Design of Planar Inverted F Dual Frequency Microstrip Patch Antenna

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Abstract— With the constant change in technology, frequency band reconfigurable antennas are important innovations. The new devices limit the physical space so the need of multiple antennas is eliminated. This is especially vital in mobile devices such as cell phones that receive multiple frequency bands. For this application we used MICROSTRIP PATCH antenna. Dual-band phones can cover GSM networks in pairs such as 900 and 1800 MHz frequencies or 850 and 1900 MHz. For this application in mobile phones PLANAR INVERTED F ANTENNA (PIFA) is widely used. These antennas have principal advantages, their compactness and their low manufacturing costs, in addition to their significant performances. The side-goal of the project is to incorporate the use of SMD components which are used for switching between two frequencies. The benefits of using these antennas are very small package size, high isolation loss, low insertion loss, low power consumption, better efficiency and reflection coefficient. The goal of this project is to check the effect of SMD component and PIF technique on antenna parameter.

Key words: Microstrip patch antenna, PIF antenna, dual frequency patch antenna, antenna designing for GSM, Planar Inverted F antenna (PIFA)

I. INTRODUCTION

In today's world of wireless communication, recent developments in wireless communication industry continue to deliver requirement of small, compatible and affordable microstrip patch antennas. A patch antenna is a narrowband, wide beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric[1].

Development of reconfigurable antennas has received a great deal of attention in recent years as functional diversity is integrated in small antennas to accommodate the demanding requirements of modern wireless communication systems. There are types of reconfigurable antennas: frequency reconfigurable, polarization diversity, radiation pattern diversity and combined antennas.[10][11] Reconfigurable antennas and conventional antennas have similar radiation performance, but reconfigurable antennas are more compact and experience less co-site interference. Substrate such as a printed circuit board with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. Microstrip antenna suffers from disadvantages like they have less bandwidth and gain. For obtaining multiband and wideband characteristics, different techniques have been used like cutting slot in patch.

Switching components, such as PIN diodes, varactor diodes, and micro-electromechanical system (MEMS) switches, are frequently adopted in the design of reconfigurable antennas to electronically change the operating frequency band, the radiation pattern, and/or the polarization. Among these switching devices, PIN diodes are very reliable and compact because they have high switching speeds and low resistance and capacitance in the on and off states, respectively.

II. ANTENNA CONFIGURATIONS AND DESIGN PROCEDURE

A. *Microstrip Patch.[8]*

The Microstrip Patch Antenna is a single-layer design which consists generally of four parts (patch, ground plane, substrate, and the feeding part). The metallic patch is normally made of thin copper foil plated with a corrosion resistive metal, such as gold, tin, or nickel .The procedure for designing a rectangular microstrip patch antenna is explained.

1) Having a relative dielectric constant Ɛr in the range of 1.0–2.0. This type of material can be air, polystyrene foam, or dielectric honeycomb.
2) Having *εr* in the range of 2.0–4.0 with material consisting mostly of fiber glass reinforced Teflon.
3) With an Ɛr between 4 and 10. The material can consist of ceramic, quartz, or alumina.

In this procedure there are three essential parameters for the design: the frequency of operation *fr*, the dielectric constant of the substrate Ɛr and the height of the dielectric substrate *h*. Generally, substrate materials can be separated into three categories according to the dielectric.

1) *Step 1: Determination of the Width (W)*

$$W=\frac{\lambda 0}{fo\sqrt{(\varepsilon r+1)/2}}$$

2) *Step 2: Calculation of effective dielectric constant, εreff, which is given by equation*

$$\varepsilon reff=\frac{\varepsilon r+1}{2}+\frac{\varepsilon r-1}{2}[1+12\frac{h}{W}]\text{^}\frac{1}{2}$$

3) *Step 3: Calculation of the length extension ΔL,*

$$\Delta L=0.412\frac{(ereff+0.3)(\frac{W}{h}+0.246)}{(ereff-0.258)(\frac{W}{h}+0.8)}$$

