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SNR Analysis on L-band Mobile Satellite System under Building Effect

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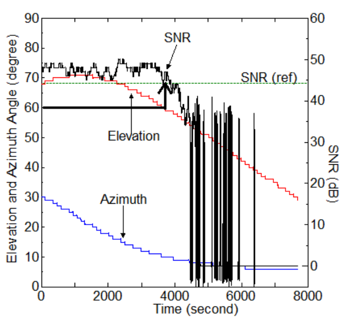
Graphical abstract



Abstract

This paper presents the method to analyse the effect of building on the L-band Mobile Satellite (MS) system using low-power Global Positioning System (GPS) receiver. The method includes measurement, experimental and data analysis. The analysis of the signal performance under building effect measurement was carried out with respect to the signal to noise ratio (SNR), elevation and azimuth angle. In measurement method, the National Marine Electronics Association (NMEA) sentences obtained from the satellite via GPS receiver was used to get the signal propagation parameters. The NMEA Extractor used to extract the NMEA data using C++ programming language and Ngraph software to construct the graphical presentation for analysis method. The analysis shows relationship between SNR and elevation and azimuth angle. The comparison between open space and building effect was carried out and the results have shown that the presence of the building affect the quality of the satellite signal received.

Keywords: MS system, GPS,building effect, L-band, SNR, elevation angle, azimuth angle

1.0 INTRODUCTION

MS system refers to transmission via satellite from non-stationary's transmitter and receivers. MS systems are suitable for mobile user and more flexible in terms of navigation systems on moving vehicles [1]. The main advantage of MS system compare to Fixed Satellite (FS) system is how the coverage signal of MS system is spotty over rural area and it is available for movement transceiver. Therefore, the MS system is suitable to system of mobile user and more flexible in terms of navigation system on moving vehicles.

GPS is the system in navigation in an accuracies range from a few millimetres until 15 meters [2]. Constellation of GPS is at least 24 Medium Earth Orbit (MEO) satellite that transmit microwave signal in six orbital planes and requiring a minimum of four satellites per planes. GPS satellites are orbiting the earth about 12,000 miles above the earth with speed of 7,000 miles an hour [3]. It makes two complete orbits in 24 hour. The GPS system enables the user to locate the accurate position by consulting radio receiver.

The main factors that cause the propagation impairment in MS system are shadowing effect, ionospheric effect and multipath fading. Shadowing effect such as building, tree and terrain is interacted with wave propagation via diffraction, reflection and scattering. The signal that was blocked by building caused the signal propagated into different path before it arrived at receiver. These multipath signals interfere with each other, leading to rapid fading effect [4].

This research aims to gain L-band signal performance under building effect measurement. L-band is a portion of microwave band of electromagnetic spectrum ranging from 1 GHz to 2 GHz. Within 1 GHz of total spectrum, only 30 MHz are used as uplink or downlink [5]. L-band signal travel in line-of-sight (LOS) propagation, which has less affected by the ionospheric effect.

2.0 RESEARCH METHODOLOGY

The research methodology was divided into three main steps including data acquisition, data analysis and data characterization.

2.1 Data Acquisition

By using Garmin eTrex GPS receiver, satellite parameter such as SNR, elevation and azimuth angle were obtained. The experiment was carried out in Universiti Malaysia Sarawak at Development and Assets Management building. GPS receiver connected to computer via RS-232 serial cable and GPS System v1.0 used as interface software. The software detected GPS receiver at transfer rate 4800 bit/s of 8 data bits and 1 stop bits. It act as satellite NMEA data collector from GPS receiver and the data saved into computer in text file format as shown in Figure 1.

Figure 2 shows the flow chart of data acquisition and based on the figure above, the distance between GPS receiver and the building measured before the measurement started. There are two distances between GPS receiver and the building that has been measured which are 6.35m and 11m. The distance is related to elevation angle limit (θ_{min}) as shown in Figure 3. The limitation of GPS receiver occurred when the satellite elevation angle below than 15°, the measured signal drop significantly due to path antenna used in GPS receiver [6].

