# INTERFERENCE MITIGATION FOR WIRELESS SENSOR NETWORK USING FREQUENCY HOPPING

SITI HADIJAH BINTI ISHAK

UNIVERSITI TEKNOLOGI MALAYSIA

INTERFERENCE MITIGATION FOR WIRELESS SENSOR NETWORK USING
FREQUENCY HOPPING

SITI HADIJAH BINTI ISHAK

A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Electronic and Telecommunication)

School of Electrical Engineering
Faculty of Engineering
Universiti Teknologi Malaysia

AUGUST 2022

# DEDICATION

This project report is specially dedicated to my beloved parents and siblings who have encouraged and support me for being able to go through the journey of my part time study. The struggle is real, as for me with high commitment work as full-time private worker and unpredictable condition along the journey as to complete the project. Somehow, the challenge is there and need to face and finish it till the end. Slowly but surely end.

# ACKNOWLEDGEMENT

First of all, Alhamdulillah, Thanks to Allah S.W.T for His blessings and mercy, for giving me strength to complete this project till the end.

Next, I would like to express my heartily gratitude to my supervisor, Dr Ahmad Shahidan Bin Abdullah for big support during completion of my project. Not forgotten, I would like to express my sincere appreciation to PM. Dr Rozeha for the guidance and sharing her knowledge with me.

My special appreciation also goes to my family member for the encouragement, love and emotional support along the journey. My fellow postgraduate student who keeps support give motivation and advice to me regardless their busy schedule. My colleague who understands and provide assistance at various occasion especially during my weekend classes. And of course, to my workplace management who give permission and allowed me to continue further study for the future.

Finally, yet importantly, a million thanks to those whom I deal directly and indirectly which teaching and helping me for this whole journey.

Thank you so much.

# ABSTRACT

The rise of Internet of Things (IoT) application over past few years, has introduced Wireless Sensor Network (WSN) a famous technology used for IoT. However, initial measurement shows that the wide-ranging growth number of wireless devices operating in the 2.4GHz unlicenced band which the WSN is being implemented on, suffer from heavy interference. It observed among all the technology using the 2.4GHz unlicensed band, WSN is most vulnerable to this interference and had big effect towards the performance of the network. This raises the need for agile methods and apply appropriate actions in order to make the communication success and improve the operational robustness and reliability of the WSN system. In this project, a study about WSN based on interference mitigation is proposed. The interference mitigation algorithm is studied by using Simulink Matlab and frequency hopping technique with considering dummy signal as the interference signal.

# ABSTRAK

Kebangkitan Internet Perkara (IoT) sejak beberapa tahun yang lalu telah memperkenalkan Rangkaian Sensor Tanpa Wayar (WSN) sebagai teknologi terkenal yang digunakan untuk IoT. Walaubagaimanapun, pengukuran awal menunjukkan bahawa kenaikan dimana mana bilangan peranti tanpa wayar yang beroperasi di jalur yang tidak berlesen 2.4GHz yang WSN sedang dilaksanakan, mengalami gangguan berat. Ia diperhatikan dikalangan semua teknologi yang menggunakan jalur tidak berlesen 2.4GHz, WSN paling terdedah dengan gangguan ini dan telah terbukti menjejaskan prestasi rangkaian. Ini menimbulkan keperluan untuk kaedah tangkas yang menilai keadaaan saluran dan menggunakan tindakan yang sesuai untuk menjayakan komunikasi dan meningkatkan kemantapan operasi dan kebolehpercayaan system WSN. Oleh itu, dalam projek ini, satu kajian terhadap WSN berdasarkan pengurangan gangguan ringan dicadangkan. Algorithm pengurangan gangguan dikaji dengan menggunakan Simulink Matlab dan Teknik lompat frekuensi disamping menggunakan isyarat tiruan sebagai isyarat gangguan.

