

## Planar Inverted-F Antenna for GPS Application - A study

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### Abstract –

A survey of recent studies and findings on wireless technology and its applications are explored aggressively in few areas that have the greatest potential for achieving entirely new capabilities using antennas. we have presented in depth conceptual understanding of antennas and potential application in wireless communication an exhaustive list of reference has been proceed.

**Keywords** - Slotted, Planar Inverted-F Antenna (PIFA), HFSS, Ground plane.

### I. INTRODUCTION

Planar inverted-F antennas (PIFA) are widely used in many recent portable and small wireless devices owing to their advantages such as low in profile, small in size and ease of fabrication. Many antenna types for portable applications are extensions of PIFA antenna, which is considered as one of the strongest candidates for Global Positioning System (GPS).[1] The GPS applications are becoming very popular in everyday life because of recent advances in electronics technology. The GPS signal is transmitted in the L1 (1.575 GHz) and L2 (1.227 GHz) frequency bands and it is right-hand circular polarized (RHCP).[2]The main element of PIFA are rectangular planar element, ground plane and the short circuit strip. In PIFA, a short circuit plate is placed between the radiator plate and the ground plane in order to reduce the length of the rectangular element. The changes in the size of the ground plane direct affects the impedance bandwidth of the PIFA antenna. The appropriate positioning of feed pin and ground aids too better impedance matching of PIFA.[3]

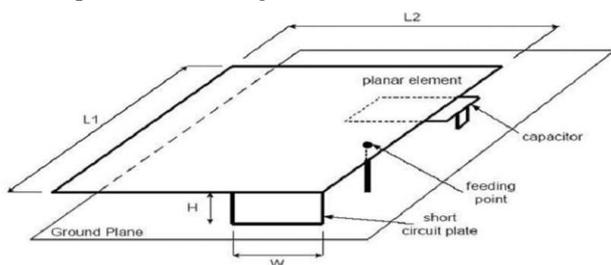


Figure 1 Geometry of Planar Inverted-F Antenna Structure[2]

### II. MICROWAVE REGION

Microwave spectral region is a form of electromagnetic radiation with wavelengths ranging from as long as one meter to as short as one millimeter, or in terms of frequencies between

300 MHz (0.3 GHz) and 300 GHz. This broad definition includes millimeter waves ( both UHF and EHF) and different sources use various boundaries. In most of the cases, microwave includes the entire SHF band at 3 to 30 GHz, with Radio-Frequency engineering often restricting the range between 1 and 100 GHz (300 and 3 mm). Most common applications are within the 1 to 40 GHz range.[15,16]

The various band of microwave region is given in Table 1 below.

Sr. No.	Name of band in microwave	Frequency Range	Application
1	High Frequency(HF)	3 - 30 MHz	Shortwave broadcast, RFID, Marine & mobile Communications
2	Very High Frequency (VHF)	30 - 300 MHz	FM, Television broadcasts and Line of sight communications, Mobile communications, Weather radio
3	Ultra High Frequency (UHF)	300 - 3000 MHz	Television broadcasts, Microwave oven, Microwave-device/communication, Wireless LAN, Bluetooth, ZigBee, GPS
4	Long wave (L)	1 - 2 GHz	Military telemetry, GPS, Mobile phone (GSM),Amateur radio
5	Short wave(S)	2 - 4 GHz	Weather radar, Surface ship radar, Some satellite communication
6	C-Band	4 - 8 GHz	Long distance communication
7	X-Band	8 - 12 GHz	Satellite communication, Terrestrial broadcast radar, Space communication, Amateur radio
8	Ku-Band	12 - 18 GHz	Satellite communication

9	K-Band	18 - 27 GHz	Astronomical observation, Automotive radar, Satellite communication
10	Ka-Band	27 - 40 GHz	Satellite communication
11	V-Band	40 - 75 GHz	Millimeter wave radar communication and other Scientific research
12	W-Band	75-110 GHz	Millimeter wave radar & Satellite communication, Military radar applications
13	Millimeter-Band	110 - 300 GHz	Millimeter scanner, DBS, Direct-energy weapon, Satellite television broadcasting