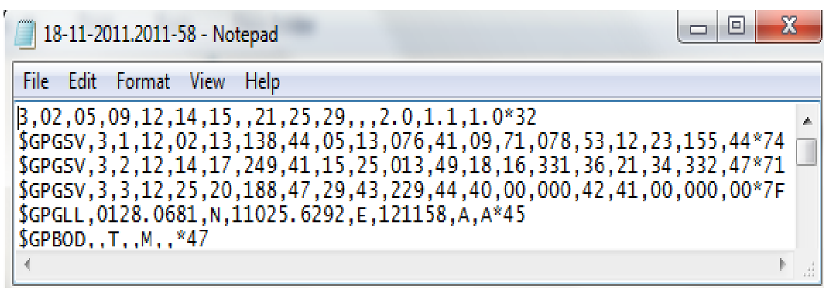


Figure 1 NMEA sentences

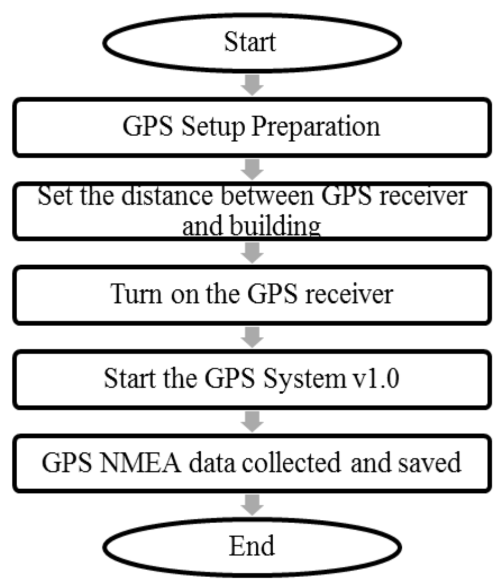


Figure 2 Flow chart of data acquisition

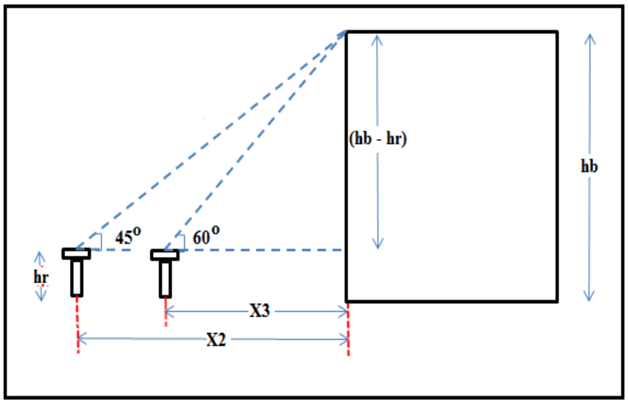


Figure 3 Distance measurement between GPS and building

2.2 Data Analysis

The acquisition data obtained from GPS satellite extracted using C++ programming language called NMEA Extractor that parses the NMEA sentences according to the corresponding satellite. It decodes the required parameter in NMEA sentence such as Universal Time Coordination (UTC) by referring to the GPRMC sentences, and number of satellite in view by refers GPGSV. NMEA Extractor started the sentences read process by line and by column. The extracted data then used to generate graph using Ngraph software.

2.3 Data Characterization

There are two types of data characterization that has been discussed which are data analysis based on measurement setup and data analysis based on measurement condition. The measurement setup distance between GPS receiver and building consist of two measurements which are 6.35 m (θ_{min} = 60°) and 11 m (θ_{min} = 45°), while measurement condition discussed the difference between open space and building effect.

3.0 RESULTS AND DISCUSSION

3.1 SNR Characteristic With Respect To Satellite Elevation And Azimuth Angle

The curves are presents in three axis; x-axis, y-axis and r-axis that indicated as azimuth and elevation angle, time variable and SNR. The data was taken within 2 hour 13 minutes. There are two satellites has been detected that can be used for this research; PRN9 and PRN27. As shown in Figure 4, PRN9 used as signal-shadowed for elevation 60° and PRN27 used as signal-shadowed for elevation 45°. For PRN9, the satellite signal penetrated through the building by its elevation angle while signal from PRN27 was obstructed by building by its azimuth angle. PRN9 moved from point A to point B of the building, the signal shadowed at the top of the building. PRN27 moved from point C to point D of the building, the signal shadowed at the edge of the building.

