



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**DESIGN MICROWAVE LINK BUDGET AND INTERFERENCE  
ANALYSIS**

This report submitted in accordance with requirement of the Universiti Teknikal  
Malaysia Melaka (UTeM) for the  
Bachelor's Degree in Electronics Engineering Technology (Telecommunications)  
(Hons.)

by

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## **APPROVAL**

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

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## ABSTRAK

Permintaan yang semakin meningkat dalam data komunikasi menyebabkan pembangunan kaedah inovatif untuk memenuhi keperluan komunikasi semasa dan baru. Kejuruteraan pautan radio bermula dengan melakukan analisis bajet pautan. Sistem radio yang diberikan mempunyai peningkatan sistem yang bergantung kepada reka bentuk radio dan modulasi yang digunakan. Antena yang lebih besar memberikan kadar peningkatan yang lebih tinggi. Kawasan yang luas dan bebas digunakan untuk menentukan semakin tinggi jarak kawasan semakin rendah kadar kehilangan. Gelombang mikro adalah salah satu bentuk radiasi elektromagnetik dengan panjang gelombang yang setara, dengan frekuensi antara 300 MHz dan 300 GHz. Ini juga melibatkan pengiraan peningkatan dan penurunan yang berkaitan dengan antena, pemancar dan penghantaran talian iaitu untuk menentukan jarak maksimum di mana sebuah pemancar dan penerima boleh beroperasi. Dalam kajian kes, ia akan memberi tumpuan kepada mengurangkan gangguan. Gangguan dalam komunikasi dan elektronik terutamanya dalam telekomunikasi adalah apa-apa yang mengubah, diubah suai atau mengganggu isyarat yang bergerak di sepanjang saluran antara sumber dan penerima. Semakin rendah nilai gangguan atau bunyi yang diandaikan dengan nilai yang terhad, lebih rendah nilai gangguan. Oleh itu, bajet pautan gelombang mikro yang menggunakan GUI akan memudahkan lagi untuk mengira jarak maksimum antara dua menara iaitu menara pemancar, TX dan menara penerima, RX berdasarkan latitud dan longitud dengan nilai yang terhad. Semakin tinggi jarak antara TX dan RX, semakin rendah nilai penerimaan kuasa dan lebih mudah untuk mengira dan mengurangkan gangguan dengan nilai yang terhad dengan bunyi yang digunakan.

## ABSTRACT

The increasing demand for data communications and connectivity has resulted in the development of innovative methods to satisfy current and emerging communication requirements. Radio link engineering begins by doing a link budget analysis. A given radio system has a system gain that depends on the design of the radio and the modulation used. The gains from antenna at each end are added to this gain. The free-space loss of the radio signal as it travels over the air is then subtracted from the system which is the longer the link the higher the loss. Microwaves are a form of electromagnetic radiation with wavelengths which is equivalently, with frequencies between 300 MHz and 300 GHz. This is also calculation involving the gain and loss factors associated with the antennas, transmitters and transmission line which is to determine the maximum distance at which a transmitter and receiver can successfully operate. In case study, it will focus on the reducing interference. Interference in communications and electronics especially in telecommunication is anything which alters, modified or disrupts a signal as it travels along a channel between a source and a receiver. The lower the value of interference or noise that assumed with the limited value, the lower the value of reducing interference. Hence, microwave link budget that used the GUI will easier to calculate the maximum distance between two towers which is transmitter tower, TX and receiver tower, RX based on latitude and longitude with the limited value of input parameters. The longer the distance between TX and RX the lower the value of receive power and the higher the value of path loss Also, easier to calculate the reduce interference with the limited value of noise that used.

## **DEDICATION**

This thesis is dedicated to my family and many friends. A special feeling of gratitude to my loving parents, En.Mohamad Razali Bin Abdullah and Pn.Rosnimi Binti Hj. Alias whose words of encouragement and push for tenacity ring in my ears. My brothers and sister Shafiq, Shahril and Nurul Amira have never left my side and are very special.

