UNIVERSITI MALAYSIA SARAWAK
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STUDY THE EFFECT OF IONOSPHERE ON THE RECEIVED MOBILE SATELLITE SIGNAL USING LOW-POWER GPS RECEIVER

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ABSTRAK

Project tahun akhir ini memperkenalkan satu kaedah untuk mengkaji kesan ionosfera terhadap penerima isyarat satelit mobil dengan menggunakan penerima *Global Positional System (GPS)* berkuasa rendah. Kajian termasuk pengukuran, ekperimen, dan analisis. Dalam projek ini, satu penerimaan data yang ringkas, mudah dah berkos rendah untuk pengukuran dan ekperimen dicadangkan. Analisis terhadap prestasi isyarat dilakukan dengan mengambil kira nisbah isyarat, ketinggian dan azimut. Pengekstrak data NMEA diguna dengan menggunakan bahasa pengaturcaraan C++ bagi mengekstrak data NMEA. Graf dibentuk dari data NMEA yang telah diekstrak dengan menggunakan pengisian yang dikenali sebagai Ngraf. Ngraf digunakan kerana ianya ringkas, berkos rendah dan mudah untuk dianalisis. Perbandingan kajian di antara situasi biasa dan dibawah persekitaran yang lapang dilakukan bagi menunjukan pretasi isyarat satelit.

ABSTRACT

This project presents a method to analyse the effect of ionosphere on the eceived Mobile Satellite signal using low power Global Positional System (GPS) receiver. The research involves measurement, experimental and analysis data. In this project, a simple, easy and low-cost data acquisition that can be used for experimental and measurement work to stimulate and visualize the mobile satellite signal performance is proposed. The analysis of the signal performance under the normal situation measurement is performed with respect to signal noise ratio (SNR), elevation and azimuth angles. The NMEA Extractor was used to extract the NMEA data using C++ programming language. The graphical presentation is constructed based on the NMEA extractor data using software called Ngraph. Ngraph is used because the software is simple, cheap and analysis can be done easy. The comparison between the normal situation and open space measurement is carried out in order to shown the satellite signal performance.

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CHAPTER 1

INTRODUCTION

1.1 Project Overview

This is a study about the effect of ionosphere on the received Mobile Satellite signal using low power Global Positional System (GPS) receiver. The research involves measurement, experimental and analysis data.

Type of frequency being used in the mobile satellite communication is L-band. L-band refers to the frequencies between 1 to 2GHz. Only 30 MHz are used as an uplink and downlink within this 1 GHz of total spectrum.

The advantage of the Mobile Satellite System (MSS) compare to the Fixed Satellite System (FSS) is that the coverage of the system is the connection exists while on the move and this reflects the reliability of the system to the mobile users. However, mobile satellite is experiencing channel impairment due to factors such as the ionosphere effect, multipath effect and shadowing. There are lacks of propagation data obtained regarding channel impairment in this particular region to be properly studied especially the effect of the ionosphere.

In this project, a normal situation measurement using the handheld GPS receiver is conducted and the measured satellite signal obtained is analyzed. A simple and low-cost data acquisition system is used for the experimental work to stimulate and visualize the mobile satellite signal performance.

1.2 Introduction

GPS is a satellite-based radio-positioning. Generally, GPS use to determine the location (longitude, latitude, and altitude) in any weather, day or night, anywhere on Earth. However, we cannot expect our GPS to be accurate. This is because there are many variables that can affect GPS accuracy such as ephemeris errors, ionosphere conditions, troposphere conditions, timing errors, multipath errors and poor satellite coverage.

GPS satellite is located at semi –synchronous altitude. GPS satellite is vulnerable to ionosphere effect. The ionosphere affects GPS receivers by degrading the signal performance, in some cases causing loss of carrier lock, and degrading the accuracy of differential corrections.

The normal situation measurement using the handheld GPS receiver and the comparison with the open space measurement data is carried out in order to study the effect of ionosphere on the received mobile satellite signal. The analysis of the satellite Signal-Noise-Ratio (SNR) is carried out. Since there are no building shadowed and no tree shadowed for the open space measurement, the mobile satellite performance is affected by the ionosphere effect.

