MULTIBAND ANTENNA FOR MOBILE HANDSET

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The GOD has blessed me
with a wonderful family
to whom this thesis is dedicated

To my beloved Parents,
my elder brother Tahseen and his wife,
my younger brother Farhan,
and my cute nephew Maheen.

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Abstract

Modern cellular phone systems currently operate at a number of frequency bands, the most common being 900MHz, 1.8GHz and 2.0GHz. As mobile phones are becoming smaller it is not feasible to simply equip the handset with an array of antennas, each tuned for a specific frequency band. This has resulted in a demand for antennas that can operate at multiple bands without the need for multiple antennas. The Inverted-F Antenna (IFA) has been demonstrated to be capable of operating at multiple frequencies. Another approach dealing with the ever-diminishing space available on handsets is to conform the antenna. This involves wrapping the microstrip antenna around a cylindrical surface. The results of this approach using the IFA are encouraging, especially in terms of space minimization, bandwidth enhancement and return loss reduction. The purpose of this thesis is to design a conformal antenna for a mobile handset. The first step is to choose a suitable planar triple-band antenna capable of operating at 900MHz, 1.8GHz and 2.0GHz. The antenna that is selected for this thesis is the E shaped planar IFA. This antenna should easily be tuned for correct frequency operation and possess a compact design. The design is created by using , an electromagnetic simulation software package. Once the planar version of the antenna will be simulated, the antenna will then made conformal.

Abstrak

Sistem telefon selular moden beroperasi di dalam bebarapa jalur frekuensi, dan antara yang paling kerap digunakan ialah 900MHz, 1.8GHz dan 2.0GHz. Dengan berkurangnya saiz telefon bimbit, maka adalah tidak munasabah untuk melengkapi telefon bimbit tersebut dengan satu siri antena di mana setiap satunya diselaras bagi frekuensi yang tertentu. Ini telah menjuruskan kepada permintaan bagi antena yang boleh beroperasi pada pelbagai jalur geombang tanpa memerlukan antena yang berasingan. Antenna F Songsang (IFA) telah diuji berkesan untuk beroperasi pada pelbagai frekuensi. Salah satu pendekatan yang perlu diambil dalam menghadapi ruang telefon bimbit yang terbatas ialah penyesuaian antena. Ini termasuklah membalut antena jalur mikro di sekeliling permukaan silinder. Hasil daripada pendekatan ini adalah menggalakkan, terutama sekali di dalam ruang yang terbatas, penambahan lebar jalur dan pengurangan kehilangan kembali. Tujuan tesis ini ialah untuk mereka penyesuaian antena ini untuk diaplikasikan di dalam telefon bimbit. Langkah pertama yang perlu diambil ialah memilih planar antena tiga-jalur frekuensi yang berupaya beroperasi pada 900MHz, 1.8GHz dan 2.0GHz. Antena yang telah dipilih di dalam tesis ini ialah planar IFA berbentuk E. Antena ini akan dapat diselaraskan kepada frekuensi operasi yang betul dan memiliki reka bentuk yang padat. Reka bentuk ini dilaksanakan dengan menggunakan pakej program simulasi elektromagnet. Penyesuaian antena akan dilakukan setelah versi planar yang hendak digunakan disimulasi.

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CCA	Ceramic Chip Antenna
DCS	Digital Communication System
FDTD	Finite-Difference Time Domain
GSM	Globel System For Mobile Communications
IFA	Inverted-F Antenna
ILA	Inverted L Antenna
IMTS	International Mobile Telecommuncation
MSA	Microstrip Antenna
PCS	Personal Communication System
PIFA	Planar Inverted-F Antenna
PTFE	Polytetrafluoral Ethylene
SNM	Spatial Network Method
VSWR	Voltage Standing Wave Ratio
WLAN	wireless local area networks

CHAPTER 1

Introduction

1.1 Overview

Mobile communications, wireless interconnects, wireless local area networks (WLANs), and cellular phone technologies compose one of the most rapidly growing industrial markets today. Naturally, these applications require antennas. Moreover the mobile handsets have been demanding that those are small, lightweight and compact. These demands are drought on the development of low-profile internal antenna with superior performance. This being the case, portable antenna technology has grown along with mobile and cellular technologies. It is important to have the proper antenna for a device. The proper antenna will improve transmission and reception, reduce power consumption, last longer and improve marketability of the communication device. However, designing an internal antenna is technically challenging due to the limited antenna volume and influence of the case of the mobile handset terminal.

1.2 Problem Background

Traditionally most mobile phones and handsets have been equipped with the monopole antenna. Monopole antennas are very simple in design and construction and are well suited to mobile communication applications. The most common $\lambda/4$

monopole antenna is the whip antenna, which can operate at a range of frequencies and can 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 the 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.

