A MULTI-BAND ANTENNA FOR MOBILE HANDSET

ZAKARIA ABDESLAM KABBOUR HANZAZ

UNIVERSITI TEKNOLOGI MALAYSIA

To

my Beloved Mother, Father, Brothers and Sisters.

ACKNOWLEDGMENT

In the name of Allah, Most Gracious, and Most Merciful

Praise be to Almighty Allah (Subhanahu Wa Ta'ala) who gave me the courage and patience to carry out this work. Pease and blessing of Allah be upon his last prophet Mohammed (Sallulaho-Alaihe Wassalam) and all his companions (Sahaba), (Razi-Allaho-Anhum) who devoted their lives towards the prosperity and spread of Islam.

My deep appreciation and heartfelt gratitude goes to my supervisor, Dr. Nor Hisham Bin Hj Khamis for his kindness, constant endeavor, guidance and the numerous moments of attention he devoted through out this work.

I extend my deepest gratitude to my sister, M.Eng. Assia A. K. Hanzaz for her encouragement and motivation. I would like to convey a heartfelt thanks to my parents, brothers, sisters and other family members including all my uncles, ants and their families; their prayers and encouragement always helped me take the right step in life.

Acknowledgement is due to my senior colleagues and friends and my classmate, and a heartfelt gratitude and acknowledgement are due to the International student community in UTM, Skudai for their kindness, care, valuable advices and cooperation.

ABSTRACT

Conventional microstrip antennas in general have a conducting patch printed on a grounded microwave substrate, and have the attractive features of low profile, light weight, easy fabrication, and conformability to mounting hosts. Microstrip antennas however have a narrow bandwidth, and bandwidth enhancement is usually demanded for practical applications. In addition to being broadband, they should be capable of operating in multiple frequency bands too. Compactness of structure is another feature desired in present-day mobile communication systems in order to meet the miniaturization requirements of mobile units. Thus, mobile phones antennas require reduction in size and broadband operation for compatibility with different standards essentially operating in different frequency bands. This project reviews the techniques used to incorporate these two essential features to a conventional microstrip antenna. Planar Inverted-F Antenna has been developed and the information acquired from these techniques is appropriately used to explain the design of operation for mobile phones. The quarter-wavelength Planar Inverted-F Antenna (PIFA) combines the use of a slot, shorted parasitic patches and capacitive loads to achieve multi-band operation. The result is a compact structure capable of broadband operation in six different frequency bands used by four standards – GSM900 (Global System for Mobile), GPS (Global Position System), DCS1800 (Digital Cellular Systems), PCS1900 (Personal Communication Systems), UMTS2000 (Universal Mobile Telecommunication Systems) and WLAN2400 (Wireless Local Area Network).

ABSTRAK

Konvensional mikrostrip antena secara umumnya mempunyai pengalir tampalan yang dicetak di atas satu substrat gelombang mikro yang dibumikan, dan mempunyai ciri-ciri yang menarik seperti profil rendah, ringan, teknik pembuatan yang mudah, dan mempunyai keseragaman dalam proses pemasangan. Antena mikrostrip bagaimanapun mempunyai lebar jalur yang sempit, dan penambahan lebar jalur biasanya diperlukan untuk aplikasi secara praktikal. Untuk menghasilkan jalur lebar, antena ini sepatutnya boleh beroperasi dalam pelbagai jalur frekuensi. Struktur yang padat pula merupakan ciri yang perlu ditekankan dalam penggunaan sistem komunikasi bergerak masa kini di mana syarat-syarat pengecilan pada unit bergerak perlu dipenuhi. Oleh itu, antena telefon mudah alih memerlukan pengurangan dari segi saiz dan beroperasi pada jalur lebar dalam memastikan keserasian terhadap piawaian yang berbeza yang pada dasarnya beroperasi pada jalur frekuensi yang berbeza. Projek ini mengulas mengenai teknik-teknik yang digunakan untuk mengggabungkan dua ciri penting ini pada satu konvensional mikrostrip antena. Planar antena Inverted-F telah dibangunkan dan maklumat yang diperolehi daripada teknik-teknik ini sesuai digunakan untuk menjelaskan reka bentuk operasi telefon mudah alih. Suku gelombang Planar antena Inverted-F (PIFA) menggabungkan slot, pintasan tampalan parasitik, dan beban kapasitif untuk menghasilkan multi jalur operasi. Hasilnya, sebuah struktur padat berupaya beroperasi pada jalur lebar dalam enam jalur frekuensi yang berbeza yang digunapakai pada empat piawai – GSM900 (Sistem Bergerak Global), GPS (Sistem Kedudukan Global), DCS1800 (Sistem Selular Digital), PCS1900 (Sistem Telekomunikasi Peribadi), UMTS2000 (Sistem Telekomunikasi Bergerak Universal) dan WLAN2400 (Rangkaian Kawasan Tempatan Wayarles).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

