

EVALUATION OF RADIO FREQUENCY INTERFERENCE (RFI) ON
GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS) SIGNALS

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ON GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)
SIGNALS

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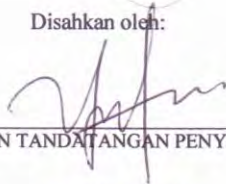
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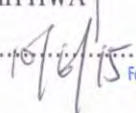
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Special dedicate:

I dedicated in thankful appreciation for support, encouragement and understanding to my beloved family, supervisors and friends.

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ABSTRACT

This project is aimed at evaluating Global Navigation Satellite System (GNSS) performance during simplistic intentional jamming on GNSS receiver, whereby jamming is conducted using a signal generator with horn antenna, which poses different level signal interferences. The project is designed using GNSS receivers Arduino Compatible Development Board with GPS/GLONASS that receives real GNSS signals. The test evaluation is conducted via field measurement located at Uni. Teknikal Malaysia Melaka (UTeM). Signal generator as a jammer employs the GPS L1 coarse acquisition (C/A) signal which is 1575.42 MHz. Varying different signal power levels, GNSS signals strength and Dilution of Precision DOP of GNSS satellites are observed for different times. Variation in other GNSS error parameters, including ionospheric and tropospheric delays, satellite clock, ephemeris and multipath errors, and unintentional signal interferences and obstructions, could have also resulted in the variation of GNSS signals performance. As the jamming signal power level is increased, probable error of signal reception increase due to decreasing carrier-to-noise density (C/N₀) levels for GNSS satellites tracked by the receiver. The increased of DOP value also due to the degradation of satellites accuracy after intentional jamming on the receiver. In the end, the findings will show and discuss the effect of radio frequency interferences (RFI) on GNSS signals.

ABSTRAK

Projek ini bertujuan untuk melakukan penilaian tentang kesan gangguan radio frekuensi terhadap signal daripada Global Navigation Satellite System (GNSS).Projek ini dijalankan dengan melakukan gangguan jamming terhadap alat penerima GNSS dengan menggunakan Signal generator dan Horn antenna. Projek ini direka menggunakan alat penerima GNSS Arduino Development Board with GPS / GLONASS yang akan menerima signal GNSS sebenar. Penilaian ini dijalankan di kawasan lapang yang terletak di Universiti Teknikal Malaysia Melaka (UTeM). Signal generator sebagai jammer menggunakan frekuensi 1575.42 MHz selari dengan isyarat GPS L1.Penilaian akan dilakukan untuk mengkaji GNSS signal strength dan Dilution of Precision (DOP) pada masa yang berlainan dengan memacar gangguan signal yang berbeza-beza dari jammer. Kepelbagaian ralat parameter pada signal GNSS seperti ionospheric dan tropospheric delays, satellite clock, ephemeris dan multipath errors telah menjejaskan prestasi signal GNSS. Jika isyarat jamming yang dilakukan adalah tinggi, penerimaan isyarat pada GNSS receiver akan terganggu disebabkan oleh tahap carrier-to-noise density(C/N0) pada satelit-satelit GNSS yang semakin berkurang. Peningkatan nilai DOP selepas jamming juga disebabkan degradasi kedudukan satelit-satelit apabila GNSS receiver diganggu. Akhir sekali, hasil kajian daripada projek ini akan menunjukkan kesan gangguan radio frekuensi (RFI) pada signal GNSS.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGES
	TITLE PAGE	i
	REPORT STATUS VERIFICATION FORM	ii
	DECLARATION	iii
	DEDICATION	v
	ACKNOWLEDGEMENT	vi
	ABSTRACT	vii
	ABSTRAK	viii
	TABLE OF CONTENTS	ix
	LIST OF TABLES	xiii
	LIST OF FIGURES	xiv
	LIST OG GRAPHS	xvi
	LIST OF ABBREVIATIONS	xviii
I	INTRODUCTION	
	1.1 INTRODUCTION	1
	1.2 PROBLEM STATEMENTS	3
	1.3 OBJECTIVES	3