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

x

# LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| WSN | - | Wireless Sensor Network |
| WIFI | - | Wireless Fidelity |
| MATLAB | - | Matrix Laboratory |
| FFR | - | Fractional Frequency Reuse |
| GLSD | - | Geo-location spectrum database |
| PADM | - | Power Allocation for Distributed MIMO |
| BER | - | Bit Error Rate |
| AWGN | - | Add white Gaussian Noise |
| OFDM | - | Frequency Division Multiplexing |
| MIMO | - | Multiple Input Multiple Output |
| 8-PSK | - | 8 Phase Shift Keying |
| CW | - | Continuous Wave |
| FMCW | - | Frequency Modulated Continuous Wave |
| SINR | - | Signal to Interference plus Noise Ratio |
| FFT | - | Fast Fourier Transform |
| FH | - | Frequency Hoping |
| PSK | - | Phase Shift Keying |
| PN | - | Pseudorandom Noise |

# LIST OF SYMBOLS

xii

Hz     -     Herts (unit for Frequency)

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Wireless Sensor Network (WSN) is one of the famous technologies used in IoT. It can be defined as device network which can be communicate the information gathered from a monitored field through wireless links. It consists of base stations and wireless sensor (number of nodes) whereby the data is pass through and finally connected to other networks like wireless Ethernet. Each node contains of radio transceiver, power components and microcontrollers. There are many applications for WSN in our surrounding. For examples, in Environmental Monitoring, have air pollution monitoring as to monitor gas concentration and fire detector by having sensor to measure the temperature. In Health Monitoring & Medical Devices, also have heartbeat sensor and blood pressure sensor, purposely to measure patient heart and blood reading level and many more. Most of WSN are created in small size, low cost, longer time and the most important one is low power consumption which give more benefit to users. But, as everyone know, there're many numbers of wireless operating at unlicensed band 2.4GHz, including WSN. But the increasing of wireless number caused WSN suffer of the heavy interference and become more vulnerable towards the interference. For example, easy to get distracted by others element such as Bluetooth, microwave and etc.
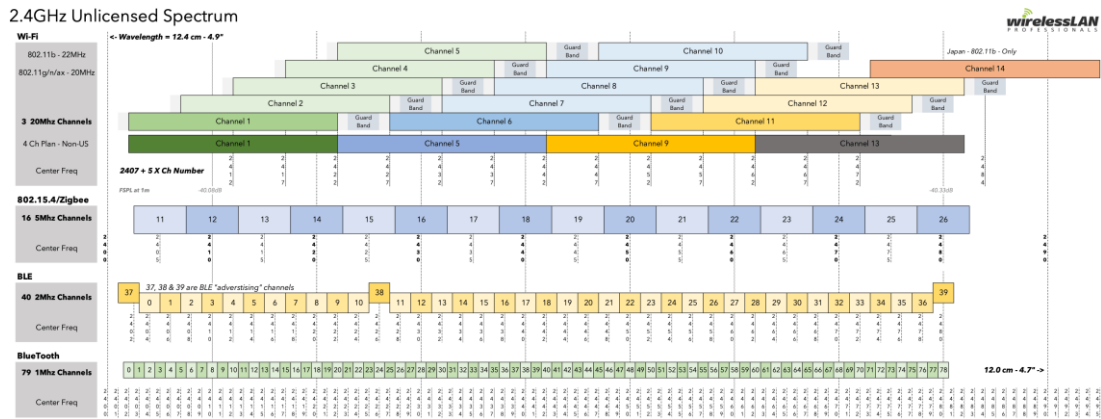
Figure 1.1: 2.4GHz Unlicensed Spectrum

Interference mitigation is basically a technique to reduce the interference between network which operating at same spectrum band. There are many interferences mitigation technique can be implemented in wireless communication system. One of the techniques is by reducing the power level of radio frequency signal. Filtering and equalizers technique also effective in communication channel either the characteristic is known or unknown. Another method is by doing transmission at different places, frequency and times.

Matlab is one the programming platform develop by Mathworks, purposely to design and analysis system. It allows plotting graph, data and function, implementation of algorithm, make a user interface, create models and applications. Signal processing, image and video processing are one of those application using the platform. Matlab Simulink is one of those Matlab based graphical programming for modelling, simulating and analysing. It provides customize block library, graphical editor and solver for the modelling system.

Figure 1.2: Matlab Simulink

## 1.2 Problem Statement

The increasing number of wireless devices operating in the 2.4 GHz unlicensed band which the WSN is being implemented on, WSN is most vulnerable and suffers from this heavy interference which adversely affect the performance of the network. The modulated interference signal is created as to evaluate the interference performance on transmit signal.