AMPS	-	Advanced Mobile Phone Systems
CPW	-	Coplanar Waveguide
CP	-	Circular Polarization
DCS	-	Digital Communication System
DRA	-	Dielectric resonator antennas
FDTD	-	Finite-Difference Time-Domain
GPS	-	Global Position System GPS
GSM	-	Global System for Mobile Communication
EM	-	Electromagnetic
IFA	-	Inverted-F Antenna
ILA	-	Inverted-L Antenna
MIC	-	Microwave Integrated Circuits
NMT	-	Nordic Mobile Telephone
PIFA	-	Planar Inverted-F Antennas
PPI	-	Personal Communication System
PCB	-	Printed Circuit Board
SAR	-	Specific Absorption Rate
TDMA	-	Time Division Mutable Access
UMTS	-	Universal Mobile Telecommunication System
VSWR	-	Voltage Standing Wave Ratio
WLAN	-	Wireless Local Area Network
WCDMA	-	Wavelength Code Division Multiple Access

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

The rapid increase of communication standards leads to a great demand in developing multi-band internal antennas for handset devices and with the rapid growth of wireless communications there is a growing demand for mobile phones that are small, attractive, lightweight, and curvy. This has resulted in the proliferation of handsets with antennas that are internal or hidden within the device. An internal antenna makes the handset look much nicer and compact.

The sizes and weights of mobile handsets have rapidly been reduced due to the development of modern integrated circuit technology and the requirements of the users. For example, Conventional monopole-like antennas have remained relatively large compared to the handset itself. Thus, built-in antennas are becoming very promising candidates for applications in mobile handsets.

Most built-in antennas currently used in mobile phones are based on planar inverted-F antennas (PIFAs) [1]. In addition, since the antenna is inside the phone it is not prone to breakage or damage, which is commonly encountered with the so-called external stub-type antenna. Currently mobile phones with small internal antennas are already in the market.

Designing an internal antenna for a mobile phone is difficult especially when dual or Multi-band operation is required. Although obtaining dual-frequency resonance is straightforward, satisfying the bandwidth requirement for the respective communication bands is difficult. Further complications arise when the antenna has to operate in close proximity to objects like shielding cans, screws, battery, and various other metallic objects. Currently, many mobile telephones use one or more of the following frequency bands: the GSM (Global System for Mobile Communication) band, centered at 900 MHz; the DCS (Digital Communication System) band, centered at 1800 MHz; and the PCS (Personal Communication System) band, centered at 1900 MHz. Triple-band built-in antennas to operate at GSM900, DCS1800, and PCS1900 bands demonstrated in [2], [3].

If merger of technologies is considered where both advanced mobile phone systems (AMPS) and global system for mobile (GSM) systems are integrated in one phone, triple-band or even quad-band antennas may be needed. For instance, consider a device that operates in the AMPS 800, GSM 900, and TDMA (Time Division Mutable Access) /GSM1900 MHz bands. This means that the device operates in the 824–894 MHz, 880–960 MHz, and 1850–1990 MHz bands making it triple band from antenna perspective. In the lower band the required bandwidth is 136 MHz or 15.25% which is almost twice as much of that required for GSM or AMPS alone.

1.2 Mobile Communication and Wireless Revolution

Mobile communication "one of the fastest growing and consider as the most important telecommunication application" it is the most powerful catalyst for change in lifestyle of the people. The mobile communication was used in limited applications due to costly analogue technologies and restricted service (only phone calls were possible), the tiny high technologies are now become a necessary need of every individuals life.

The wireless revolution is creating a flood of new wireless devices that dramatically increase the availability of voice and data nearly anywhere in the world. While this revolution is significantly expanding the opportunity for new, smaller and better wireless communication terminals. It also requires the new and small antenna design.

Traditionally most mobile phones and handset have been equipped with the monopole antenna. Whereas the monopole antenna are very simple in design and construction and are well suited to mobile communication application. The most ¼ monopole antenna is the wipe antenna, which can operate at range of frequencies and deal with most environmental conditions better than other monopole antennas.

However, the monopole antenna possesses a number of drawbacks. Monopole antennas are relatively large in size and protrude from the handset case in an awkward way. This problem with the monopole's obstructive and space demanding structure also complicate any efforts taken to equip a handset with several antennas to enable multilane operation. Monopole antennas also lack any built-in shielding mechanisms, to direct any radiating waves away from user's body, thus increasing the potential risk of producing cancerous tumors growth in the user's head and reducing the antenna efficiency.

