Performance Analysis of Planar Inverted F Antenna for Portable Mobile Devices

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Abstract – Microstrip antennas have attracted a lot of attention due to rapid growth in communications area. Several patch designs with single feed, dual frequency operation have been proposed recently. This tries to explain the limitation of microstrip antennas in multiband operations and also explains the need of having planar inverted F antenna. The papers analysis the importance of variations in dimensions of planar inverted F antenna. Smulations are done to understand the operational changes that occurs due to slight variations in antenna dimensions.

Keywords – Mircrostrip, PIFA, Multi band operations

INTRODUCTION

In the last decade, the common mobile phone antenna used in cell phones were the whip and monopole. Conventional monopole and whip antennas are simple and their radiation pattern were omni directional. They were inexpensive and have sufficient gain at the operating frequencies, making them suitable for mobile communication system.

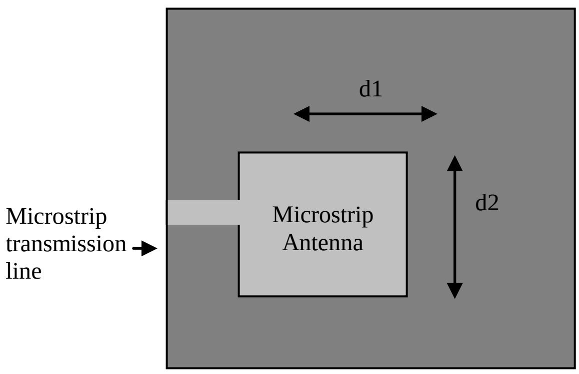
These type of antennas were relatively large compare to phone it self, and they lack shielding mechanism. The progress and dramatic development of a variety of wireless applications have increased the demand of multi-band / wide band antennas with smaller dimensions than the conventionally possible. The key parameter that influence on radiation characteristics is the dimension of antenna with respect to wave length. Competition in the phone industry has dictated the trends for miniature and power efficient terminals.

In the recent years, there is a growing tendency to employ only built in antennas, (1) instead of using only monopole antennas, that sticks out of the equipment case. With the development of built in antennas in mobile phone, there has been a dramatic decrease in weight and size of the phone. These build in antennas are called mircostrip antennas or some times called patch antennas. These microstrip antennas has omni directional radiation pattern, have high gain sufficient band width and have low back radiation. Micro strip antenna structure consist of a thin sheet of low-loss insulting material called the dielectric substrate. It is completely covered with a metal on one side, called the ground plane and partly printed on the other side, where the circuit or antenna patterns are printed. The microstrip antennas suffers from disadvantages such as narrow band width, low gain, large ohmic loss in large feed network, and excitation of surface waves. In wireless communication applications, the demand for low profile compact size planar antenna increasing day by day. The demand for light weight, small size, hard held wireless devices will never stops. Due to the short falls, the conventional PC strip are not a good candidate for the mobile wireless applications.

A modified version of micro strip antenna called planar inverted F antenna is developed and its various. Parameters are studied and analysed are, which will influence the operating characteristics of the newly developed planar inverted F antenna. (2) In general, the antennas used in mobile phone are expected to have certain characteristics.

- Minimum occupied volume with regard to portability and overall size minimization of the mobile terminal and shape.
- Light weight.
- Conformability to mounting hosts.
- Multi-band operation for different communication standards.
- Adequate bandwidth covering the frequency range used by the system, including a safety margin for production tolerances.
- Isotropic radiation characteristics (omni directional)
- Negligible human body effect.
- Low fabrication costs since it is a mass produced consumer item.

Microstrip or patch antennas are becoming increasingly useful because they can be printed directly on to a circuit board. Patch antennas are low cost, have a low profile and are easily fabricated. Typicals microstrip antennas is shown in fig(1). (3) The patch antenna is fed by a microstrip transmission line. The patch antenna, micro strip transmission line and ground plane are made of high conductivity metal generally copper. Antenna has a dimension of d1 and d2, where di is the length of microstrip and d2 is the width of the microstrip. The patch is printed on a dicltetric substrate of thickness h with permitting E_r.