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# LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

RF	-	Radio Frequency
GSM	-	Global System for Mobile
WCDMA	-	Wideband Code Division Multiple Access
LTE	-	Long-Term Evolution
UHF	-	Ultra High Frequency
EHF	-	Extremely High Frequency
SHF	-	Super High Frequency
GUI	-	Graphical User Interface
EIRP	-	Isotropic Radiated Power
MS	-	Mobile Station
BTS	-	Base Transceiver Station
RFID	-	Radio Frequency Identification
NASA	-	National Aeronautics and Space Administration
TRMM	-	Tropical Rainfall Measuring Mission's
IEEE	-	Institute of Electrical and Electronics Engineers
DSD	-	Drop Size Distribution
GPS	-	Global Positioning System
GNSS	-	Global Navigation Satellite System

# **CHAPTER 1**

## **INTRODUCTION**

### **1.1 Background**

#### **1.1.1 Radio Link**

The increasing demand for data communications and connectivity has resulted in the development of innovative methods to satisfy current and emerging communication requirements. The path on which data travels from its source to its destination is described as a communications link.

Radio link engineering begins by doing a link budget analysis. A given radio system has a system gain that depends on the design of the radio and the modulation used. The gains from antenna at each end are added to this gain. Larger antennas provide higher gain. The free-space loss of the radio signal as it travels over the air is then subtracted from the system which is the longer the link the higher the loss.





Figure 1.1a: Wireless Communication Link

The accounting of all the gains and losses from the transmitter through the medium such as free space, cable, waveguide, fiber et cetera to the receiver in telecommunication system is known as link budget. To specify power, frequency and antenna requirements the principle of data link design is needed to ensure the reliable conveyance of data across the wireless data link, while accounting for the effects of attenuation, propagation, and noise relating to the free-space transmission segment, as illustrated in Figure 1.1a.

The operating frequency of the link, the output power, and antenna parameters is included of the principle link parameters. Besides that, by increasing the output power levels can reduce certain aspect of wireless link interference but it can cause unnecessary interference to other electronic and communication system, and is not practical for mobile device with power source.

### 1.1.2 Interference Analysis

It is negatively affects of signal interference in wireless networks in transmission coverage mobile capacity, limiting overall network performance. This is becoming more prevalent of unavoidable signal in wireless networks with the increasing number of active transmitters on the RF spectrum.



Figure 1.1b: Spectrum Environment

Interference analysis has three main stages, which is detection, identification, and location. First stage of the interference analysis is the detection. It is the most commonly used test method to detect interference in spectrum analysis, which performs measurements on frequency domain. This also indicates the amount of energy or power transmitted at each frequency.

Interference identification is the second stage of the interference analysis. It is to identify the type of signal of the interference that will considerably expedite troubleshooting. For example, it is common for a cell site to support multiple technologies such as GSM, WCDMA, and LTE. Some users use mobile devices primarily for voice communication supported by GSM.