In recent years, the demand for compact handheld communication devices has grown significantly. Devices smaller than palm size have appeared in the market antenna size is a major factor that limits device miniaturization. In addition to solve the problem of broadening the antenna bandwidth to the required specification of the system, one has to worry about developing new structure for devices that require more than one frequency band of operation.

Multi-band wireless phone has become popular recently because they permit people to use the same phone in multi network that has different frequencies. Table 1.1 lists a few useful wireless applications and their operating frequencies. Systems that require multi-band operation require antenna that resonate at the specific frequencies. This only adds complexity to the antenna design problem.

Table 1.1: Frequency Bands for a Few Wireless Applications.

Wireless Applications	**Frequency Bands (MHz)**
Global System for Mobile Communication GSM-900	890 - 960
Global Position System GPS - 1575	1575
Digital Communication System DCS-1800	1720 - 1880
Personal Communication System PCS-1900	1850 - 1990
3G-(Universal Mobile Telecommunication System-UMTS2000)	1920 - 2170
Bluetooth and Wireless Local Area Network-WLAN 802.11b/g	2400 - 2484

1.3 Problem Statement

- Currently, there are many different wireless standards are available for mobile communication; therefore it requires that the same mobile phone can work for different frequency bands. Since it is not feasible to equip the device with many antennas for each frequency band, So, Multi-band antennas provide the feature of low profile and multi-band reception.

- The sizes and weights of mobile handsets have rapidly been reduced due to the development of modern integrated circuit technology and the requirements of the users.

- The built-in antennas are becoming very promising candidates for applications in mobile handsets. Conventional monopole antennas are simple, omni-directional pattern and gain that is suited for mobile application. But they have remained relatively large compared to the handset itself, and they have lack of shielding mechanisms, to direct any radiating waves away from user's body which causes potential harm to the user's health.

1.4 Objective of the Project

The main objective of this research project is to design and develop a multi band antenna, this antenna will be able to operate at a numbers of frequency bands such as GSM900, GSM1800, 3G-2000 and also including the Bluetooth and WLAN at 2.4GHz bands which is become more candidate for feature mobile handset. An efficient, low profile and realizable antenna for this objective will be determined.

1.5 Scope of the Project

In order to achieve the objectives, the research scope includes:

- A comprehensive literature review is required to obtain an antenna that we need.
- Propose a novel type of antenna with good parameters requirement.
- Verify and improve using the electromagnetic simulation software such as ZELAND FIDELITY.
- Optimize the antenna design parameters to satisfy the best return loss and radiation pattern in frequency bands.
- A prototype antenna will be fabricated and comparisons will be made between simulation and measurement results.

1.6 Methodology of the Project

In order to achieve the first objective as set out above, a comprehensive literature review is required to obtain an antenna that requires minimal modification to suit the requirements of this design. As the process of optimizing an antenna's dimensions to meet a set of specifications is highly rigorous, fading an antenna that operates efficiently at the four or more required frequencies, as well being compact and having a low profile, is very much desired.

Verify the operations of the antenna at the prescribed frequencies in terms of input impedance and field patterns, using electromagnetic simulation software ZELAND FIDELITY software. Developing the prototype and compare its performance of the antenna between simulated and measured results.

Where an interactive theoretical and experimental design approach will be utilized to optimize the structure of the antenna, the research methodology to simplify the design and the development procedures in this research project includes:

1. **Pre. Design Stage**
   - Literature review.
   - Problem statement.

2. **Design and Simulation Stage**
   - Design the optimum antenna that met specification requirement.
   - Antenna input impedance optimization.

3. **Prototype Stage**
   - Antenna fabrication.

4. **Measurement Stage**
   - Return loss and pattern loss at multi-bands range.

5. **Analysis Stage**
   - The measurement and simulation results comparison.

The antenna fabrication needs to fit within the costing constraints and the availability of the materials. The design and development procedures are briefly summarized in the flow chart of figure 1.1. In particular, this methodology provides an approximate chronological progress of the work performed to finally complete the full design cycle.