1.3 Problem Statements

The mobile satellite signal performance is not only affected by the ionosphere effect. Other factors that can affect the mobile satellite signal performance are multipath effect and shadowing. Hence, further research can be carried out for different mobile satellite environments, application, and scenario.

In general, there are two ways to carry out experimental works which is utilized the existing Geo-stationary satellite networks or airborne platform which using airplane or helicopter. These ways are both hard to handle and expensive. Therefore, a simple, easy and low cost of method is figure out which using the handheld GPS receiver to conduct the experimental works. The advantage using the handheld GPS receiver is the handheld GPS receiver is cheap and easy to purchase. Therefore, experimental works can be carried out in the less develop countries. Besides that, the handheld GPS receiver is small and easy to handle. Nowadays, many type, size, figure of the handheld GPS receiver is produced. However, the handheld GPS receiver has it own disadvantages. One of the disadvantages is the measurement using handheld GPS receiver cannot be conducted for a long time of period. This is because the handheld GPS receiver used battery as it main power which is not suitable for a long term measurement.

Nowadays, most of the experimental works have been carried out in the develop countries such as Australia, Belgium, Canada, England, France, Germany, Japan and United States but there are few data represents in less develop countries such as Asia and Africa. In order to have more study about the effect ionosphere on received mobile satellite signal, more experimental works at different place are needed. This is because the level of the effect of ionosphere on the received mobile satellite is various depend on the local time of the day, season, solar cycle, geographical location on the receiver and earth magnetic field. The more results obtained, the more analysis can be done by taking the average value from the total results.

1.4 Objectives

The main objectives of the project are listed as follows:

a) **To carry out measurement using the handheld GPS receiver in order to analyze the measured satellite signal obtained.**

b) **To simulate and visualize the mobile satellite signal performance.**

c) **To compare the measurement data with open space data.**

1.5 Project Scope

In this project, a normal situation measurement will be carried out using the handheld GPS. The measurement need to be conducted using Garmin eTrex receiver to received the data from the satellite and be used for the research. The satellites are selected and the data will be collected continuously for a given time. The comparison with the open space measurement and the analysis of the satellite SNR is carried out. The results will be present in graphical presentation. For the open space measurement, there are no building shadowed and no tree shadowed. Thus, the mobile satellite performance is affected by the ionosphere effect.

1.6 Outline of Project Report

This project has 5 main chapters. The first chapter is the introduction. This chapter is about the project overview, introduction, problem statements, objectives and the project scope. The objectives need to be achieved in order to complete the project.

Chapter 2 is the literature review. This chapter discusses about the overview of the satellite and GPS in telecommunication system and its applications. This chapter also revealed the basic idea of ionosphere and its effect to the received mobile satellite signal.

Chapter 3 is the methodology. This chapter discusses the methods used in this project. As we know, the method that been used in project is by doing the open measurement using the handheld GPS receiver. The chapter also explained the software that been used in the project.

Chapter 4 is the results, analysis and discussion. This chapter shows the results obtained based on the data from the normal situation measurement and open space measurement. The data will be comparing with the open space and the mobile satellite signal performance is analysis. Results are presented in tables, graphs and calculations.

Chapter 5 is the conclusion and recommendations. This chapter summarizes the overall process and the important thing in the project. Further work or research which can be implemented to improve the project is also being discussed.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of Satellite Communication

Satellites Communication has become a very important role in human daily life. These can see from the increases amount of the subscribers that used antenna or parabolic dishes which are fixed at their home for the television broadcasting service. Throughout the years, there are various used of satellite communication or satellite services have developed. Since then, countless communications satellites have been placed into earth orbit, and the technology being applied to them is forever growing in sophistication.

The primary function of a satellite is to reflect electronic signals. In the case of a telecom satellite, the primary task is to receive the signals from a ground station then send the signals down to another ground station that is located at different place and considerable distance away from the first. This relay action can be two-way. For example a long distance phone call. Another use of the satellite is the case with television broadcasts. The ground stations uplink the signals then downlink it over a wide region, thus it may be received by many different customers possessing compatible equipment. Still another use for satellites is observation, whereas the satellite is equipped with cameras or various sensors, and it merely downlinks any information or data it picks up from its vantage point [1].