**Table 1 : Various band of microwave region**

### 2.1 Importance

- Antenna gain is proportional to the electrical size of the antenna. Whenever higher frequencies, than more antenna gain can be obtained for a given physical antenna size, and this has important consequences when implementing microwave systems.[4]
- More bandwidth (related with data rate) can be achieved at higher frequencies.[4]
- Line of sight (LOS) communication is of prime case of microwave frequency signals as they are not bent by the ionosphere as are lower frequency signals. Satellite communication links with very high capacities are therefore possible, with frequency reuse at minimum distant locations.[5]
- Various molecular, atomic and nuclear resonances occur at microwave frequencies, creating a variety of unique applications in the different areas of medical diagnostics, basic science, remote sensing & treatment and heating methods etc.[5]

### 2.2 Microwave Devices

#### 2.2.1 Waveguides :

Any linear hollow metallic structure which confines microwave energy signals by channeling them satisfactorily from one point to another with the aid of multiple reflections between the opposite walls of the structure can be defined as a waveguide.[15,4] Various prevailing waveguides are rectangular waveguides and circular waveguides

##### 2.2.1.1 Rectangular waveguide

Rectangular waveguides are one of the earliest types of transmission lines used to transport microwave signals and used for many applications. rectangular waveguides can propagate TM and TE modes but not TEM waves since only one conductor is present.[15,16] The TM and TE modes of a rectangular waveguide have cutoff frequencies below which propagation is not possible.

##### 2.2.1.2 Circular waveguide

A hollow, round metal pipe supports TE and TM waveguide modes. Dominant mode for circular waveguide is TE<sub>11</sub> mode. In this waveguide TE<sub>10</sub> mode cannot be propagated but TE<sub>01</sub> mode can be propagated.[4]

##### 2.2.1.3 Ridge waveguide

The ridge waveguide consists of a rectangular waveguide loaded with conducting ridges on the top and/or bottom walls. This loading tends to lower the cut-off frequency of the dominant mode, leading to better impedance characteristics and improve bandwidth. Ridge waveguides are often used for impedance matching purposes, where the ridge may be tapered along the length of the guide, but the power handling capacity gets decreased.[15]

##### 2.2.1.4 Coplanar waveguide

The coplanar waveguide can be viewed as a slot line with a third conductor centered in the slot region. Due to the presence of the additional conductor, it can support even or odd quasi-TEM modes, depending on the direction of the electric fields in the two slots.[15]

#### 2.2.2 Couplers :

A directional coupler, which couples part of the transmission power by a known another port with amount out of the port by setting two transmission lines near enough together such that energy passing out through one is coupled with to the other. and the directional coupler is a passive device. There are some different types of waveguide directional couplers.[15]

##### 2.2.2.1 Bethe Hole Coupler

The directional property of all directional couplers is produced through the use of two separate waves components, which add in phase at the desired coupled port and are canceled at the desired isolated port. One of the easier way of doing this is to couple one waveguide to another through a single small hole in the common broad wall between the two waveguides. Such a coupler is known as a Bethe hole coupler.[15,17]

##### 2.2.2.2 Multi-hole coupler

If the coupler is designed using a series of multiple coupling holes and the extra degrees of freedom can be used to increase this bandwidth such a couplers are called multi-hole coupler.[15]

**2.2.2.3 The Quadrature Hybrid Coupler**

The quadrature hybrid coupler is 3 dB directional coupler with a 90° phase difference in the outputs of the through and coupled arms.[16]

**2.2.2.4 Coupled Line Directional Coupler**

When two unshielded transmission lines are in close enough, than power can be coupled from one line to the other line due

to the interaction of the EM fields. Such type of lines are referred to as coupled transmission lines with coupled line directional coupler.[15]

**2.2.3 Antennas :**

An antenna is an electrical device which is converts electrical power into radio communication waves, and vice versa. Antennas are useful elements of all equipment that uses radio. They are used in systems likes as radio broadcasting, broadcasting of television, two-way radio communication, communications receivers, radar, cellular phones, and satellite communications, as well as other devices likes as Bluetooth-enabled devices, garage door openers, wireless microphones, various wireless computer networks.[16] Comparison of some different types of antennas are given as in Table 2 below.