1.4	SCOPE OF THE PROJECT	3
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II LITERATURE REVIEW

2.1	Global Navigation Satellite System (GNSS)	5
2.1.1	GPS and GLONASS	5
2.1.2	Satellite Propagation	6
2.1.3	How GPS Works	8
2.2	Radio Frequency Interference	11
2.3	Factors That Trigger GNSS Position Errors	13
2.4	The Effects of RFI on GNSS Receiver Output	16
2.5	Code Division Multiple Access (CDMA)	17

III PROJECT METHODOLOGIES

3.1	Project Methodology	19
3.1.1	Project Start	21
3.1.2	Literature Review	21
3.1.3	Equipment Preparations	21
3.1.4	Test Setup Analysis for Field Evaluations	24
3.1.5	Performing Test via Field Evaluations	25
3.1.6	Performance Analysis	25
3.1.7	Report Writing	26

IV RESULTS AND DISCUSSIONS

4.1	Time Span Length and Test Circumstances	28
4.2	Absolute Signal Power and NMEA Data	29
4.3	GNSS Signal Measurements	31
4.3.1	Signal Power Interference of 20 dBm	31
4.3.1.1	Satellite PRN 26	31
4.3.1.2	Satellite PRN 22	32
4.3.1.3	Satellite PRN 18	32
4.3.1.4	Satellite PRN 14	32
4.3.1.5	Satellites Overview	33
4.3.2	Signal Power Interference of 10 dBm	34
4.3.2.1	Satellite PRN 26	34
4.3.2.2	Satellite PRN 22	34
4.3.2.3	Satellite PRN 18	35
4.3.2.4	Satellite PRN 14	35
4.3.2.5	Satellites Overview	35
4.3.3	Signal Power Interference of 0 dBm	37
4.3.3.1	Satellite PRN 26	37
4.3.3.2	Satellite PRN 08	37
4.3.3.3	Satellite PRN 18	38
4.3.3.4	Satellite PRN 14	38
4.3.3.5	Satellites Overview	38
4.3.4	Signal Power Interference of -10 dBm	40
4.3.4.1	Satellite PRN 26	40
4.3.4.2	Satellite PRN 22	40
4.3.4.3	Satellite PRN 18	41

4.3.4.4	Satellite PRN 14	41
4.3.4.5	Satellites Overview	41
4.3.5	Overall Signal Interference in Each Satellite	42
4.3.6	Dilution of Precision (DOP)	44
4.4	Discussions and Analysis	46
4.4.1	GNSS Signals Strength	46
4.4.2	Dilution of Precision (DOP)	47

V CONCLUSION AND RECOMMENDATION

5.1	Conclusion	48
5.2	Recommendation	49

REFERENCES 50

APPENDICES 54

LIST OF TABLES

NO	TITLE	PAGES
2.1	GNSS Frequencies and Bandwidths	11
3.1	Cost of Equipments	23
4.1	Extracting NMEA Data	29

LIST OF FIGURES

NO	TITLE	PAGES
1.1	GNSS Position Errors	2
2.1	GNSS Satellite Overview	6
2.2	GNSS Satellite Propagation	8
2.3	Signals from 1 satellite	9
2.4	Signals from 2 satellites	9
2.5	Signals from 3 satellites	10
2.6	Signals from 4 satellites	10
2.7	The DOP Value either Smaller or Greater	14
2.8	Example of Stable GPS Positioning	15
2.9	Example of Unstable GPS Positioning	15
3.1	Flow Chart of Project Methodologies	19
3.2	Hittite HMC-T2000 700MHz-8GHz Signal Generator	22
3.3	Horn Antenna	22
3.4	Arduino Compatible Development Board	22
3.5	Internal GPS/GLONASS Active Antenna	23

3.6	SMA-to-U.FL Connector Cable	23
3.7	Notebook	23
3.8	Block Diagram of setup analysis	24
3.9	Equipments setup analysis	24
3.10	Location of Field Measurement	25
3.11	GNSS Viewer interface taken at UTC time: 02:38:33	26
4.1	Location of Test Measurement Conducted	28
4.2	Sample of NMEA Data Measured at 20 dBm Power Signal	29