4) *Step 4: Now to calculate the length of patch*

$$L=\frac{\lambda 0}{fo\sqrt{ereff}}-\Delta L$$

5) *Step 5: Calculation of Ground Dimensions*

$$Lg = 6h + L$$

$$Wg = 6h + W$$

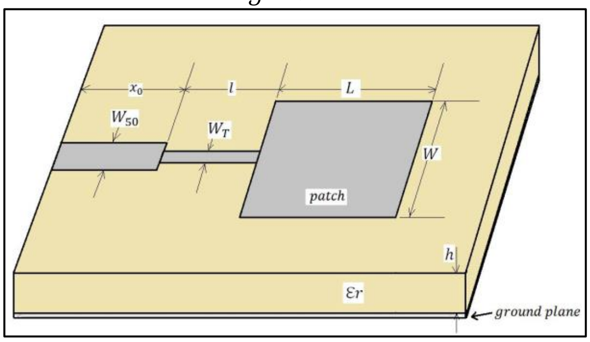

Fig. 1: Rectangular patch antenna design [8]

Similarly we also calculate the length of the patch by using these formula .This method of feeding is very widely used because it is very simple to design and analyse and very easy to manufacture.

The impedance of the patch is given by

$$Za=90\ \frac{\epsilon r\hat{}2}{\epsilon r-1}\left(\frac{L}{W}\right)\hat{}2$$

The characteristic impedance of the transition section should be

$$Zt=\sqrt{Za+50}$$

The width of the transition line is calculated from

$$Zt=\frac{60}{\varepsilon r}\ln\left(\frac{8d}{Wt}+\frac{wt}{4d}\right)$$

The width of the 50Ω microstrip feed can be found using the equation

$$Z0=\frac{120\Pi}{\left(1.393+\frac{w}{h}+\frac{2}{3}\ln\left(\frac{w}{h}+1.444\right)\right)\sqrt{\epsilon reff}}$$

Where Z0=50Ω

The length of the transition line is quarter the wavelength

$$l=\frac{\boldsymbol{\lambda}}{\mathbf{4}}$$

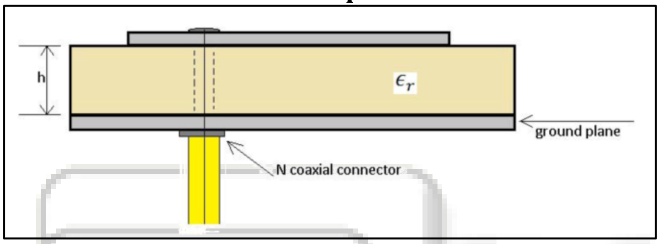

Fig. 2: Rectangular patch antenna design with coaxial cable [8]

B. *PIF antenna*

Planar Inverted-F Antenna (PIFA) and Microstrip Antenna (MSA) have been popular for handling wireless devices because these antennas have low profile geometry instead of protruding as most antennas do on handheld radios. PIFA is a quarter wavelength shorted patch, which consists of a finite ground plane, a top radiator, a coaxial probe and a shorting mechanism that short the top radiator to the ground plane. These antennas can be further optimized by adding new parameters in the design, such as strategically shaping the conductive plate, or judiciously locating loads. The major limitation of many low profile antenna narrow bandwidth. Bandwidth in these antennas is almost always limited by impedance matching. In this design using slots on the patch, miniaturization of the PIFA is achieved from .Among other types of radiators, inverted-F Antennas (IFAs) (wire element, planar or printed ones) have been utilized in diverse areas of communication systems ,exhibiting low profile structure and flexibility in impedance matching . Furthermore, previous works showed that planar IFAs constitute good candidates for dual-frequency, triple and Quad band of operation. With the advance of wireless communication systems and increasing importance of other wireless applications in recent years, small size Multiband antennas are in great demand for both commercial and military applications. Meander line and zig-zag antennas have been studied for their capability in antenna size-reduction. However, the fractal concept can also be used to reduce antenna size. Cohen was the first to develop an antenna element using the concept of fractals, reducing antenna size without degrading the performance. It can be hiding in to the housing of the mobile when comparable to whip, rod and helix antenna. It is having reduced backward radiation towards the user's head, minimizing the electromagnetic wave power absorption (SAR) and enhances antenna performances. Instead of wire radiator in IFA, PIFA has a patch type of radiator above certain height from the ground plane, and the shorting pin which shorts the ground plane and the radiating patch and it consists of co-axial probe feed. Different from Euclidean geometries, fractal geometries have two common properties, space filling and self-similarity. It has been shown that the self-similarity property of fractal shapes can be successfully applied to the design of Multiband fractal antennas, such as the Sierpinski Gasket Antenna, while the space-filling property of fractals can be utilized to reduce antenna size.