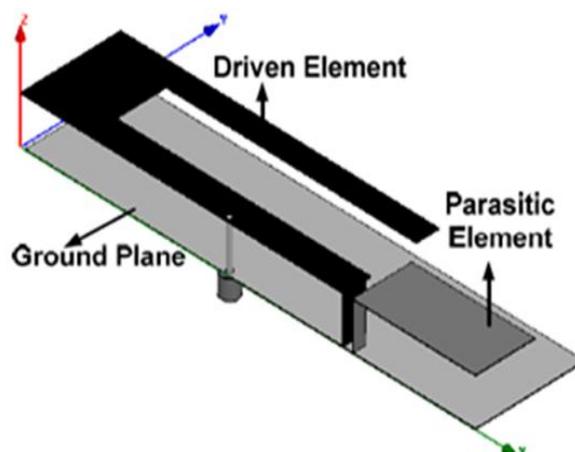
Antenna Type/Parameter	Mono-pole	Slot	Micro-strip Patch	PIFA
Radiation Pattern	Omnidirectional	Roughly omnidirectional	Directional	Omnidirectional
Gain	Higher	Moderate	Higher	Moderate to high
Modeling & Fabrication	Modeling is quite difficult	Fabrication on PCB is easy	Easier to fabricate and model	Easier fabrication on PCB
Applications	Radio broadcast, Vehicular antenna	Radar, Cell phone base station	Satellite Communication	Internal antennas of cellular phones

<b>Merits</b>	Compact size, Large bandwidth support, cost, Low fabrication	Design simplicity, Radiation characteristics remains unchanged due to tuning	Low weight & cost, Easy to integration	Reduced backward radiation for minimizing SAR, Small size, Low cost
<b>Problems</b>	Difficulty in Fabrication at higher frequencies	Reduced in size for mobile handheld devices	No band pass filtering effect	Narrow bandwidth characteristics

**Table 2 : comparison of different types of antennas**

**III. RELATED WORK**

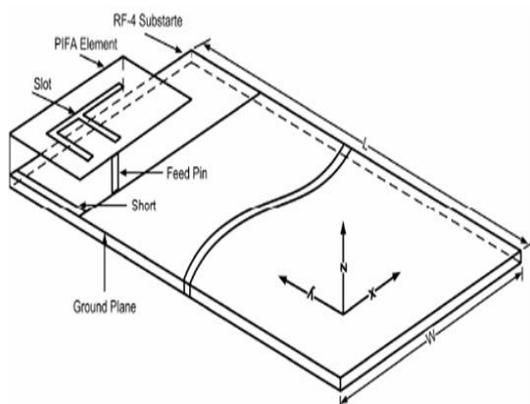
Mayank Agarwal, Manoj Kumar, & Rajesh Singh [8] have developed a dual-band linearly polarized planar inverted-F antenna (PIFA) for GPS/WiMAX applications.



**Figure 2 3-D layout of antenna[8]**

They have designed PIFA antenna which is constructed from a driven F-shaped element and a parasitic L-shaped. Both of the patches are inverted in shapes and bends with face to face over a finite ground plane. [8] In this paper linearly polarized antenna exhibits a relatively high gain and good impedance matching performance in both GPS and WiMAX band.

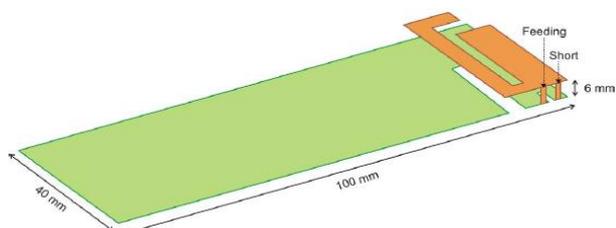
Rashid Ahmad Bhatti, Viet-Anh Nguyen, Seongook Park and Ngoc-Anh Nguyen [9] have designed of a compact internal antenna for multi-band personal communication Handsets.