2.2 Satellite Services

There are three type of satellite services provided which is the Fixed Satellite Service (FSS), Mobile Satellite Service (MSS) and Broadcast Satellite Service (BSS). For FSS, a Fixed Earth Station (FES) which is stationary located on the ground location is required. Two or more FES at given positions and one or more satellites are being used for the communication links. Type of frequency used in FSS is Ku-band. The frequencies range is between 11.7 GHz to 12.2 GHz. Type of FSS applications are television and radio broadcast, telephony and data communication.

MSS is the communication that exists on the move which required portable terrestrial terminal. In other hand, MSS is contrast to FSS. The service is operated in the form of connection from Mobile Earth Station (MES) to satellite through the service link. Type of frequency used in MSS is L-band. The frequencies range is between 1 GHz to 2 GHz. Generally, the portable terrestrial terminal is mounted on ship, automobile, plane or carried by users. Type of MSS applications are portable satellite telephone and GPS receiver where the services are enabling anywhere on the earth.

BSS is a one-way communication. The signals are transmitted by earth station or retransmitted by the space stations and received directly by the end user on the ground via satellite receiver. Type of frequency used in BSS is Ku-band similar to FSS but the frequencies range is between 12.2 GHz to 12.7 GHz. Type of BSS applications are satellite TV, Digital Audio Broadcasting (DAB) systems and satellite Internet services.

2.3 Satellite Orbits

Satellite orbits are the path followed by a satellite in space. A satellite always moves in a fixed plane called the orbital plane, and in the case of a satellite orbiting the earth this plane always passes through the center of the earth. The orbit of a satellite can be elliptical or circular in shape. Generally, the remote sensing satellites are usually put in circular orbits.

A satellite is in a polar orbit if its orbit is inclined at more than 45° to the equatorial plane while if an orbit is less steeply inclined therefore the orbit is called an equatorial orbit. Satellite orbits are designed according to the capability and objective of the sensors they carry. Orbit selection can vary in terms of altitude and their orientation and rotation relative to the earth.

The velocity of the satellites are depends on the orbital height. According to the laws of gravity, a satellite in a higher orbit travels more slowly than one in a lower orbit. A higher-orbiting satellite also takes a good deal longer to circle the earth compare to the low-orbiting satellite.

There are two general classes of circular orbits are widely used for meteorological, navigation and environmental observations of the earth which is geostationary orbits and sun-synchronous near-polar orbits or polar orbits.

2.3.1 Geostationary Orbits

Geostationary orbits refers to the satellites which orbiting at altitudes of about 36,000 km and travel at speeds which match the rotation of the earth so they seem stationary relative to the earth's surface. Geostationary satellites complete an orbit in 24 hours. This allows the satellites to remain over specific areas and monitor and collect information continuously and constantly. The orbit is circular, and its inclination is zero degrees, which means that it is above the earth's equator. Geostationary orbits mostly used in communications, broadcasting and weather observation.

2.3.2 Sun Synchronous Orbits

Sun synchronous orbits refers to the satellites pass over each area of the earth surface at a constant local time of day called local solar time. To achieve this condition, the orbit cannot exactly follow a true north-south track to go over the poles. In fact, the orbit must be slightly tilted with a steep inclination angle of about 98º. This will introduces a slow precession in the orbital plane westwards over the ground at a rate comparable with the earth rotation, approximately one degree per day. Precession ensures that the equatorial crossing times of the satellites in terms of the local solar time is remaining nearly constant throughout the year.

2.4 Global Positioning System (GPS)

GPS is a satellite-based radio-positioning and time transfer system. Generally, GPS is the system used in navigation. GPS determined the position of certain location on earth whether in land, sea or air by timing the signal sent by the constellation of GPS satellite located above the earth. GPS has demonstrated a significant benefit to the civilian community who are applying GPS to a rapidly expanding number of applications.