Research of electromagnetic radiation influence of power lines on satellite signals distribution

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Abstract – The article focuses on researching the influence of the magnetic field of power lines to satellite measurements at different distances from power lines.

Key words – GPS, GNSS, coordinates, power lines

I. Introduction

Today, probably, one of the most simple, fast and economical methods of locating points on the Earth's surface with the accuracy of 1-3 m for absolute and 1-5 mm for relative coordinates is GNSS-method (Global Navigation Satellite System). Such results can be achieved using modern technologies [1].

Reception of the terrestrial signal receiver from the GPS satellite can be drown out with the normal high-frequency radiation at 1500 MHz with a power of only 2 watts. The thickness of the atmosphere, especially the ionosphere and troposphere distorts the signal from the satellite and weakens its power to approximately 150 dB. In the ground layer of the troposphere there is the weakest signal and it can be affected by the electromagnetic fields produced by high voltage power lines (EPL), cellular basic stations and other high-frequency radiation. The error for additional signal reflection can be taken into account using mathematical filters, such as Kalman filter. The signal refraction, if any, will be systematic and will not be taken into account during processing, which can significantly affect the accuracy of the coordinates setting.

II. The analysis of existing research on the influence of electromagnetic fields of power lines on satellite signal distribution

Instructions for technical use of GPS receivers contain no reservations about working in electromagnetic fields (EMF). It is unknown if a signal that gets in the revolted environment of high-frequency radiation will be stable. In scientific literature this question has been little studied [2-5].

Electromagnetic radiation occurs in two forms. One of them, intrinsic noise is the result of the random motion of electrons in the contour of elements of electric device. The second form of interference occurs as a result of the signals emitted from other circuits and systems.

Electric noise interferes the satellite signal passing that presents information and makes alteration into information it contains.

Electrical noise can cause errors in timing of signals measurements or the signal phase. If the signal phase error is present this can lead to wrong calculation results of RTK measurements. Typically electric noise will manifest itself in the form of the electromagnetic field around high-voltage lines. GNSS method of the coordinates setting is used to create the geodetic networks and at facilities located in the electromagnetic field, such as power stations.

There is a statement that GNSS receivers operate with a certain delay nearby EPL, in particular there are certain malfunctions, and also certain inaccuraciesof coordinates setting of points are observed.

Group of scientists from the University of Southern Queensland (USQ) conducted tests to determine the frequency with which failed initialization takes place in satellite receivers Trimble 4700 [6]. Field studies were conducted under the transmission lines of high and low voltage in RTK mode. The work was organized at several points as follows: satellite receiver was installed directly under the power line, and then rearranged at a distance of 30 m, 60 m and 80 m. Initialization was about 180 sec. directly under power lines of high voltage, while at a distance of 30m receiver was initialized in 90 sec. The greater distance from EMF, the faster work of the receiver.

Another similar research was conducted by the authors [7]. On the lines of EMF with power of 330 and 750 kV there was conducted a static observation lasting 2 hours and 15 min using Leica SR 20 satellite receiver. At points there was held additional tacheometric observation using Sokkia SET 610 total station. Observations were conducted in sunny and rainy weather. The accuracy of coordinates setting near the EMF was significantly worse than at a distance of ~ 150 m. It should be noted that the power line created in sunny weather also affect the results of GNSS - measurements, but significantly less than in rainy one. The magnitude of this effect occurs within the measuring accuracy.

Analyzing the results of measurements obtained for the 15-minute session, we see that the error of the GPS-measurement is naturally greater than the for the two-hour sessions, namely 12-68 cm in plan.

III. Selection of points and the experimental measurements

For experimental measurements it was selected an area on the territory of Gozhulivski village council of Poltava region. Through this area there is a power line of 330 kV. The venue for the GNSS observations was selected so that in the research area there was no tall trees and buildings, which can lead to additional reflection of the satellite signals.

The research was carried out on 10th October 2014. The weather was sunny, the humidity was low, and therefore the natural factors had minimal effect to the accuracy of measurement.

The first point of observation was located right in the center, directly under power lines.

The observation time in static mode lasted 1 hour and 20 minutes, the number of satellites fluctuated in the region of 5-8 pieces. Monitoring in kinematic mode lasted for 45 seconds with 6 satellites. Initialization was ~ 25 s.

