UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Design satellite simulation tool using Matlab

This report is submitted in accordance with the requirement of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronic Engineering Technology (Telecommunication) with Honours

By

NUR NABILAH BT MOHD AKHIR

B071210252

930903085094

FACULTY OF ENGINEERING TECHNOLOGY

2015

DECLARATION

I hereby, declared this report entitled "Design Satellite Simulation Tool by using Matlab" is the results of my own research except as cited in references.

Signature   :

Author's Name   :

Date   :

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfilment of the requirement for the degree of Bachelor of Engineering Technology (Bachelor of Electronic Engineering Technology (Telecommunication)) (Hons). The member of the supervisory is as follow:

....

(ABDUL HALIM BIN DAHALAN)

ABSTRAK

Komunikasi adalah pemindahan maklumat dari sumber ke destinasi seperti penghantar kepada penerima. Komunikasi satelit adalah contoh yang terbaik untuk komunikasi wayarles. *Transponder* adalah salah satu yang terdapat dalam satelit di mana *transponder* yang melibatkan antena penerima untuk menerima isyarat dari stesen bumi, penerima band luas, sebuah pemultipleks input, dan penukar frekunsi di mana ia digunakan untuk mengalihkan isyarat yang diterima melalui berkuasa tinggi penguat untuk pautan turun. Untuk menghantar isyarat ke bumi mesti mempunyai stesen bumi. Ia boleh menjadi pautan naik, menghantar stesen atau pautan turun, menerima stesen. Matlamat utama projek ini adalah untuk mencipta bentuk alat simulasi satelit dengan menggunakan Matlab. Projek ini hanya melibatkan perisian. Dalam projek ini, Matlab GUI digunakan untuk mereka bentuk alat penyelakuan. Alat simulasi digunakan untuk menentukan koordinat satelit dan stesen bumi dan prestasi satelit. Ia juga dapat mengetahui jarak antara satelit dan stesen bumi.

ABSTRACT

A communication is the transfer of information from source to destination likes transmitter to receiver. A Satellite communication is a best example for the wireless communication. The transponder is one of composed in the satellite where transponder includes the receiving antenna to pick-up signals from the ground station, a broad band receiver, an input multiplexer, and frequency converter where it is used to reroute the received signal through a high powered amplifier for downlink. To send the signal to the earth must have ground station. It can be uplink, transmitting station or downlink, receiving station. The main goal of the project is to design satellite simulation tool by using Matlab. This project involves only software. In this project, Matlab GUI is used to design the simulation tools. The simulation tool is used to determine the coordinate of satellite and earth station and the performance of satellite. It is also can know the distance between satellite and earth station.

DEDICATIONS

To my beloved parents

Mohd Ahir B.Mohd Isa

Supiah Bt Jaafar

To my supervisor

En. Abd Halim B. Dahalan

ACKNOWLEDGEMENT

I would like to express my sincere to my supervisor En. Abd Halim B Dahalan for the continuous support of my bachelor degree project for his patience, motivation, and immense knowledge. His guidence helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisor and mentor for my bachelor degree project.

Beside my supervisor, I would like to thank the rest of my thesis support: En Chairulsyah B Wasli for his comments and guideline towards my project.

I thank my fellow friends for the stimulating discussion, for the sleepless nights we were working together before deadlines, and for all the fun we have had in the last four years.

Last but not least, I would like to thank my family: my parents and to my brother and sister for supporrting me spiritually throughout writing this project and my life in general.

TABLE OF CONTENT

CHAPTER 1: INTRODUCTION

CHAPTER 2: LITERATURE REVIEW

CHAPTER 3: METHODOLOGY

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

This chapter presents an overview of the project. This chapter will explain about the background project, problems statements, objectives of the project, scope of project, and the outline report.