LIST OF GRAPHS

NO	TITLE	PAGES
4.1	C/N Ratio of Satellite PRN 26 at 20 dBm Signal Interference	31
4.2	C/N Ratio of Satellite PRN 22 at 20 dBm Signal Interference	32
4.3	C/N Ratio of Satellite PRN 18 at 20 dBm Signal Interference	32
4.4	C/N Ratio of Satellite PRN 14 at 20 dBm Signal Interference	32
4.5	Line Graph of Overall Satellite at 20 dBm Signal Interference	33
4.6	Bar Graph of Overall Satellite at 20 dBm Signal Interference	33
4.7	C/N Ratio of Satellite PRN 26 at 10 dBm Signal Interference	34
4.8	C/N Ratio of Satellite PRN 22 at 10 dBm Signal Interference	34
4.9	C/N Ratio of Satellite PRN 18 at 10 dBm Signal Interference	35
4.10	C/N Ratio of Satellite PRN 14 at 10 dBm Signal Interference	35
4.11	Line Graph of Overall Satellite at 10 dBm Signal Interference	35
4.12	Bar Graph of Overall Satellite at 10 dBm Signal Interference	36
4.13	C/N Ratio of Satellite PRN 26 at 0 dBm Signal Interference	37
4.14	C/N Ratio of Satellite PRN 08 at 0 dBm Signal Interference	37
4.15	C/N Ratio of Satellite PRN 18 at 0 dBm Signal Interference	38

4.16	C/N Ratio of Satellite PRN 14 at 0 dBm Signal Interference	38
4.17	Line Graph of Overall Satellite at 0 dBm Signal Interference	38
4.18	Bar Graph of Overall Satellite at 0 dBm Signal Interference	39
4.19	C/N Ratio of Satellite PRN 26 at -10 dBm Signal Interference	40
4.20	C/N Ratio of Satellite PRN 22 at -10 dBm Signal Interference	40
4.21	C/N Ratio of Satellite PRN 18 at -10 dBm Signal Interference	41
4.22	C/N Ratio of Satellite PRN 14 at -10 dBm Signal Interference	41
4.23	Line Graph of Overall Satellite at -10 dBm Signal Interference	41
4.24	Bar Graph of Overall Satellite at -10 dBm Signal Interference	42
4.25	Overall Signal Interference at Satellite PRN 26	42
4.26	Overall Signal Interference at Satellite PRN 18	43
4.27	Overall Signal Interference at Satellite PRN 14	43
4.28	Overall Signal Interference at Satellite PRN 22	43
4.29	Dilution of Precision (DOP) at 20 dBm Signal Interference	44
4.30	Dilution of Precision (DOP) at 10 dBm Signal Interference	44
4.31	Dilution of Precision (DOP) at 0 dBm Signal Interference	44
4.32	Dilution of Precision (DOP) at -10 dBm Signal Interference	45
4.33	Position Dilution of Precision at all Signal Interference	45
4.34	Horizontal Dilution of Precision at all Signal Interference	45

LIST OF ABBREVIATIONS

GNSS	-	Global Navigation Satellite System
GPS	-	Global Positioning System
GLONASS	-	GLObal NAvigation Satellite System
DOP	-	Dilution of Precision
PDOP	-	Position Dilution of Precision
HDOP	-	Horizontal Dilution of Precision
VDOP	-	Vertical Dilution of Precision

CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

Today, the increasing wireless RF congestion, GNSS systems are becoming more at risk of signal degradation due to interference. The definition of GNSS (Global Navigation Satellite System) is a satellite system that is used to determine the exact location and position of a user's receiver anywhere in the world. Now, there are two GNSS systems that are currently active which are Global Positioning System (GPS) built by United States and the Global Orbiting Navigation Satellite System (GLONASS) built by Russian Federation. Each of the GNSS systems employs a constellation of orbiting satellites working in conjunction with a network of ground stations. Satellite-based navigation systems use a concept of triangulation to locate the user through calculations involving information from a number of satellites. Each satellite has different transmits coded signals at precise intervals.