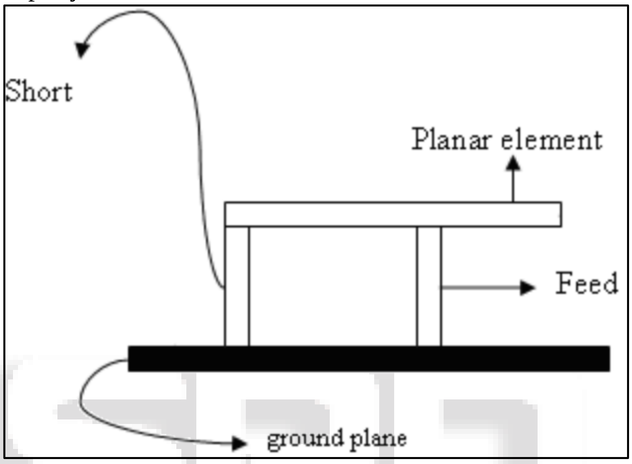

Fig. 3: Planar inverted F structure

III. SIMULATION & EXPERIMENTAL RESULTS

In order to validate the simulated results, the proposed antenna has been designed. The design was fabricated on FR-4 substrate with thickness (h) = 1.57 mm. antenna, far field and simulated reflection coefficients are shown in below figures