Substrate
Fig (i)
(a) Top View of Patch Antenna

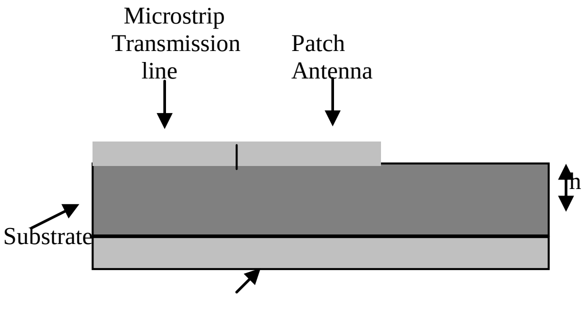


Fig (ii) Side View of Microstrip Antenna

The figure (i) shows the top view of the microstrip patch antenna and figure (ii) represent the side view of the microstrip atenna. The frequency of operation of the microstrip antenna is determined by the length d_1. The centre frequency of the microstrip antenna should be approximately calculated using the formula

$$fc = \frac{C}{2di\sqrt{Er}} = \frac{1}{2di\sqrt{E_1\ Er/_0}}$$

Studies reported earlier, says that the width d2 of the microstrip antenna controls the input independence. The large widths also can increase the band width. For a antenna as shown in figure (i), where d1=d2, the input impedance will be in the order of 300 ohms. Studies shows that by increasing the width, the input impedance can be reduced. To decrease the input impedence to 50 ohms, normally requires a very wide patch antenna, which take up a lot of valuable space. To reduce the input impedance to 50 ohms there are alternative methods of feeding the microstrip antenna. Feeding is a term used describing how antenna is connected to the received or transmitter.

Commonly employed methods to reduce the input impedance are insect feed and probe feed. Fig (iii) will show insect feed fig(4) probe feed.

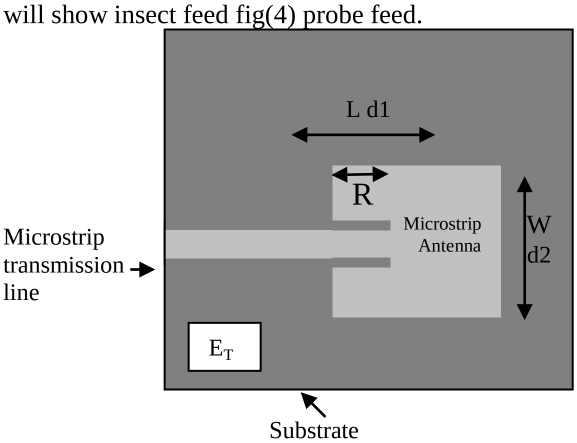


Fig (3). Patch Antenna with an Inset Feed

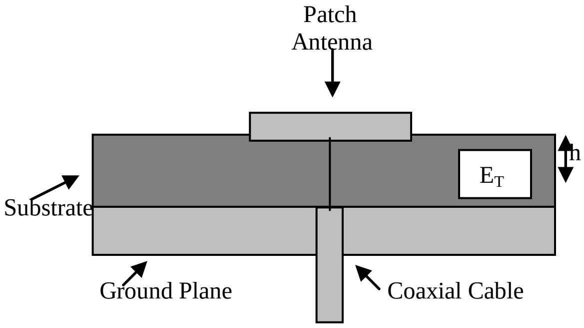


Figure (4)
Coaxial cable feed of patch Antenna

The concept behind insect feed, is the input impedance could be reduced if the patch was fed closer to the center. If we take R = d1/4 thin the input impedance can be reduced by 50%. The microstrip antennas can also be fed from underneath via probe as shown in fig(4). The outer conductor of the probe is connected to the ground plane and the center conductor is extended up to the patch antenna. To modify a M strip antenna to behave as a multi band antenna, (4) and to reduce the size, several techniques have been employed, that includes dielectric loading, top hat loading, use of shorting pins and plates and also by using multilayed fold or bends. In the developed method we are modifying a microstrip antenna is to a planar inverter F antenna by use of shorting pin. Here since the patch is shorted at one end, the current at the end of patch antenna is no longer forced to be zero. There will be a slight reduction in gain but over all physical dimension can be reduced by 40%. The following figure describe the concept of modifying a M strip antenna to act as a PIFA.

