UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BANDWIDTH ENHANCEMENT OF RECONFIGURABLE PLANAR INVERTED-F ANTENNA (PIFA) FOR GPS BAND APPLICATION

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

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 Electronic Engineering Technology (Telecommunication) with Honours. The member of the supervisory is as follow:

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Name: MR ADIB BIN OTHMAN

(Project Supervisor)

ABSTRAK

Antena Inverted-F Antenna (PIFA) merupakan elemen untuk operasi di frekuensi 1.5GHz di Global Positioning System (GPS). Di antara ciri-ciri PIFA mempunyai kelebihan profil rendah, padat dan sangat sesuai untuk komunikasi tanpa wayar masa kini. PIFA yang direka dipisahkan menjadi beberapa patch dengan slot dan mereka disambungkan bersama konduktor. Keputusan menunjukkan bahawa pelaksanaan slot pada patch telah meningkatkan lebar jalur (BW) antena ke 1.482MHz jika dibandingkan dengan PIFA konvensional dengan jalur lebar 1.0788MHz. Selain itu, juga didapati bahawa, ketinggian patch dan panjang substrat mempengaruhi ciri antena, dari segi kekerapan operasi dan jalur lebarnya. Pengukuran antena fabrikasi menghasilkan hasil yang signifikan dalam hal menghasilkan jalur lebar lebar walaupun terdapat pergeseran dalam kekerapan operasi. Singkatnya, ia telah dibuktikan daripada peningkatan jalur lebar untuk PIFA boleh dicapai dengan pengenalan slot pada patch.

ABSTRACT

A compact Planar Inverted-F Antenna (PIFA) as an element for operation at 1.5GHz Global Positioning System (GPS) Band is proposed. Among various possible antennas, PIFAs have advantages of low profile, compact size and very suitable for present-day wireless communication. The PIFA patch designed is separated into multiple patch by slot and they are connected together with conductor. Results show that, implementation of slot on the patch has profoundly enhance the bandwidth (BW) of the antenna to 1.482MHz if compared to conventional PIFA with bandwidth of 1.0788MHz. Furthermore, it is also found that, the height of patch and length of substrate are affecting the antenna characteristic, in term of its operating frequency and bandwidth. Measurement of fabricated antenna produce significant result in term of producing wide bandwidth even though there is shifting in operating frequency. In a nutshell, it has been proved than bandwidth enhancement for PIFA can be achieved by introduction of slot on the patch.

DEDICATION

Dedicated for my lovely father, Mr Basrey Bin Janor and mother, Mrs Ramlah Binti Lela also my siblings, my super cool supervisor, En Adib Bin Othman and coursemate with love and care.

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LIST OF ABBREVIATIONS

PIFA	-	Planar Inverted-F Antenna
CST	-	Computer Simulation Technology
GPS	-	Global Positioning System
SAR	-	Special Absorption Rate
SMA	-	Sub Miniature Version A

CHAPTER 1

INTRODUCTION

This chapter will give an overview of the project such as project introduction, problem statement, objectives, scope of the project and schedule. This chapter will explain briefly about the work from the beginning until the end of project.

1.1 Introduction

Recently, wireless communications are widely used in people daily life. As a result, it will increase the demand of high speed data rate and bigger data carrier. Therefore, nowadays wireless communication devices are deemed to small in size with high speed and moderate gain. In addition, the designed need to avoid usage of two antennas and can allow video, voice and data information to be transmitted. Hence, Planar Inverted-F Antenna (PIFA) such are suitable antenna that can fulfilled those demands. PIFA have advantages like low profile antenna and promising to be a good candidate for future technology due to the flexibility of the structure as it can be easily incorporated into the communication equipment

1.2 Problem Statement

Nowadays, the increasing use of mobile communication systems requires antennas to have properties such as compact with high data rate transfer and moderate gain for human Special Absorption Rate (SAR) consideration. Moreover, the market request for low cost and compact antenna design is overwhelming demands due to the limited space available in wireless devices. Therefore, to address this requirement, the antenna must able to operate in selected band and can support multiple communication standards. So, the PIFA is suitable antenna due to its compactness and suitable characteristic.

1.3 Objectives

The objectives of the project are:

1. To design and simulate Reconfigurable PIFA for GPS Band application with CST software.
2. To validate the measurement value of reconfigurable PIFA for GPS Band Application.