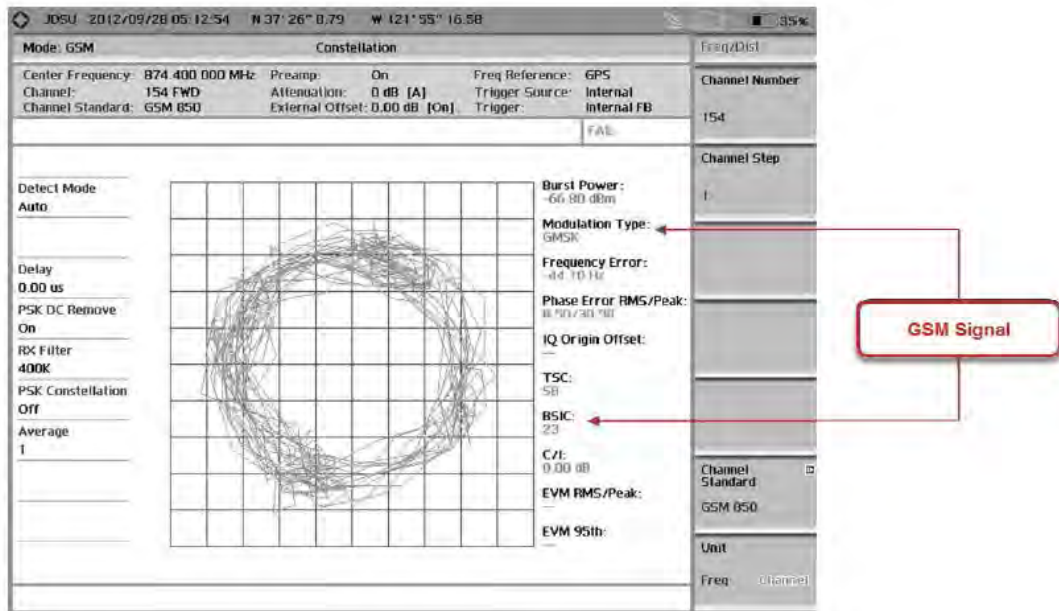


Figure 1.1c: Interference from GSM

Last stage of the interference analysis is the interference location. After an interferer signal has been detected, its transmission frequency obtained, and signal analysis performed for its identification, the next step is to obtain the geographical location of the interferer. It is normally requested to cease its transmission, generally by giving a warning or proceeding legally against the interferer at the interferer location.

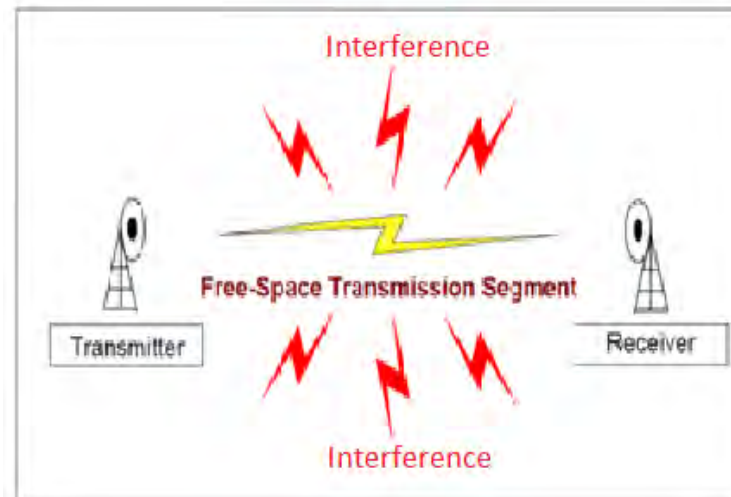


Figure 1.1d: Interference on Wireless Communication Link

Electronic interference is the condition of electromagnetic energy disrupting the normal operation or function of electronic devices. The source of the electronic interference can be categorized as environmental or naturally occurring, incidental or intentional. Interference is present at all frequencies, vary according to a specific frequency band, and affect the speed, accuracy and range of communication. Interference also known as unwanted interaction between electronic systems.

However, the primary sources of interference that effect wireless communication systems are electromagnetic in nature and can result in the magnetic and radio frequency disruption or intermittent failure of electronic, communication and information systems.

The inherent physical, technical and mechanical design parameters associated with wired data links for example fiber optic or cable often offer a level of immunity from noise and interference sources. In addition, wired media has certain attributes that can limit the effect of noise and interference which adversely affect wireless data links.

### 1.1.3 Microwave Radio Frequency

Table 1.1: RF Microwave

Light comparison			
Name	Wavelength	Frequency (Hz)	Photon energy (eV)
Gamma ray	less than 0.02 nm	more than 15 EHz	more than 62.1 keV
X-ray	0.01 nm – 10 nm	30 EHz – 30 PHz	124 keV – 124 eV
Ultraviolet	10 nm – 400 nm	30 PHz – 750 THz	124 eV – 3 eV
Visible	390 nm – 750 nm	770 THz – 400 THz	3.2 eV – 1.7 eV
Infrared	750 nm – 1 mm	400 THz – 300 GHz	1.7 eV – 1.24 meV
<b>Microwave</b>	<b>1 mm – 1 meter</b>	<b>300 GHz – 300 MHz</b>	<b>1.24 meV – 1.24 <math>\mu</math>eV</b>
Radio	1 m – 100,000 km	300 MHz – 3 Hz	1.24 $\mu$ eV – 12.4 feV