The rapid growth in the development of Global Navigation Satellite Systems (GNSS) in current market, having penetrated various consumer products, such as cell phones, personal navigation devices (PNDs), cameras and assimilation with radio-frequency identification (RFID) tags are lead to degradation of GNSS signals. Thus, there is a need to characterize GPS signal degradation and quantify the effects of interference sources. GPS signal degradation typically occurs by signal masking caused by natural and man-made obstructions, ionospheric scintillation, Doppler shift, multipath, jamming, spurious satellite transmissions, and antenna effects. The impact of these interferences can result in total loss of tracking and possible tracking errors, depending on the severity of the effect and the receiver tracking characteristics. Tracking errors, especially if undetected by the receiver firmware, can result in large position errors. Partial loss of tracking results in geometry degradation, which in turn affects position accuracy. These error parameters can influence the accuracy of GNSS readings and in a number of cases it can disrupt GNSS signals as shown in Figure 1.1. This paper provides an overview of radio frequency interference (RFI) on the performance of GNSS signals strength and the Dilution of Precision (DOP) of the GNSS satellites via field evaluations.

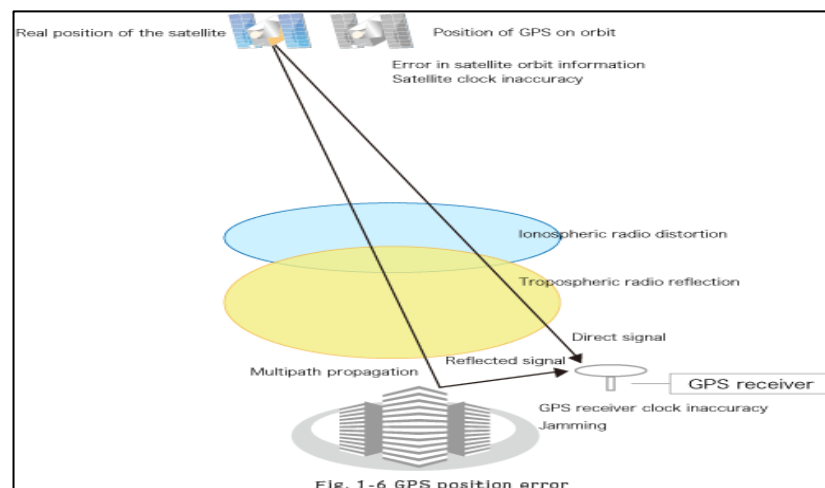


Figure 1.1 GNSS Position Errors

1.2 PROBLEM STATEMENTS

Global navigation satellite system (GNSS) is powered by photocells, which are approximately 20200 km above the surface of earth. GNSS signal that reach the earth has very low power levels approximately -160 to -130 dBm, rendering them highly susceptible to jamming. Radio frequency Interference (RFI) has a significant influence on the tracking of GNSS satellite signals by a GNSS receiver. This can range from a degradation of the performance to a total prohibition of satellite signal acquisition and tracking. Any signals transmitted in or near the GNSS frequency bands will interfere with the reception of the GNSS signals.

So in this project, the performance of GNSS signals had been evaluated by an intentional jamming on the GNSS receiver. The test evaluation is conducted via field measurement by using GNSS receivers Arduino Compatible Development Board with GPS/GLONASS that receives real GNSS signals. The findings will be analysed using GNSS Viewer software.

1.3 OBJECTIVES

- 1) To observe the effect of radio frequency interference (RFI) on GNSS signals in real environment.
- 2) To study the signals strength and Dilution of Precision (DOP) of GNSS satellites before and after an intentional jamming.