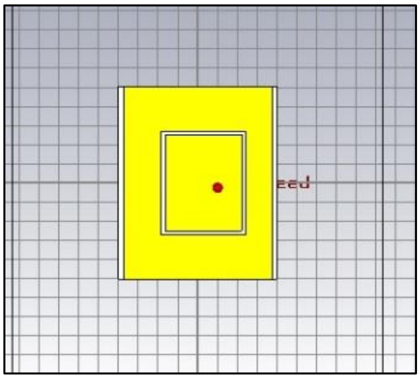

Fig. 4: microstrip patch antenna for 1800MHz

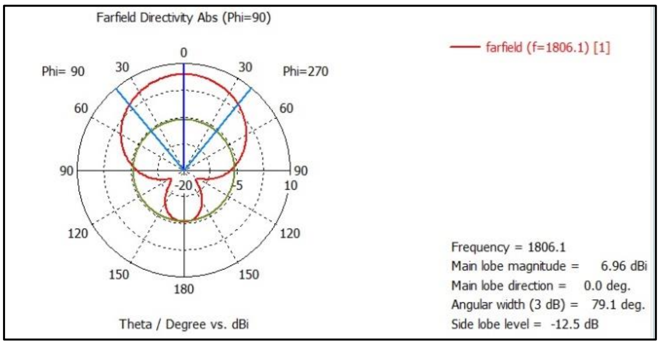

Fig. 5: Radiation Patern for 1800MHz

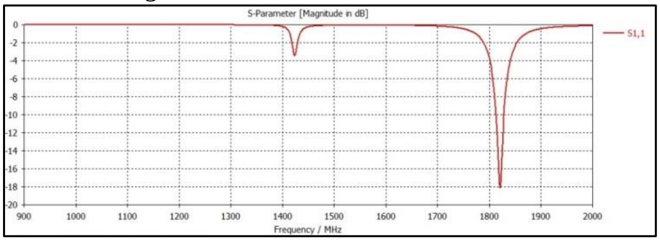

Fig. 6: S11 parameter for 1800MHz

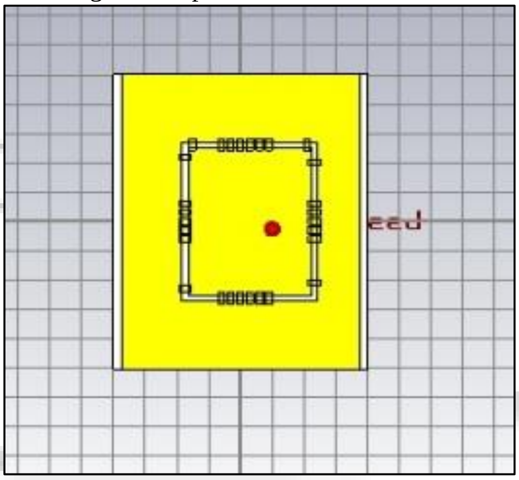

Fig. 7: microstrip patch antenna for 900MHz

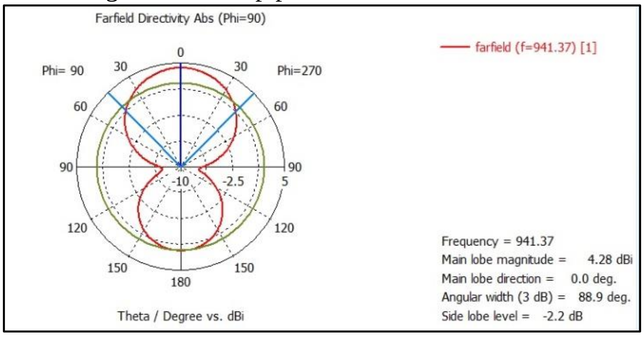

Fig. 8: Radiation Pattern for 900MHz

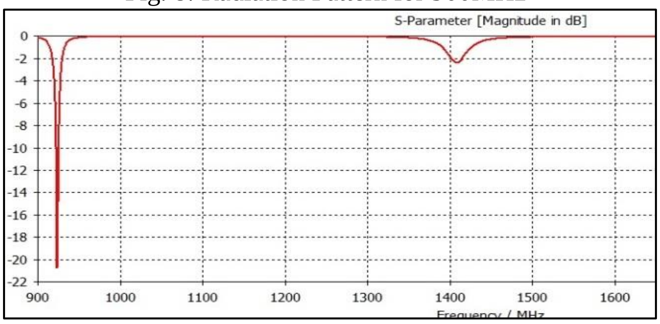

Fig. 9: S11 parameter for 900MHz

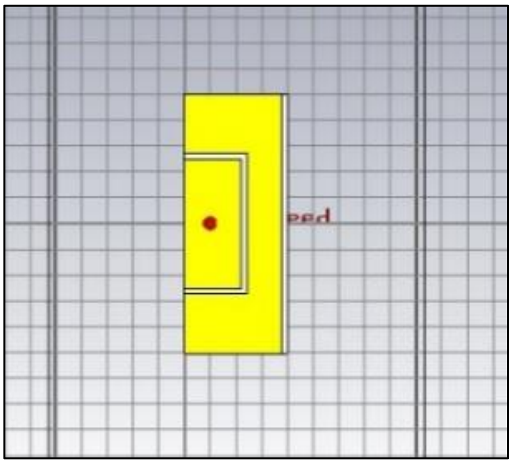

Fig. 10: PIF antenna for 1800MHz

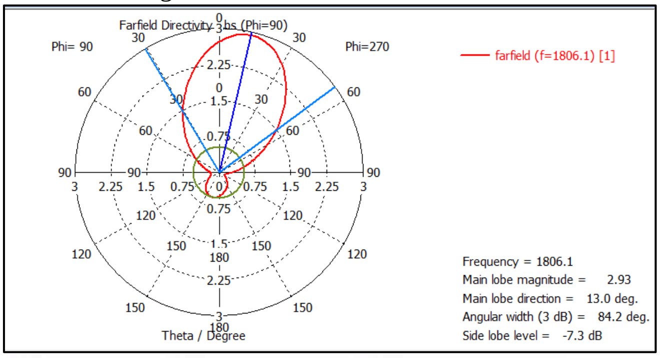

Fig. 11: Radiation Pattern for 1800MHz PIF antenna

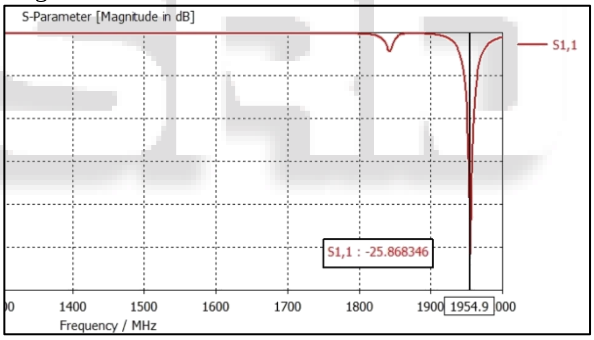

Fig. 12: S11 parameter for 1800MHz PIFA

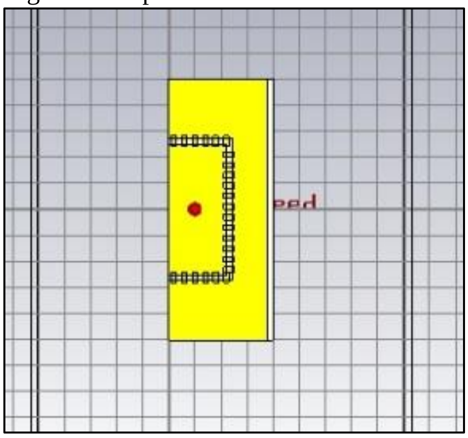

Fig. 13: PIF antenna for 900MHz

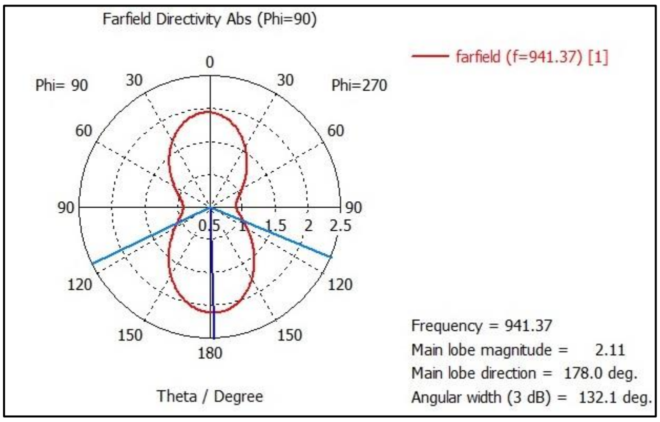

Fig. 14: Radiation Pattern for 900MHz PIF antenna

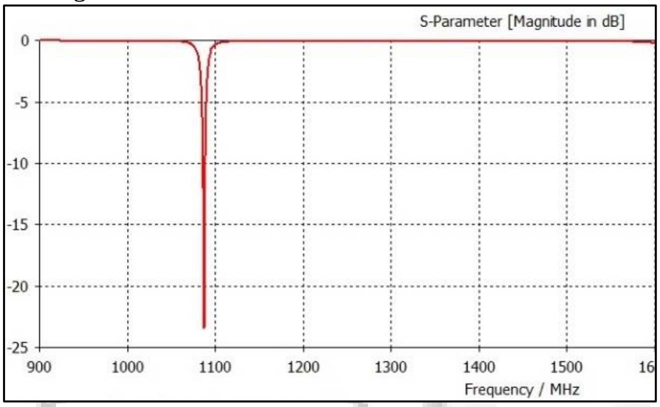

Fig. 15: S11 parameter for 900MHz PIFA

IV. PROTOTYPE OF PROPOSED ANTENNA