**Figure 3 Multiband inverted F antenna[9]**

Authors have designed and analyzed a compact multiband antenna with reduced height and small size. The proposed antenna operates at DCS, PCS, UMTS, ISM and WLAN 5 GHz bands. F-shaped slot is on the top radiating patch and its dimensions are optimized for enhance band coverage of 5 GHz band. Use of extra shorting strip enhances bandwidth at lower band while slot on the patch enhances bandwidth at higher frequency band.[9] The height of the PIFA antenna is reduced compared to conventional entire structures thus, less overall volume.

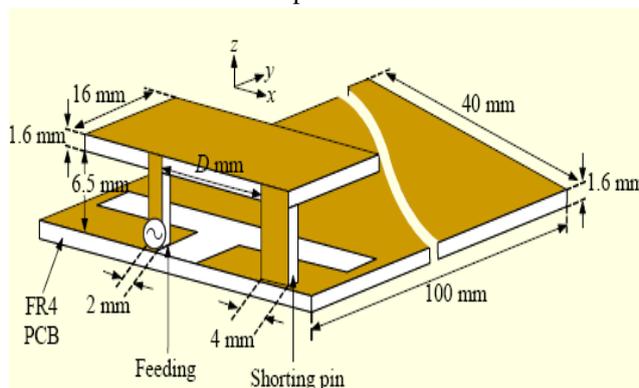
Arnau Cabedo, Jaume Anguera, Cristina Picher, Miquel Ribo[10], "Multiband Handset Antenna Combining a PIFA, Slots and Ground Plane Modes"



**Figure 4 Multiband PIFA handset antenna[10]**

Authors have designed PIFA antenna structure with slots on the ground plane. Antenna covers low frequencies like GSM 850/900 & high frequencies like DCS, PCS, Bluetooth, UMTS. Three slots are used which has two functions mainly i.e. for tune the ground plane resonance at low frequencies & for act as parasitic radiator at high frequencies. Use of slots on ground plane enhances bandwidth both at low & high frequencies without increase in the volume of the antenna.[10]

Sinhyung Jeon, Hyengcheul Choi, and Hyeongdong Kim [11], "Hybrid Planar Inverted-F Antenna with a T-Shaped Slot on the Ground Plane"

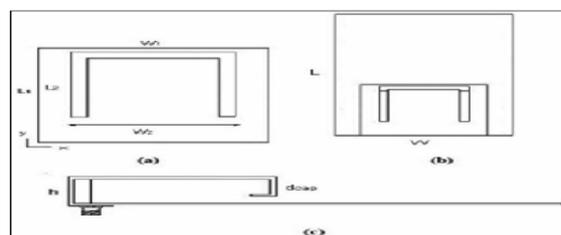


**Figure 5 Hybrid PIFA with T-shaped slot on the ground plane[11]**

A novel

antenna was designed by authors. The structure make use of T-shaped ground plane along with radiating rectangular patch to achieve resonance at desired frequencies. The frequency bands covered by the antenna are DCS, WiBro, Bluetooth and S-DMB bands.[11] The structure of top patch is simple in construction and introduction of T-shaped slot on ground plane resulted in resonance frequency at 2.4 GHz band with improve enhanced bandwidth coverage.

Pasquale Dottorato [12] has developed design of a planar inverted-F compact dual frequency antenna for wireless, mobile and automotive applications"



**Figure 6 Top layer of PIFA[12]**

In this paper the upper radiating patch is designed and insert a slot in the U shape for the purpose of obtaining a dual-frequency operation. The purpose of this paper to design a compact antenna dual frequency for mobile applications. The antenna used as Planar Inverted-F Antenna (PIFA). It has characteristics that simplicity of low cost, small size and realization. The compacted PIFA antenna was a small percentage bandwidth on the two working frequencies (900 MHz and 1800 MHz).[12]

#### IV. CONCLUSION

Antenna has gained prime importance in the field of communication, security, material testing, and sensing application. New types of electronic and photonic structures are needed for efficient communication.

In table1 represents the various bands of EM spectrum along with its application. This paper presents a summary of recent development of various structures of antennas for microwave applications have been listed for reference. The design aspect such as dimension will play crucial role in determining resonant frequency. Despite of obstacles the potential for new valuable application is driving towards research in communication through GPS at 1.575 GHz.

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