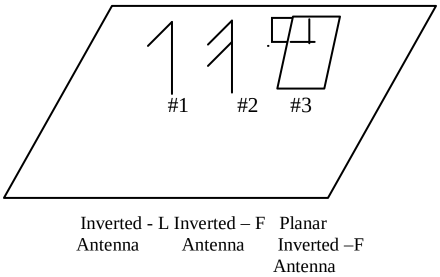


Figure (5) The Planar Inverted-F Antenna (PIFA)

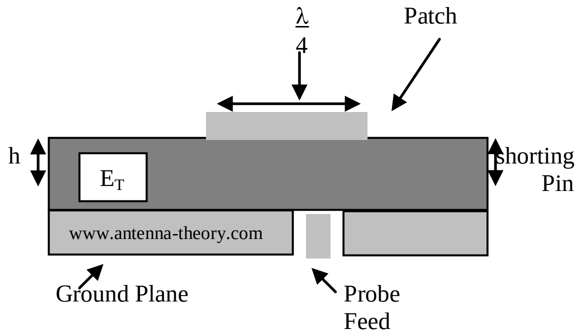


Figure (6) The Planar Inverted-F Antenna (PIFA)

Microstrip antenna have certain limitations

1. Size at lower microwave frequencies : The microstrip antennas do have a compact size and structure, but at the lower microwave frequency regions (900 MHz-

2GHz) the size of a half-wavelength structure is quite large when compared to the size of the mobile unit that it should be installed in.

2. Narrowband operation : This is one of the main limitations of microstrip antennas. The bandwidth of this type of antennas is around 2-3% which is very inadequate to use them as mobile phone antennas. This problem has to be overcome using various techniques.
3. Poor efficiency of high dielectric substrate antennas : The microstrip antennas fabricated on a substrate with a high dielectric constant are strongly preferred for size reduction and easy integration with RF front-end circuitry. However, use of high dielectric constant substrate leads to poor efficiency and narrow bandwidth.
4. Excitation of surface waves : The ground dielectric substrate (without the microstrip line) can guide energy as well. These guided waves are called surface waves. These waves can produce to spurious radiations or couple energy at discontinuities, leading to distortions in the main pattern or unwanted loss of power.

Planar inverted F antenna can be considered as a kind of linear inverted F antenna (5) with the wire radiator element replaced by a plate to expand the bandwidth. As seen in fig(5) the planar inverted F antenna has many advantaged like, easy to fabricate, low manufacturing cost, it can be hide in the housing of the mobile phone when comparable to whip/rod/helix antenna and simple structure. Another important fact that it has reduced backward radiation towards the user's head, minimizing the electromagnetic wave absorption. Planar inverted F antenna is an attractive for wireless systems where the space volume of the antenna is limited. The design variables for the planar inverted F antenna are the height, width and length of the top plate, the width and location of shorting plate and the location of the feed wire. Planar inverted F antenna (6) exhibits moderate to high gain in both vertical and horizontal states of polarization. There are different methods for reducing the antenna size. In this work, we have added shorting pin near the feed probe to reduce (7) the size. By properly tuning the resonant frequency the planar inverted F antenna can be used for the following application.

Table 1

Applications	Frequency
Global positioning satellite	1575 MHz and 1227 MHz
G.S.M.	890-915 MHz and 935-960 MHz
Wireless LAN	2.40-2.48 GHz
Cellular video	28 GHz

Using the simulation software, works has been carried out to understand the influence of various parameter on different characteristics of the planar inverted F antenna. (8) Table (ii) below, summarises the parameters and their effect.

Table 2

Parameters	Symbol	Effect
Width	d2	Control impedance matching
Length	d1	Increase induction of the antenna and determine resonance frequency
Height	λ	Control band width
Width of short pin	W	Increase band width
Feed position from short pin	Ri	Affect on resonance frequency and bandwidth

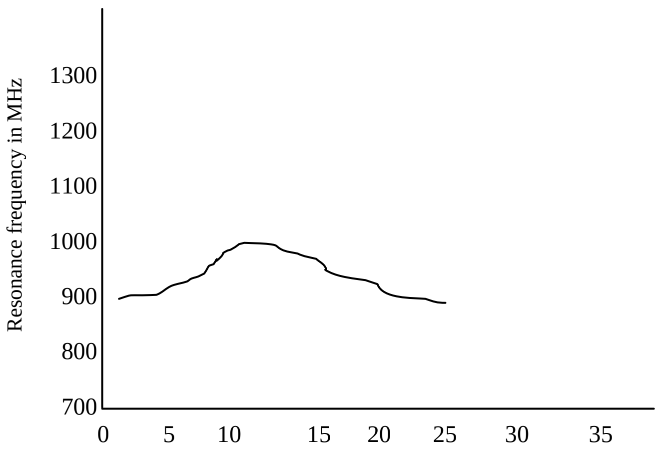


Fig (7)
(mm)
Distance of feed point from the edge

The fig(5) shows the variation in resonant frequency as a function of distance of feed point from the edge of antenna. As indicated in the figure as the distance from edge increases resonance frequency increases too, but upto a point. As the distance approaches middle point, it tries to comis to the initial value. This is became of the high electric field intensity around the middle portion.

