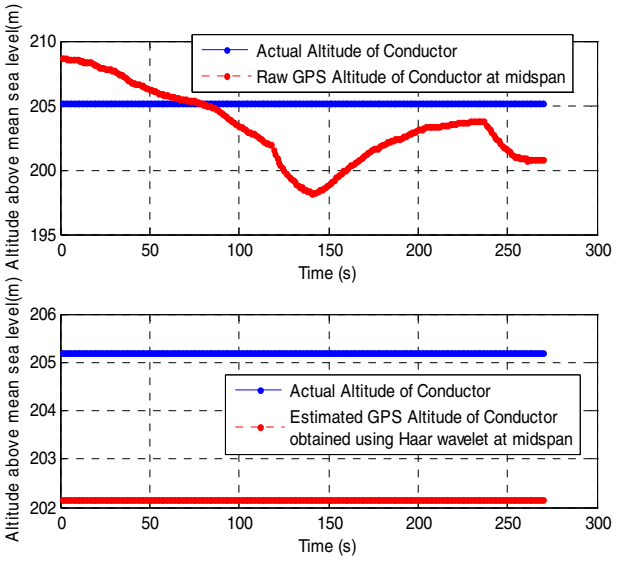

Fig. 9. Comparison of Estimated GPS altitude measurements resulting from Haar wavelet using raw GPS measurements with actual altitude of conductor at mid span

Thus use of Wavelet analysis to further reduce errors in estimated GPS altitude measurements resulting from LSPE method gives better accuracy of raw GPS altitude measurements taken for overhead conductor sag measurement in power distribution line.

5 Conclusion

It can be concluded that Web based system may be used for online overhead conductor sag measurement of 440V power distribution line using Global Positioning System (GPS) at substation. It is concluded from the test results that user can access GPS data transmitted using TCP/IP for overhead conductor sag measurement at anywhere in the world using internet connection. The Least Square Parameter Estimation and Wavelet Analysis methods have been used to improve accuracy of GPS altitude measurements. These methods reduce error significantly. Better results are found using wavelet analysis method if it is used to process estimated GPS altitude measurements resulting from LSPE method. The DGPS receiver may also be used to get better accuracy as compared to handheld GPS receiver.

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