Based on Figure 5, propagation of SNR signal was obstructed by the building at elevation angle of 60° (left) as the satellite signal moved from point A to point B before the signal faded. The signal experienced fluctuation due to the building shadowed started from 3800 s to 7800 s. For PRN27 (right), the SNR signal experienced fluctuation at azimuth angle of 10° as the satellite signal moved from point C to point D of the building before the signal faded.

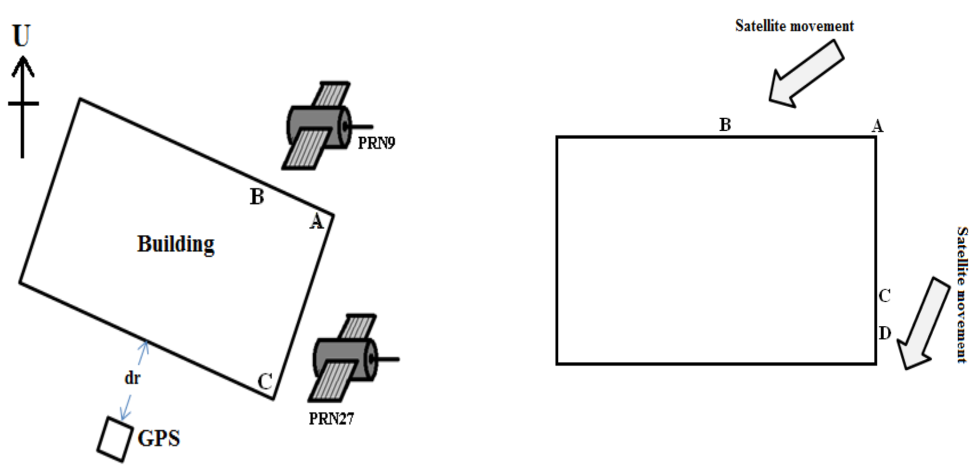


Figure 4 Top view of building and PRN9 and PRN27 (top), and front view of building and satellite movement (bottom)

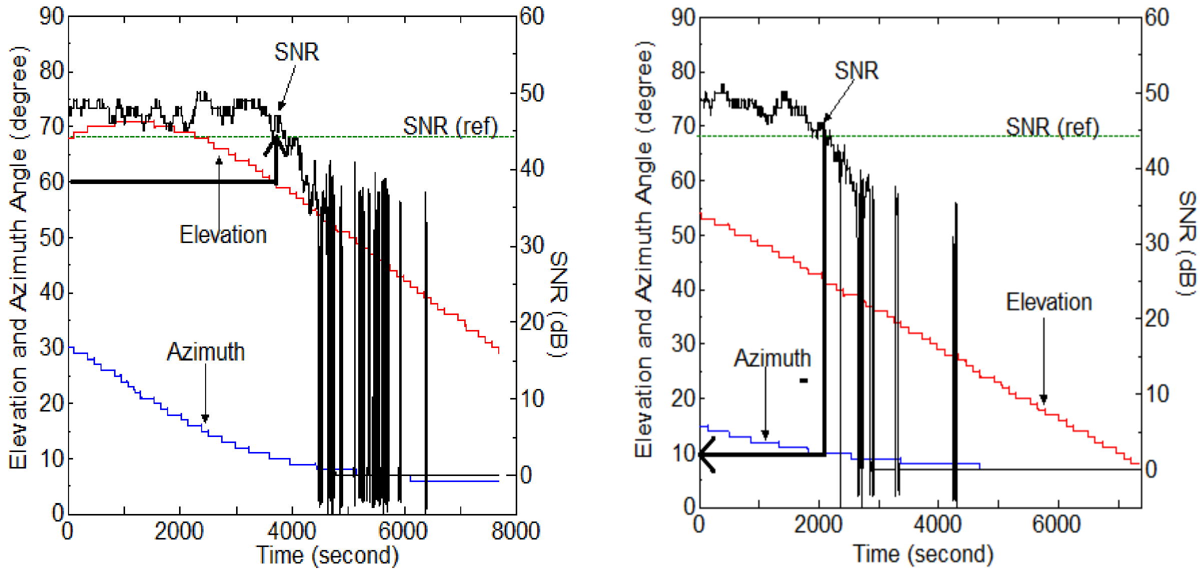


Figure 5 SNR vs. Elevation and Azimuth angle for building effect for PRN9(top), SNR vs. Elevation and Azimuth angle for building effect for PRN27 (bottom)