1.4 SCOPE OF PROJECT

This project is to study radio frequency interference (RFI) on Global Navigation Satellite System (GNSS) conducted via field evaluations. The tests were conducted at Faculty of Electronic and Computer Engineering, Uni. Teknikal Malaysia Melaka. During the open-sky tests measurement with the real GNSS signals, the performance of the receivers was determined for a certain number of RFI

configurations. There are six measurement samples were taken with variable number of power signals (dBm) which are 20dBm, 15dBm, 10dBm, 0dBm, -10dBm and -20dBm. But only four power signals were taken to be discussed. The interference signal used was an FM signal by using signal generator with carrier frequency of 1,575.42 MHz (the fundamental frequency of the GPS L1 coarse acquisition (C/A) signal) and bandwidth of 30 kHz. The time span of each measurement is two minutes. The first minute is without interferences and the second minute is with interference which is jammed by signal generator through horn antenna. After all, from the observations on the findings, this project report will discuss the effect of radio frequency interference on the GNSS signals strength and Dilution of Precision (DOP) of the GNSS satellites.

CHAPTER II

LITERATURE REVIEW

2.1 GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)

There are multiple constellations of GNSS satellites circling the earth. A constellation is essentially a precise arrangement of satellites, normally 20 to 30, in circles that have been intended to give a desired coverage, for instance, local or worldwide. GNSS satellites orbit well over the atmosphere, around 20,000 km over the world's surface. They are moving rapidly, a few kilometres for each second. There are two GNSS right now over the atmosphere which are GPS and GLONASS.

2.1.1 GPS AND GLONASS

The use of GLONASS in addition to GPS, results in there being a larger number of satellites in the field of view, which has the following benefits:

- 1) Reduced signal acquisition time
- 2) Improved position and time accuracy
- 3) Reduction of problems caused by obstructions such as buildings and foliage

To determine a position in GPS-only mode, a receiver must track a minimum of four satellites. In combined GPS/GLONASS mode, the receiver must track five satellites, at least one of which must be a GLONASS satellite, so the receiver can determine the GPS/GLONASS time offset.

With the availability of combined GPS/GLONASS receivers, users have access to a satellite combined system with over 40 satellites. Performance in urban areas and other locations with restricted visibility improves as more satellites are accessible by the receiver [3].

2.1.2 SATELLITE PROPAGATION

GNSS signals pass through the near-vacuum of space, then through the various layers of the atmosphere to the earth, as illustrated in Figure 2.1.

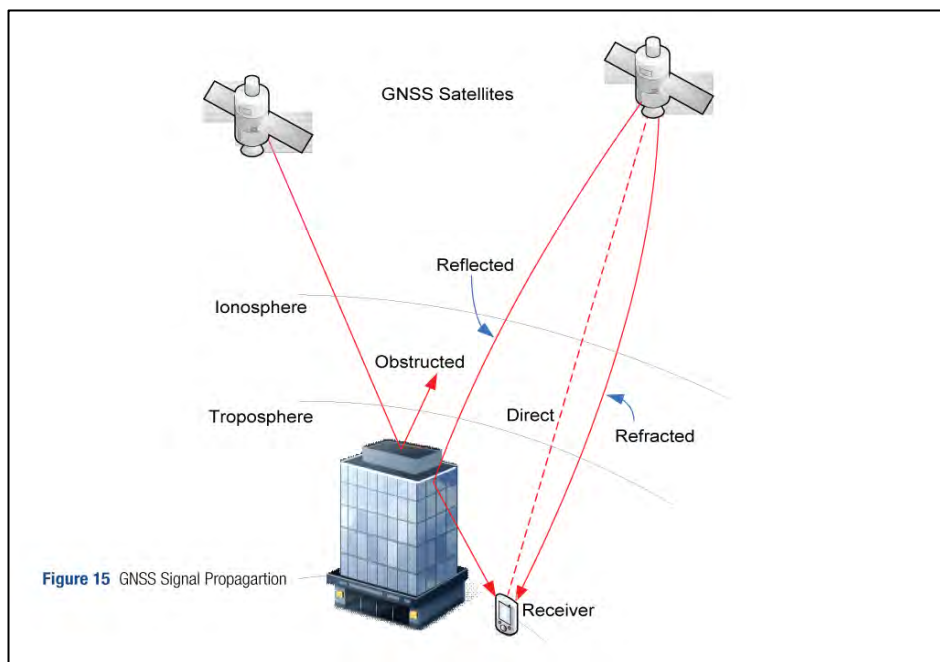


Figure 2.1: GNSS Satellite Overview