1.4 Scope of the Project

There are some limitations that need to be considered in this project which are the operating frequency of the antenna need to range of 300MHz until 3GHz. It is because the designed antenna need to operate in GPS Band application. Other than that, slots have been applied to the PIFA to accomplish the bandwidth enhancement in order to obtain wideband characteristic. In addition, FR4 are material chosen as substrate to fulfilled the design of PIFA due its low cost among dielectric materials.

1.5 Thesis Organization

This study is presented in five chapter. The thesis begins with an introduction brief idea of the project. It focused on the overview of the project, detailing the objectives, the problems statement, scope and outcome of the project. Chapter 2 is basically literature review about past study on PIFA. Then, literature review will contain the facts or other aspect that we need correspond to the project that will build. Methodology on how this study is under taken is discussed deeply in Chapter 3. This chapter include the design PIFA conventional and PIFA with slotting air gap small and large between substrate and patch of the antenna. In addition, project implementation also includes in this chapter. Chapter 4 is focused on discussion of results obtained from simulation process and hardware process. Conclusion and future recommendation for this study were briefly stated in Chapter 5.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Recently, the increasing use of mobile communications systems requires antennas having different properties such as small size, high speed and moderate gain [2], and because of the limited space available in wireless devices, the request of the design of low cost and small size of the antenna is necessary. Today, there is a growing need a gather all the wireless services in one device, particularly, the integration of Bluetooth technology, GPS Band/Wi-Fi, WiMAX and LTE in some portable devices with a high- speed data transmission and high quality. However, this normally requires many antennas that operate in multiple bands are required to support multiple standards. So, the idea is to enhance the functionality and performance of wireless communication devices and to cover the existing wireless communication frequency bands. Therefore, the planar inverted-F antennas (PIFAs), is particularly interesting due to their compactness and suitable performance. PIFA antenna has been adopted in portable wireless units because of its low profile, light weight, and conformal structure [3].

Nowadays, planar inverted-F antenna (PIFA) remains as one of the most popular antenna used in mobile phones. It is because the limited space availability in wireless devices. So, with the kind of size of this type of antenna small and appropriate for portable wireless units without degradation of performance in terms of bandwidth and radiation pattern [4]; so, the radiation pattern should close to be omnidirectional and it should cover required operating frequency band for the IEEE 802.16 standard.

In [5], H.T. Chattha, Y. huang, M.K. Ishfaq and S.J. Boyes presented bandwidth enhancement techniques for planar inverted-F antenna with a thickness of substrate t = 1.0 mm and three techniques of enhancing the bandwidth of PIFA have been presented in 3.4GHz to 107GHz. Meanwhile in [6] Zi Dong Liu et.al presented dual frequency planar inverted-F antenna that are made operate at 0.9 and 1.76GHz and produce omnidirectional at both frequencies.

2.2 Basic of Auntenna Configuration

For the regular PIFA antennas, each PIFA-patch element will be designed carefully based on approximately equation [6]. This equation is a very rough approximation which does not cover all the parameters with significantly affect the resonant frequency of PIFA.

$$f_r = \frac{c}{4(Lp + W_p)\sqrt{\varepsilon r}} \tag{2.1}$$

Where:

- f_r is the resonance frequency at desired band.
- Lp is the length of the radiating element.
- W_p is the width of the radiating element.
- εr is the dielectric constant of the substrate.
- c is the speed of light.

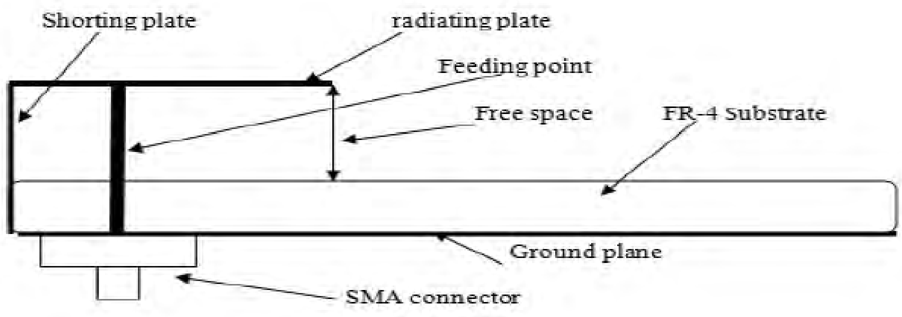

Figure 2.1: The geometry of the PIFA antenna proposed

The configuration of the PIFA is shown in Figure 2.1. The radiating plate has the dimensions of Wp×Lp (Figure 2.2) and ground plane dimensions are Wg×Lg. There is an FR-4 substrate (hs=1.6mm) has a relative dielectric constant of 4.4 and it is between the rectangular ground plane and radiating plate. The antenna height is h=ha+hs and the space between the top plate and the substrate are also filled with air (free space). The PIFA antenna is fed by a coaxial cable through a subminiature version A (SMA) connector. The software package used for simulation is CST Microwave Studio v.11 and High Frequency Structure Simulator (HFSS).