## 1.3 Research Objectives

The main aim of this research is to improve Wireless Sensor Network (WSN) based on interference mitigation. The specific objectives of this study are as below: -
  i) To study the interference mitigation algorithm for WSN using frequency hopping technique
  ii) To validate the suitable frequency hopping parameters for interference mitigation against dummy signal interference for WSN.

## 1.4    Scope of Study

In order to achieve the objectives of this project, there were two scopes had been outlined. The tools that had been used is Simulink Matlab and the interference signal consider is only dummy signal.

## 1.5    Thesis Organization

This thesis is organized into five chapters. The thesis is start with an introduction in Chapter 1 which gives a simple overview the background of the project. Besides, it also discussed about the problem statement, research objectives, and the scope of the study.

Then, follow by other four chapters which explain the project in more detail. Chapter 2 covered more on theory and literature review on the previous research that have been done before.

Next, Chapter 3 briefly is about the methodology that had been applied in this project. The step to develop the software of this project also had been discussed in this chapter. Meanwhile, in this Chapter 4 the result of the project had been presented.

Finally, Chapter 5 gives the comprehensive conclusion about this project.

# REFERENCES

1. Ahmed Ibrahim Abdelaal; Maged Mohamed Ghoneima; Bassem Amin Abdullah, "Towards a Novel MATLAB Framework for VANETs Simulation (Vehicular Ad-hoc Networks)" 2021

2. P. Gasnier; B. Alessandri; T. Fayer; N. Garraud; E. Pauliac-Vaujour; S. Boisseau, "Modelling and Characterization of a High-Efficiency, Cm-Scale and Low Velocity Airflow-Driven Harvester for Autonomous Wireless Sensor Nodes", 2019

3. Aarti Kochhar, Pardeep Kaur & Preeti, "Simulation Platforms for Wireless Sensor Networks: How to Select?", 2019

4. Akeel Othman; Dusan Maga, "Relation Between Security and Energy Consumption in Wireless Sensor Network (WSN)", 2018

5. Mohammed H. Al-Obaidi and Kasim M. Al-Aubidy, "Wireless Sensor Network Based Real-Time Monitoring and Control for Factory Automation", 2018

6. Qutaiba Ibrahem Ali; Akram Abdulmaowjod; Hussein Mahmood Mohammad, "Simulation & Performance Study of Wireless Sensor Network (WSN) Using MATLAB", 2010

7. JA Oyedepo; YO Salihu; A Folaponmile, "Interference mitigation techniques in wireless communications systems", 2010

8. Stefan Panic; Mihajlo Stefanovic; Jelena Anastasov; Petar Spalevic; "Fading and Interference Mitigation in Wireless Communications", 2013

9. SassanAhmadi, "Mobile WiMAX", 2011

10. George K. Karagiannidis, "Interference mitigation techniques in modern wireless communication system", 2016

11. Elesa Ntuli; Chunling Du; Fisseha Mekuria, "Review of Interference Mitigation Techniques for White Space Networks" 2019

12. Georgios Nikolaidis, "Practical Interference Mitigation for Wi-Fi Systems", 2016

13. Henrik Lundgren; Anand Prabhu Subramanian; Theodoros Salonidis; Marianna Carrera; Pascal Le Guyadec; "Interference Mitigation in WiFi Networks using Multi-sector Antennas", 2015

14. N. Azmi; L. M. Kamarudin; M. Mahmuddin; A. Zakaria; A. Y. M. Shakaff; S. Khatun; K. Kamarudin; M. N. Morshed, "Interference issues and mitigation method in WSN 2.4GHz ISM band: A survey", 2014

15. Mohammad J. Abdel Rahman; Marwan Krunz; Richard Erwin, "Interference Mitigation Using Spectrum Sensing and Dynamic Frequency Hopping", 2012

16. Andrew Worthen; Wayne Stark, "Interference mitigation in frequency-hopped spread-spectrum systems", 2000

17. Maqbool Shahet et al,"Congestion Control in Wireless Sensor Networks- An overview of Current Trends", 2016

18. Ruoshui Liu et al, "Frequency Diversity Measurements at 2.4 GHz for Wireless Sensor Networks Deployed in Tunnels", 2014

19. Sharef Neemat; Oleg Krasnov; Alexander Yarovoy, "An Interference Mitigation Technique for FMCW Radar Using Beat-Frequencies Interpolation in the STFT Domain", 2018