1.1 Background of the project

In essence, a communication satellite is a microwave repeater in the sky that consists of a diverse combination of one or more of the following: receiver, transmitter, amplifier, regenerator, filter, onboard computer, multiplexer, demultiplexer, antenna, waveguide and other electronic communication circuit ever developed. A satellite radio repeater is called a transponder. The satellite is related with earth station, thus earth station will be either uplink or downlink. This project is about to analyse satellite performance related with link design, look angle determination and satellite location by using Graphic User Interface (GUI) in Matlab software. In addition, also analyse the location difference from satellite to earth station through map (world) by GUI. To know the location from satellite to earth station or information for satellite communication design just substitute latitude and longitude value into the simulation tool and the location will appear in the map (world). As known, the satellite MEASAT located at GEO, so for the latitude of satellite is zero. Thus, the user just enters the value for longitude of satellite and latitude and longitude for earth station. For the earth station, the user is analysis three states which are Langkawi, Pahang and Johor. Through this design it is also want to analysis the look angle and link budget for satellite and earth station.

1.2   Problem Statement

In the present, an engineer had difficult to get information for satellite communication design. Like coordinate and performance of the satellite and earth station on the map (world). Otherwise, it is also difficult to get accurate location and performance from satellite to earth station by using calculation. For example, the formula of look angle likes azimuth angle and elevation angle and link design like equivalent isotropic radiated power (EIRP) and path loss. Last but not least, nowadays tool for satellite are expensive.

1.3   Objective(s)

The main objective of this project is to design satellite simulation tool by using GUI in the Matlab. In order to make this project successful, the objectives have been declared these objectives must be achieved in completing this project. Objectives are a guidance of any project, so the objectives have been listed below:

1) To study the coordinate satellite (MEASAT) and earth station
2) To analysis satellite performance by using GUI in Matlab software
3) To develop simulation of satellite communication design.

1.4   Scope

The scope of this project where to design satellite simulation tool using Matlab based on the objective and to solve the problem faced as much as it can. The scope of this project is to collect the data where need to find the information about the satellite communication and calculation of satellite performance like look angle example azimuth angle and elevation angle, uplink and downlink and link design example EIRP and path loss. Next, the project scope is to describe information by using tool like coordinate satellite, earth station and performance of satellite based on the power and losses. By this tool also will describe the

2

position of satellite and earth station in the map (world). Lastly, to perform the simulation by using GUI software this is because it is easy to analyse than calculate by using formula so that it can make sure the simulation tool well function as stated in the objective.

1.5   Organization of the project

This report will be conducted in few chapters and each stated as below:

Chapter 1: Introduction
This chapter will simply introduce about the project. This chapter contains introduction, objectives, scope of project and problem statement.

Chapter 2: Literature Reviews
This chapter shows about the studies and research that relevant to the project.

Chapter 3: Methodology
This part will show the flow about the project methodology used in this project.

Chapter 4: Result and Discussion
This chapter will talk about the discussion of the result of the project.

Chapter 5: Summary and Conclusion
This chapter will discuss about the summarization of the project and the major conclusion of the project.

CHAPTER 2

LITERATURE REVIEW

2.1   Introduction

In this chapter, reviews of the previous researches project that are related with this project will be discussed. The information will be become additional source for the project in becoming more successful. To have a brief understanding of the researches related to the project, a few literature reviews had been done. This chapter will describe the related literature reviews based on the project.

2.2   Past Related Research

The main sources for this project are the previous project and thesis that related to the project. The aim of this chapter towards this project it is still same but the tool their uses are different.

2.2.1 A nowcasting integrated display platform for FY satellite data based on Matlab GUI

In this article (2009), author want to tell about FY satellite data serves as an important basis for weather analysis and forecast. The main objective in this article is wanted to deal with the data in a visible way thus it had used visible software for FY satellite data where it had used Matlab GUI. Based on Matlab GUI technique, the platform has a friendly and convenient interface for the user, and provides various functions including data selection, latitude & longitude display. The performance indicates its effectiveness for tracking and forecasting. The application of this journal is to improve the display and optimize the interface, and produce algorithms to calculate and analyse the weather process (Li Nan).