The microwaves radio frequency are a form of electromagnetic radiation with wavelengths , or equivalently, with frequencies between 300 MHz and 300 GHz. This broad definition includes both ultra high frequency (UHF) and extremely high frequency (EHF) and various sources use different boundaries. In all cases, microwave includes the entire SHF band, with RF engineering often putting the lower boundary at 1 GHz and the upper around 100.

### 1.1.4 Graphical User Interface (GUI)

GUI also known as graphical user interference that provides point-and-click control of software applications, eliminating the need to learn a language or type commands in order to run the application.

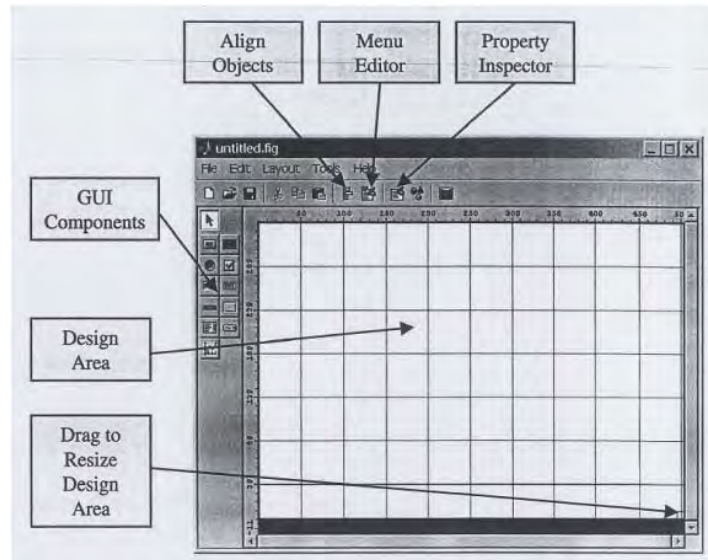


Figure 1.1e: GUI started.

MATLAB apps are self-contained MATLAB programs with GUI front ends that automate a task or calculation. The GUI typically contains controls such as menus, toolbars, buttons, and sliders.

GUIDE which is graphical user interface design environment provides tools for designing user interfaces for custom apps. GUIDE then automatically generates the MATLAB code for constructing the UI.

## 1.2 Problem Statement

Determine the maximum distance at which a transmitter and receiver can operate. Besides that, interference that effect wireless communication systems are electromagnetic in nature and can result in the magnetic and radio frequency disruption or intermittent failure of electronic, communication and information systems.

### **1.3 Objectives**

The objective of this project is to reduce the interference and to design the simulation of microwave link budget that can be easily to determine the maximum distance of transmitter and receiver.

### **1.4 Scope of Project**

There is a few scope of this research project, it will include:-

- i. Study the effect of frequency interference.
- ii. Study the radio frequency (RF) of the microwave link budget.
- iii. Design the simulation base on link budget.
- iv. Design the simulation of reducing the frequency interference.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Link Budget Analysis**

The calculation that involving the gain and loss factors associated with the antennas, transmitters, transmission lines and propagation environment which is to determine the maximum distance at which a transmitter and receiver can successfully operation known as link budget. Radio frequency of microwave is start from 300 MHz and goes up to 300 GHz that have wavelength of 1m to 0.01 m. Hence, for the interference is the signal in wireless networks negatively affects transmission coverage and mobile capacity that limiting overall network performance.

##### **2.1.1 Radio Link**

The free band beyond 300 GHz of communication systems are of interest for short distance communication. The realistic link budget analysis is needed to assess the feasibility of such a communication system. For the link budget analysis it focused on the measurement of transmission losses using all electronic Tx-Rx system that operating from 325 to 500 GHz.