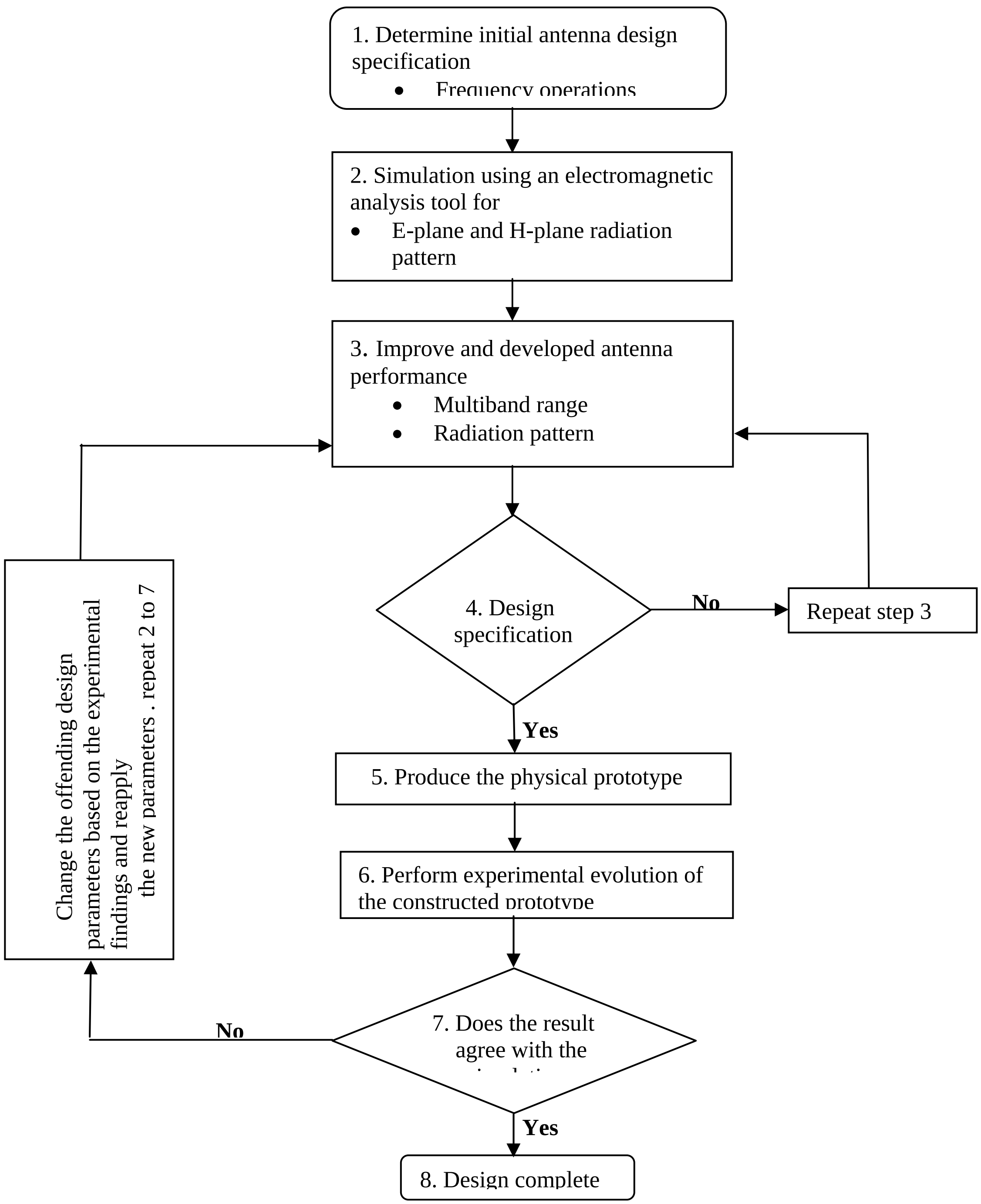

Figure 1.1: Antenna Design and Development Flow Chart

1.7 Thesis Outline

This thesis will concentrate on designing a multiband antenna that operate at as least five band for mobile application and wireless communication, and that will be by understanding the microstrip antenna and go to the Planar Inverted-F Antenna which the best candidate for future of designing antennas like this application, and the thesis will be as follows:

Chapter one concerns with the introduction of the study in hand, which start with brief introduction, and continues stating the problem, the objective, the scope of the study and finally the methodology to carry out this work.

Chapter two which is the first chapter of the literature review, presents some general review on mobile generation and its characteristics and the stages of developing it, and some general antennas on mobile, and some recently research in mobile antenna paper that show the latest design in the mobile with various design.

Chapter three shows the concept of the microstrip antennas and the basic formula to start design microstrip or Planar Inverted-F Antenna, and we focusing on the technique that is used in previous work, and it is use to increase bandwidth, also how to reduce size, and important relation factor which make the antenna adequate for our application and in good efficiency.

Chapter four explain the way how we have started the designing and what kind of method that will execute, and will show the execution of the project by presenting a preliminary design by using the simulation software ZELAND FIDELITY.

Chapter five introduces the results from the simulation software for the return loss and radiation pattern of the antenna and also show the fabrication result for the same factors and a discussion for these result, and comparison between the simulation and the measurement results.

Chapter six summarizes and emphasizes the obtained results and the contribution of the study, also this chapter propose the future work that can be done for more enhancement for the antenna parameters and more compact structure for the antenna prototype.