2.2.2 Research on satellite interference geolocation based on satellite system.

In this article (2009), author want to introduced new method of earth surface passive geo-location with TDOA (Time Differential of Arrival) for fixed interfering source where it is based on traditional way. In this article also it has more focus to study the method which includes introducing temporary variable, and analyzing its performance. In this article had use Matlab to do the simulation where the result proves that the new method is able to reduce the computations and the possibility of not clear solution. It is also study the relationship between the interference source location and the precision of the geo-location results for quadruple satellite system at the precision of 10 and 20ns. (Han Jianying)

2.2.3 Research and performance simulation on a carrier recovery phase error detection algorithms in satellite communications

In this article (2007), it is about how to the deduce the general architectures of recovery loop, which is based on the maximum aposteriori estimation. Next, it also introduced and analyses the characteristic of the carrier phase error detection algorithm and carrier recovery loop in high speed demodulator using in satellite communication. To get the result this article had used the Matlab simulation that obtained the figure between the phase demodulation characteristic and the theory calculation thus at the end the result shows that under low signal-to-noise ratio situation, QPSK is more appropriate to this carrier recovery loop (Zhang Zhenchuan).

2.2.4   Satellite design model based on modularization

In this article (2006), the satellite design model based on modularization is presented to raise the speed of satellite seriating development. Four components including satellite digitize design, satellite model virtual assembly, satellite model virtual prototype evaluation and satellite distributive cooperation simulation are elaborated. It is necessary to investigate satellite digitize design and distributive

cooperation simulation platform and apply it into new concept satellite. The software that had been used to construct the powerful platform of satellite integrative modelling, simulation and analysis is Matlab (DU Yunxi).

2.3 Theory of satellite performance

2.3.1 Look angle

Look angle is required such that the earth station antenna points or "looks at" the satellite directly. From a location on earth, the 2 look angles that are needed are Azimuth and angle elevation. Angle of elevation and azimuth both depend on the latitude of the earth station and the longitude of both earth station and the orbiting satellite.

2.3.1.1 Angle of elevation

The angle of elevation is the angle formed between the plane of a wave radiated from an earth station antenna and the horizon, or the angle delimit at the earth, station antenna between the satellite and the earth's horizon. The smaller the angle of elevation, the greater the distance a propagated wave must pass through the earth's atmosphere. Otherwise, if the angle of elevation is too small and the distance the wave is within the earth's atmosphere is too long, the wave may down to a degree that it provides insufficient transmission.

2.2.1.2 Azimuth angle

The azimuth is the angle between the north vector and the perpendicular projection of the star down onto the horizon. Azimuth is usually measured in degrees (°) as shown in figure 2.1. It is also defined as the horizontal pointing angle of an earth station antenna. It is measured in a clockwise direction in degrees from true north. The angle of elevation and the azimuth both depend on the latitude of the earth station and the longitude of both the earth station and the orbiting satellite.
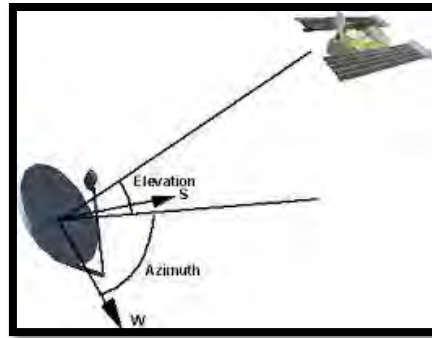
6

Figure 2.1: Azimuth angle

2.3.2 Link design

Link design is a communications subsystem that involves a link between a transmitting earth station and a receiving earth station via a communications satellite. The four factors related to satellite system design:

1. The weight of satellite

2. The choice frequency band

3. Atmospheric propagation effects

4. Multiple access technique

2.3.3 Uplink & Downlink

Uplink is signal from earth station to satellite while downlink is signal from satellite back to earth station this features can be seen in figure 2.2.
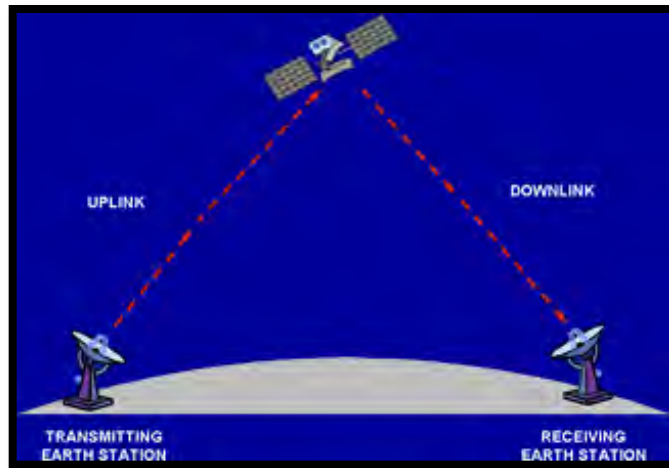
Figure 2.2: Uplink & Downlink

The uplink section of a satellite system is the earth station transmitter consist of an IF modulator, an IF to RF microwave up-converter, a high-power amplifier (HPA) and filter. In figure 2.3 shows the block diagram of a satellite earth station transmitter. Where IF modulator converts the input baseband signals to either an FM, a PSK, or a QAM modulated intermediate frequency. The up-converter converts the IF to an appropriate RF carrier frequency while the HPA provide enough input sensitivity and output power to propagate the signal to the satellite transponder.
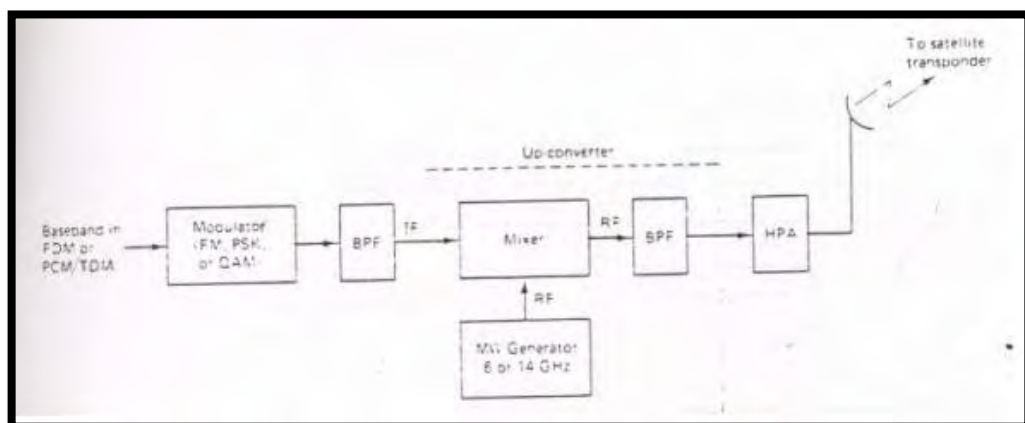