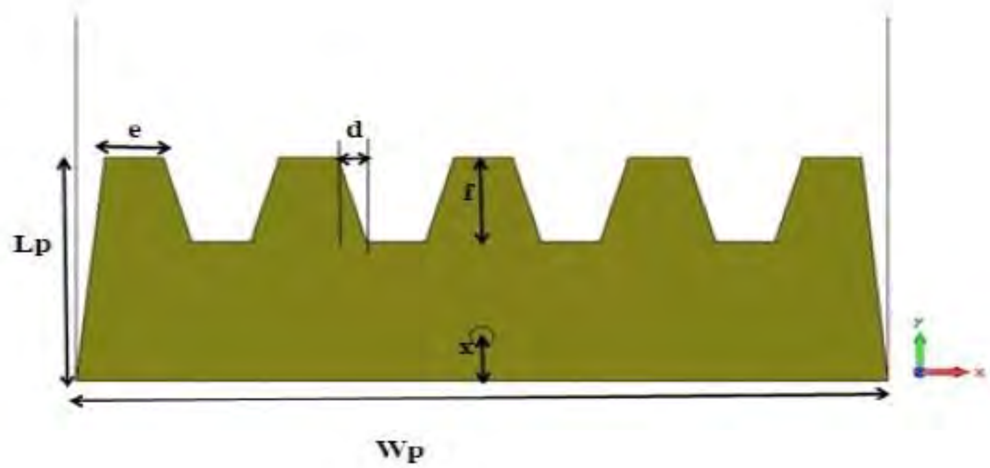

Figure 2.2: The geometry of the top radiating plate

Table 1.1: Detailed dimension of the proposed antenna

Name of the parameter	Symbol	Value (mm)
Upper radiating patch length	Lp	10
Upper radiating patch width	Wp	30.7
Feed plate length	Lg	90
Feed plate width	Wsh	3
Ground plane length	Lg	90
Ground plane width	Wg	30.7
FR-4 substrate height	Hs	1.6
FR-4 substrate length	Ls	90
FR-4 substrate width	Ws	30.7
Feed point location	(x,y)	(2,0)
Feed pin radius	R	0.45
---	d	1.1
---	e	2.2
---	f	3.8

Table 2.1 shows the values of different variables of the PIFA proposed. The position of the feed pin was changed by modifying the values of the horizontal distance x from 1.5 to 3.6 mm, the length of the radiating plate Lp from 8 to 20 mm, the width of the radiating plate Wp from 24 to 50 mm and height between substrate and the radiating plate ha from 3 to 10mm. Therefore, the effects on PIFA characteristics are observed while others parameter are constant.

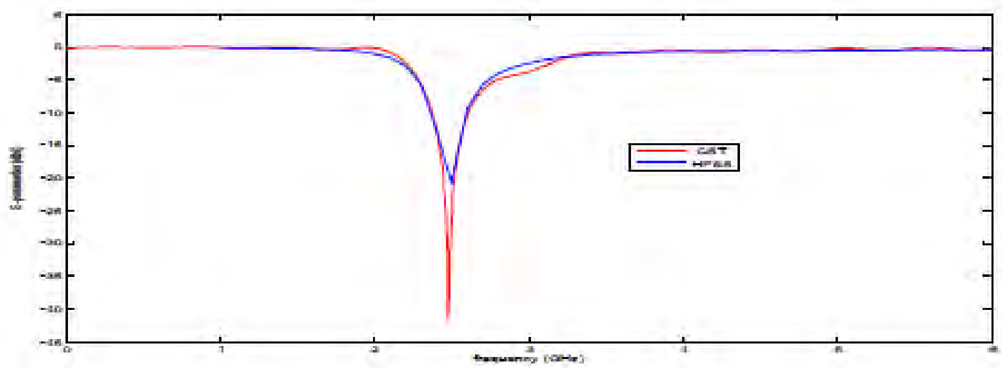

Figure 2.3: The simulated return loss for the proposed antenna

The S-parameter simulated with CST microwave studio and High Frequency Structure Simulator (HFSS) are shown in figure 2.3 so that can see that the minimum bandwidth is about 400 MHz (2.31 GHz to 2.71 GHz). The different modes on the radiator top plate and ground plane of the PIFA are excited to produce the desired diversity gain. It is observed from the parametric study that the dimension of ground plane greatly affects the resonant frequency [7]