3.2 Comparison Between Open Space And Building Effect

Figure 6 shows the comparison received SNR signal between open space and building effect with different azimuth and elevation angle. The satellite that has been analysed was PRN 27. In normal situation, the satellite transmitted the signal without any noise (SNR ≥ 44 dBHz). As shown in Figure 6, the received SNR signal for open space (left) has decibel power up to 44 dBHz, while the received signal for building effect (right) has the fluctuation from elevation of 45° to 9°. It shows that the building blockage causes the satellite signal disturbed. The received SNR signal for building effect was dropped to 0 dBHz at lower elevation angle (θ ≤ 15°). Theoretically, when the elevation angle equal or higher than 15°, the received SNR signal should be greater than 44 dBHz, but it can be decreased due to signal blocked by shadowing, incoherent scatter, coherent reflections, multipath fading and ionospheric effect [7].

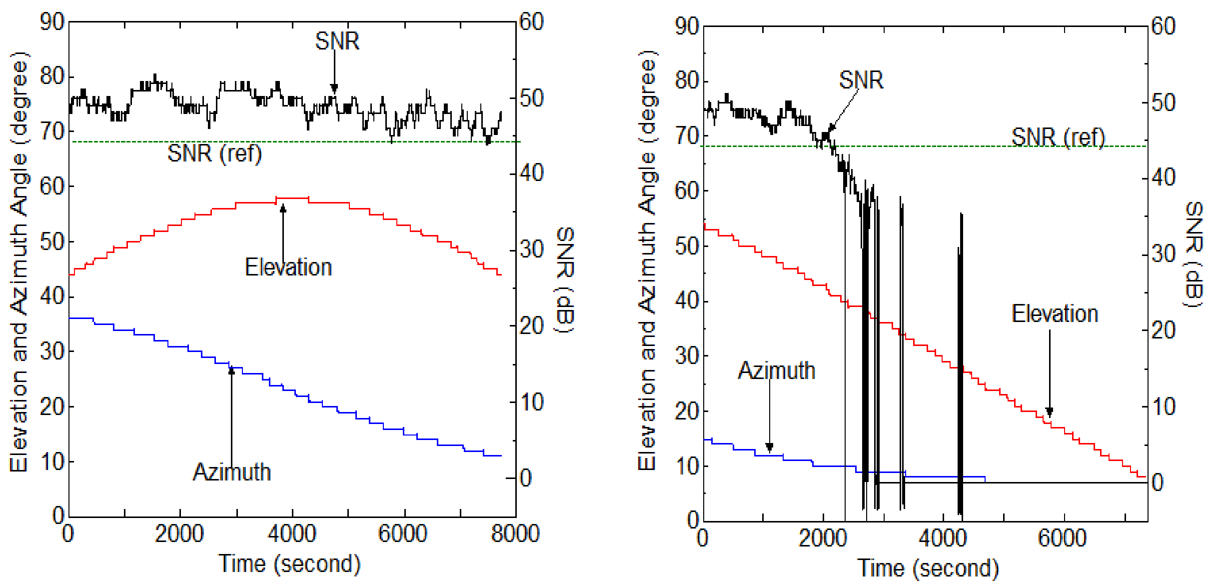


Figure 6 Comparison SNR for PRN 27 between open space (left) and building effect (right)

4.0 CONCLUSION

MS signal performance was affected by several factors such as ionospheric effect, multipath fading and shadowing effect. This study aims to collect and analyse the offect of signal performance to buildings. Results have shown that obstacles such as buildings will affect the MS signal performance over the elevation angle limit. Two elevation limit measurements have been done and these two measurements come with same results with different elevation angle.

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