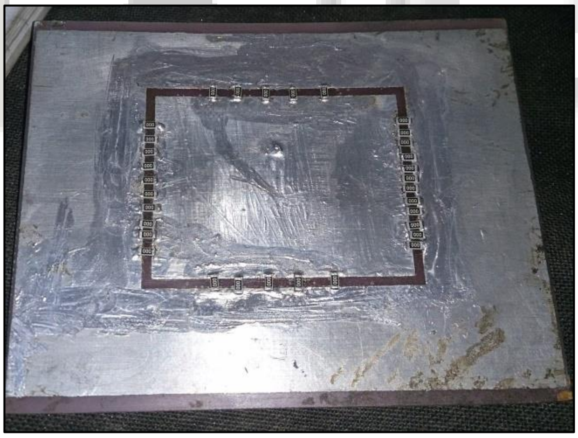

Fig. 16: Prototype of dual frequency Patch antenna

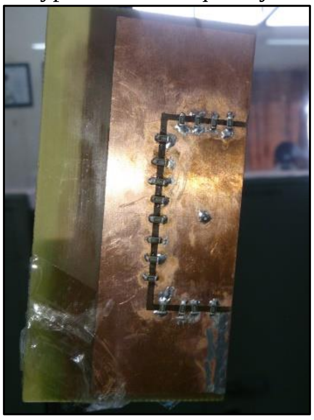

Fig. 17: Prototype of dual frequency PIF antenna

V. RESULT ANALYSIS

Antenna type	Frequency (MHz)	Hardware result		Software result	
		S11	VSWR	S11	VSWR
Patch antenna	1800	-	-	-42	1.01
Patch antenna	900	-	-	-35	1.04
Combined Patch antenna(1800+900)	1800	-10.50	1.58	-18.14	1.28
Combined Patch antenna(1800+900)	900	-11.01	1.38	-21	1.20
Combined PIF antenna(1800+900)	1800	-14.06	1.34	-26	1.10
Combined PIF antenna(1800+900)	900	-15.87	1.36	-24	1.14

VI. CONCLUSION

– We design the microstrip patch antenna for the GSM frequencies successfully.
– For the dual frequency application, we combine two antennas of different frequencies using SMD.
– The size of the antenna is reduced by using the PIFA technique.
– This antenna used in mobile applications and because of the good S11 parameter for both frequency the mobile device work efficiently for both frequencies.

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