2.3 Antenna Geometry

Zi Dong Liu et.al [6] was examined the dual-band antenna in both configuration which is system considerations and handset design. In figure 2.4 shown the two-port antenna that consists of two separate radiating elements, with the rectangular radiating element for 1.8 GHz and the L-shaped radiating element for 0.9 GHz. The dual-band antenna has almost the same size as a single-band planar inverted-F antenna operating at 0.9MHz. The two radiating elements were grounded to the case at its corner and fed near the shorting pins using coaxial cable. The antenna impedance can be easily matched to 50Ω by appropriate choice of feed-pin position. The shorting pins were placed back to back to minimize mutual coupling. The inner conductors of the coaxial feed lines were attached to the radiating elements going through the hole on the telephone case and the outer conductors were connected to the handset case. The conducting metal case, in addition to acting as the antenna ground plane, was also used to simulate the handset.

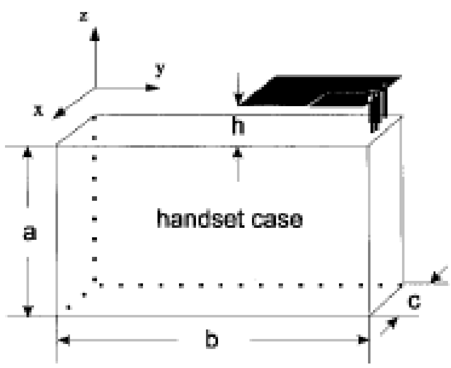

Figure 2.4: Geometrical arrangement of the dual-band antenna mounted on the conducting telephone case

With using same expression, it can be determined the approximately the size of an antenna. The conducting element for 0.9GHz has nearly the same electromagnetic field distribution in spite of its different shape from the conventional antenna.

2.4 Multiband Planar Inverted-F Antenna for Mobile Phone and GPS

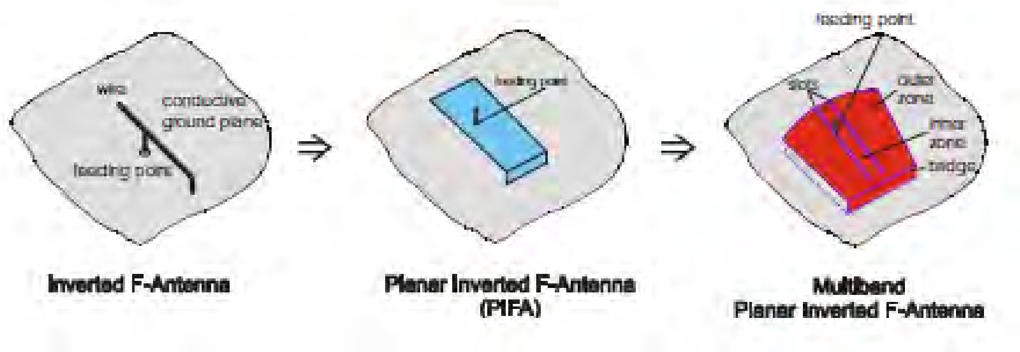

Figure 2.5: Development of multiband planar inverted-F antenna

In [8], R. Kronberger, H. Lindenmeier, L. Reiter and J. Hopf said in multiband planar inverted-F antenna for Mobile Phone and GPS, the basic structure of this low profile multiband car antenna has been the planar inverted-F antenna. Figure 2.5 shows the allows low total antenna height over conducting ground plane combined with comparatively large bandwidth. With adjusted slots in the conductive top plate of the antenna a multi resonant behaviour can be achieved. In the lower frequency range (i.e. GSM 900) the resonant frequency is defined by the total size of the complete antenna structure (area of inner and outer zones together) while in the higher frequency range 1700 - 1900 MHz (i.e. GSM 1800) the slots prevent antenna currents to the outer zones. So that, the second resonant frequency of this antenna is given mostly by the dimensions of the inner zone. Further resonant frequencies can be achieved by additional slots of course.

With the simplified equivalent circuit diagram of the antenna (Figure 2.6) the functional principle may be explained. The inserted slots in the conductive top plate of the antenna operate as a resonant circuit with parallel resonance characteristic and high impedance Z_{10} in the upper frequency range, which separates the influence of