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The second point was perpendicular to the power line at a distance of 20 m. At this point the observation time in static mode was 1 h 24 min, and the number of satellites fluctuated between 6-8 pieces. Monitoring in kinematic mode lasted for 30 seconds with 6 satellites.

The third point of the observation was perpendicular at a distance of about 60 m from power line. In static mode the observation time for a given point lasted 1 hour 18 min, when the number of satellites was from 5 to 9. In kinematic mode the observation lasted 35 seconds.

Scheme of the GNSS observation points location is shown in Fig. 1.

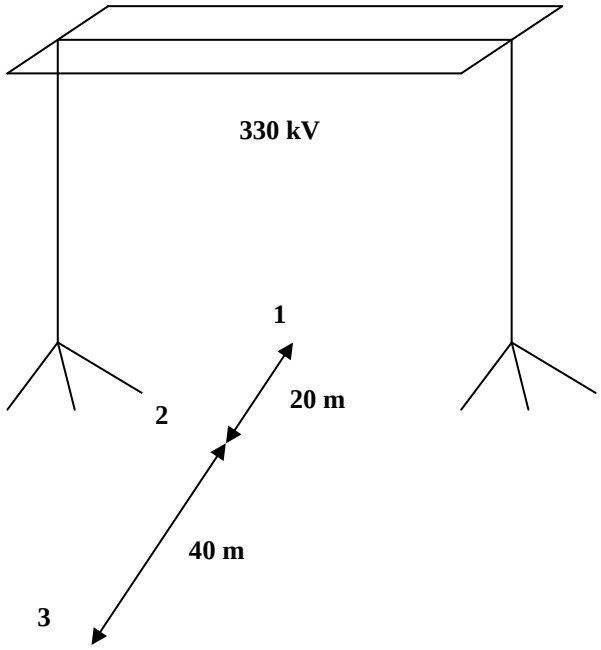

Fig. 1. Scheme of the GNSS observation points location

IV. Processing and analysis of the measurements results

At the end of the field work Trimble Business Center software package was used for processing the results of satellite observations [8]. Because of POLV reference station was located in the immediate vicinity of our work area (at a distance of about 7 km) we accepted amendments from there during the measurements in RTK mode [9].

Trimble Business Center software package is primarily intended for processing and analysis of GNSS data obtained in the field conditions.

After that, the program Digitals transforms observations results from SK42 (in which the device stores data) to SK63 and superposed on the zone 5, because the area of the Poltava is in the 5th zone.

TABLE 1

THE ACCURACY OF THE POINTS COORDINATES SETTING OF GNSS OBSERVATIONS

№ point	ΔX, м	ΔY, м	ΔH, м
1	-0.197	-0.141	0.265
2	0.139	0.113	-0.178
3	0.020	0.030	-0.142

Having the above coordinates, it was conducted the comparison of measurement results of two shooting modes and obtained the following deviations.

So, from these results we conclude the following: taking the points coordinates obtained by the static method as precise, the deviation of the measurements resulting from the GNSS observation in RTK mode for power lines of 330 kV is quite significant. So, right in the center under the power lines, that is, at point 1, the deviation of the plane coordinates (14-19 cm in plan, in height - 26.5 cm), at the observation point 2, which is 20 meters less from power lines (11 - 14 cm in plan, in height - 17.8 cm), and at the last point, which is 60 m from transmission lines reaches 2-3 cm in plan and 14 cm in height, which is negligible. So, the farther the observation point from the transmission line, the smaller the influence of electromagnetic waves and accurate shooting results.

Conclusion

As a result of the done work we have the following conclusions: The experimental research confirmed the theory of the influence of electromagnetic waves of power lines on the accuracy of GNSS measurements. On the basis of the results we obtain the deviation of the plane coordinates (14-19 cm in plan, in height - 26.5 cm) right in the center under power lines, at a distance of 20 m from the power line (11 to 14 cm in plan, in height - 17,8 cm), and at the last point, which is 60 m from power lines reaches 2-3 cm in plan and 14 cm in height, which is negligible for single frequency receiver. So, the farther the observation point from the power line, the smaller the influence of electromagnetic waves and more accurate surveying results.

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