Figure 2.3: Block diagram uplink

8

Downlink is an earth station receiver includes an input BPF and low noise amplifier (LNA) and an RF-to-IF down-converter. In figure 2.4 shows a block diagram of earth station receiver. The BPF is to limits the input noise power to the LNA where the LNA is highly sensitive like tunnel diode amplifier. Next, the RF-to-IF down-converter is a mixer/bandpass filter combination which converts the received RF signal to an IF frequency.
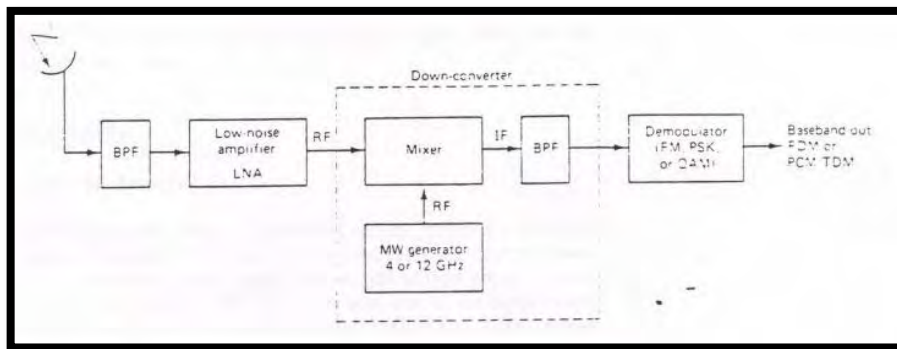

Figure 2.4: Block diagram downlink

2.3.4 Link budget

Link budget is calculated of all the gains and losses from the transmitter, through the medium (waveguide, fiber, etc.) to the receiver in a telecommunication system. The satellite link is composed primarily of three segments:

1. The transmitting earth station and the uplink media;
2. The satellite; and
3. The downlink media and the receiving earth station.

The carrier level received at the end of the link is a straightforward addition of the losses and gains in the path between transmitting and receiving earth stations. The basic carrier-to-noise relationship in a system establishes the transmission performance of the RF portion of the system, and is defined by the receive carrier power level compared to the noise at the receiver input. For example, the downlink thermal carrier-to-noise ratio is:

9

$$C/N = C - 10\log(kTB)$$

Where:

C = Received power in dBW

K = Boltzman constant, $1.38 * 10^{-23}$ W/^{0}K/Hz

B = Noise bandwidth (or occupied bandwidth) in Hz

T = Absolute temperature (^{0}K)

The link equation in its general form is:

$$C/N = EIRP - L + G - 10\log(kTB)$$

Where:

EIRP = Equivalent isotropically radiated power (dBW)

L = Tranmission losses (dB)

G = Gain of the receive antenna (dB)

2.3.5 Interference

The interferences are mainly caused by the secondary lobes in the radiation pattern of the antennas. The interference is mainly concern on:

1. Interference type
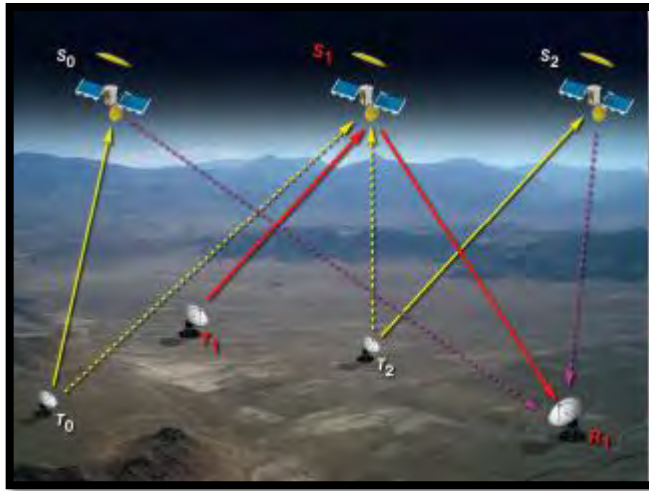2. Sources of interference
3. Causes of interference

Figure 2.5: Uplink and downlink interference due to small-antenna-aperture terminals. S_1 is the desired satellite and S_0 and S_2 are the adjacent satellites: T_1 and R_1 are the transmit and receive terminals that communicate with S_1 and T_0 and T_2 are the transmit terminals that are linked to S_0 and S_2 respectively.

2.3.5.1 Interference types:

- Digital

- Cross Polarization

- TDMA

- Intermodulation

2.3.5.2 Source of interferences:

- Neighbouring customer

- Adjacent Satellite

- Opposite polarization