There are a wide variety of methods being investigated to deal with the deficiencies of the common $\lambda/4$ monopole antenna, many of these methods being based on micro strip antenna designs. One such promising design is the Inverted-F Antenna (IFA), a distant derivative of the monopole antenna. The IFA utilizes a modified Inverted-L low profile structure, as has frequently been used for aerospace applications. The common IFA possesses a rectangular element with an omni directional radiation pattern and has exhibited a reasonably high gain. The bandwidth of the IFA is also broad enough for mobile operation, and is also highly sensitive to both vertically and horizontally polarized radio waves, thus making the IFA ideally suited to mobile applications.

In addition to solving the problem of broadening the antenna bandwidth to the required specifications of the system, one has to worry about developing new structures for devices that require more than one frequency band of operation. Multi-band wireless phones have become popular recently because they permit people to use the same phone in multi networks that have different frequencies. Table 1.1 lists a few useful wireless applications and their operating frequencies. Systems that require multi-band operation require antennas that resonate at the specified frequencies. This only adds complexity to the antenna design problem.

Table 1.1: Frequency Bands for a Few Wireless Applications

Wireless Applications	Frequency Band (MHz)	Bandwidth (MHz)
Cellular Telephone	824-894	70 (8.1%)
GSM-900	890-960	70 (7.6%)
DCS-1800	1710-1880	170 (10.6%)
PCS-1900	1850-1990	140 (7.3%)
IMT-2000	1885-2200	315 (15.5%)
ISM (including WLAN)	2400-2483	83 (3.4%)
Bluetooth	2400-2500	100 (4.1%)

As well as the benefits described before, the IFA was chosen as the basis because of its ability to facilitate multiband operation [4], [5]. Cellular phone systems currently operate at a number of frequency bands (such as 900MHz, 1.8GHz and 2.0GHz), thus there being a demand for antennas that can operate at multiple bands. As mobile phones are becoming smaller with time, it is not feasible for separate antenna elements to be used to facilitate multiband operation. The PIFA has been demonstrated to be able to operate at multiple frequencies.

As the available space for antennas on mobile handsets continues to be minimized, other approaches for minimizing space demand must be examined. One approach is the utilization of conformal antenna design. This involves wrapping the microstrip antenna around a cylindrical surface [7]. The results of this approach so far, using the conformal IFA are encouraging, in terms of space minimization, bandwidth enhancement and return loss reduction.

1.3 Objectives

The fundamental aim of this thesis is to design a multi-band PIFA antenna suitable for telephone handsets. By using a conformal antenna, the space demand of the antenna as part of a telephone handset can be minimized, thus reducing the obtrusiveness of the handset's appearance.

This thesis has three primary objectives:

1. Select and design an efficient, low profile and realizable antenna capable of operating at a number of frequency bands (900 MHz, 1.8 GHz and 2.0 GHz).

2. Verify the operation of the antenna at the prescribed frequencies in terms of input impedance and field patterns, using the antenna design software package Zeland FIDELITY.

3. Investigate the effects of conformality on the antenna in terms of performance.

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

1.4 Scope

This thesis focuses on specific attributes and behavior of the proposed design of Planar Inverted-F Antenna (PIFA).It significantly aims .

- To investigate the suitable low profile, multi-band antenna for mobile handset.
- To develop the E-shaped PIFA antenna using planar micro-strip for mobile handset terminal.
- Simulation of the design using an electromagnetic simulation software Zeland FIDELITY
- Convert the E-shaped PIFA antenna to conformal shape.

1.5 Organization of the Thesis

The literature review is performed in Chapter 2 of this thesis. Some description of the low profile antenna especially about microstrip antenna is described and articles that are deal with multi-band Planar Inverted-F Antenna (PIFA) and the effects of conformality is reviewed. Three triple-band planar IFAs in total are proposed in two of the articles and their performance is gauged in terms of input impedance, field patterns and gain. A review of a number of papers explaining the effects of conformality on planar IFAs and other microstrip antennas is also presented with brief summaries. The explanation of the FDTD method which is used in the simulation software for simulating the antenna structure is explained at the last of this chapter.

The theory and fundamentals behind the planar IFA (PIFA) are analyzed in Chapter 3. An extensive examination of the PIFA is performed as well as a study into the proposed triple-band planar IFA that will form the basis of this thesis. The majority of the theory presented as part of this chapter is from [3].

The methodology, used as part of this thesis for the simulation of results of the proposed antennas, is provided in Chapter 4. A brief introduction into the Electromagnetic simulation software, ZELAND FIDELITY, is included in this chapter.

Chapter 5 consists of the results derived from the methods explained in Chapter 4. The return loss characteristics and the far field patterns are presented in this chapter. The far field patterns are displayed in this chapter (two-dimensional graphs). A discussion of the results is also provided towards the end of this chapter.

Chapter 6 forms the conclusion of the said thesis.

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