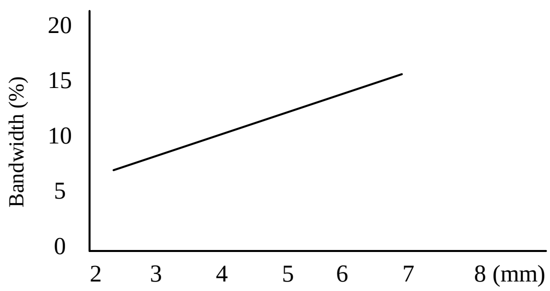


Figure (8)

The above figure shows variation of bandwidth in percentage when the width of the antenna is increased from the normal case when d1=d2.

The width of the antenna cannot increase to much because it will affect input impedance of the stimulated planar invited F antenna. At the same time, if the length of antenna is increased by keeping the width constant, (9) then there will be wide variation of band width.

The resonant frequency of the planar inverted F antenna also depends on the width 'w' of the shorting pin used here. Simulation shows that if the width of the short pin is decreased, then there will be a corresponding reduction is resonant frequency.

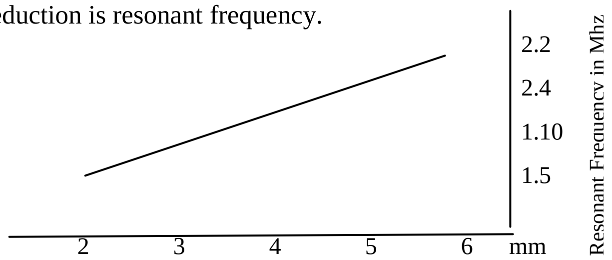


Figure (9) Width of the shorting Pin

Height of PIFA is another key parameter. As the height increases, the bandwidth increase to certain limit, as the height increase over all area of the antenna increase, due to mobile case pack limitation we could not increase h to much.

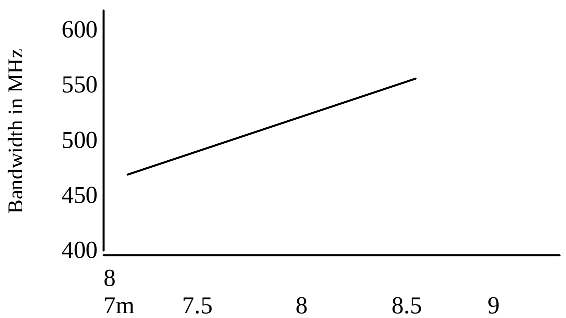


Fig (10) mm →

Discussion

From the simulation, it can be understood, that with an increase in width, the input impedance decreases so that feed point is shifted towards the edge to obtain input impedance in the range, 50 ohms to 60 ohms for a loss less communication mechanism. It is also noted that as the height (h) of planar inverted F antenna increases, the fringing fields from the edge increases, then the effective length di will increase at the cost of resoot frequency. Band width of the antenna also depends on the height it is also noted that the directivity of the antenna increases marginally with increasing height, because the effective aperture area is increased marginally due to an increase in effective length. The size of the proposed planar inverted F antenna can be further reduced by introducing the concept of capacitive loading and also by using a sobstrate of higher dielectric.

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Jacob Abraham, was born in Muvattupuzha. He received B.Tech from Mahatma Gandhi University and M.Tech in optoelectronics and optical communication from Kerala University. He has 15 years of teaching experience in PG and U.G. Now is working as associate professor in B.P.C. College, Piravom, Kerala. He published 2 papers in interntational journals and he presented 7 papers in national/international conferences. Now he is working towards Ph D (Electronics) from Mahatma Gandhi University. He is a member of Board of Studies (Electronics), Mahatma Gandhi University.