20. Archana Ogale; Shubhangi Chaoudhary; A. J. Patil,"Performance evaluation of MIMO-OFDM system using Matlab® Simulink with real time image input", 2013

21. Faruk Uysal; Sasanka Sanka, "Mitigation of automotive radar interference", 2018

22. Jibin Joseph; Rahul Raj; Vineeth V. Nair; Mohemmed Hassain; Sreejith G. Palackal, "Harmonics mitigation in distribution system by SMES sourced multilevel D-STATCOM", 2016

23. S.M. Usha; K.R. Nataraj, "Analysis and mitigation of adjacent and co-channel interference on AWGN channel using 8-PSK modulation for data communication", 2016

24. Hokyung Son Youngjun Chong, "Analysis of the Interference Effects of 5G system on Automotive Collision Avoidance Radars", 2019

25. Dr. G. Senthil Kumar, "Wireless Sensor Network", 2021

26. Waltenegus Dargie; Christian Poellabauer, "Fundamentals of Wireless Sensor Networks", 2011

27. Hodge, V.J.; O'Keefe, S.; Weeks M.; Moulds, A., "Wireless Sensor Networks for Condition Monitoring in the Railway Industry", IEEE Transactions on Intelligent Transportation Systems, 16, 1088-1106., 2015

28. Meng Hou; Fengyuang Ren; Chuang Lin; Mao Miao, "HEIR: Heteregenous Interference Recognition for Wireless Sensor Network", in IEEE Explore 09, 2014

29. Sergio Diaz; Diego Mendez; Rolf Kraemer, "ICI - Interference Characterization and identification for WSN" IEEE 2017 Wireless Telecommunication Symposium (WTS), 2017

30. lrashidi, A.; Elleithy, A.; Albogame, M.; Elleithy, K., "Underwater Wireless Sensor Network Communication Using Electromagnetic Waves at Resonance Frequency 2.4 GHz." Proceedings of the 15th Communications and Networking Simulation Symposium (CNS '12), Society for Computer Simulation International, San Diego, Article 13, 2009

31. Updated Unlicensed Spectrum Charts", 2020 Wireless LAN Professionals |

32. NA Bay Networking, "Types of Wireless Sensor Networks"

33. https://onlinelibrary.wiley.com/doi/epdf/10.1002/wcm.1089

34. Radio Frequency Interference Mitigation Frequency Interference Mitigation Algorithms &ndash;Design, Implementation and Validation using Matlab-Simulink Kaushal D. Buch Digital Backend - [PDF Document] (documents.pub)

35. Xinfen Fan; Zhiliang Tan, "Simulink Implementation of Frequency Hopping Communication System and Follower Jamming", 2018

36. Xiaoping Lu; Weiqi Wang; Lan Yi; Jie Rong; Anqi Wang, "Simulation of Frequency Hopping Communication System Based on Matlab", 2016

37. Liu Ke-Fei; Yang Dong -kai; WU Jiang, "Simulink Implementation of Frequency Hopping Communication System", 2009

38. Mr Ravi Badiger; Dr M. Nagaraja; Dr. M. Z. Kurian; Prof Imran Rasheed, "Analysis Design and Testing of Frequency Hopping Spread Spectrum Transceiver Model using Matlab Simulink", 2014

Pintukumar Yadav; Prof Usha Neelakantan, "Performance Analysis of FHSS Transceiver Model in Matlab", 2015

39. Jabir Salman Aziz; Abbas Ahmed Al-Sachi; Anwar Kasim Al-Khateeb; F.N. Pavlidou, "Parameter Estimation of Frequency-Hoping (FH-SS) Signals Using Modified Autocorrelation Techniques", 2006

40. Yuyang Wang; Shiru He; Changrong Wang; Zhi Li; Jian Li; Huajian Dai; JianLee Xie, "Detection and Parameter Estimation of Frequency Hopping Signal based on the Deep Neural Network", 2021

41. Jean-Marie Bourjolly; Souheyl Touhami, Leslie Dejoi; Ke Ding; Oumar Dioume; Michael Lominy, "Optimizing Frequency Hopping in GSM Cellular Phone Networks", 2002

42. Jian Wan; Dianfei Zhang; Wei Xu; Qiang Guo, "Parameter Estimation of Multi Frequency Hopping Signals Based on Space Time Frequency Division", 2019