ISSN: 0974-2115
www.jchps.com Journal of Chemical and Pharmaceutical Sciences

Mobile antenna design and testing for wireless frequency applications

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ABSTRACT

A new mobile antenna in Microstrip patch is proposed here. Coaxial feed is the type used to excite the antenna. The antenna is designed simulated fabricated and tested compared with their antenna parameters like return loss, VSWR, impedance. Both theoretical and experimental results give reasonable coincidence. This antenna will be useful in many wireless communication systems, including the GSM (880~960 MHz), DCS (1710~1780 MHz), UMTS (1920~2170 MHz). As navigation has become indispensable for smart mobile phone, global navigation satellite system (GNSS) (1430~1480 MHz) are also becomes one of the most important applications.

KEY WORDS: Antenna; Mobile; Microstrip; Patch Antenna; Wireless;

1. INTRODUCTION

Antennas are unavoidable in every communication device nowadays. Its usage depends upon the frequency, size, and its radiation properties. Among the various types of antennas, microstrip patch antennas are popular in mobile phone applications. Separate antenna for cellular network and GPS application are available. Mobile phone antenna design is more challenging with increasing bandwidth. To design of a multiband monopole mobile phone antenna with circular polarization for cellular network and GPS application is taken as research work. It can be applied to Mobile Phone, Tablet and Laptop etc.

Microstrip patch antenna: Among all the types of antennas, Microstrip patch antenna fulfills the requirement of wireless communications systems. These antennas find usage on base stations and handheld sets. They have a wide variety of configurations. Microstrip patch is simple antenna on a grounded dielectric substrate material with thickness $0.003\lambda_0 < h < 0.05\lambda_0$. Low profile is the main advantage of this Microstrip antenna. Narrow bandwidth is the drawback due to small size. Rectangular is one of the shape in this. Planar Inverted F Antenna (PIFA) in rectangular shape is introduced in our mobile antenna research.

2. MATERIALS AND METHODS

Mobile antenna design: The operating frequency range of this mobile antenna is selected between 0.75 GHz and 3 GHz. The dielectric substrate material has been taken as FR4. Its dielectric constant value is 4.4.

Selecting Frequencies: First, frequencies are selected to design antenna. It is confirmed that we have to design for GSM, DCS, GNSS, UMTS bands. Next, using the formula it is calculated.

Material Selection: The FR4 dielectric material is selected to have the permittivity 4.4, as it is available normally with the thickness t or h by using the formula (w/h)>1. The ground layer dimensions are given in figure 2.

PIFA Antenna design is given as proposed mobile antenna with dimension. it is shown in figure 1. The bottom view of the proposed antenna given in figure 2 and it shows the ground layer and feed point. The input impedance is given by the expression below as

$$Z_{in} = R + \frac{1}{j\omega c}$$

The width of the antenna, w is calculated by the formula given below once resonant frequency and dielectric constant are known.

$W = (v_o/2\, f_r)\sqrt{(2/(\varepsilon_r+1)}$

Where v_o is the velocity of light ($3x10^8$). The designed antenna is simulated with simulator. Figure 3 shows the S-parameter display. It gives frequency versus return loss in dB. Four resonant bands are obtained. It is shown in figure 3. Return loss is arrived less than -10 dB. Figure 4 shows the graph of frequency versus Voltage standing wave ratio (VSWR). In this, it is got less than 3.

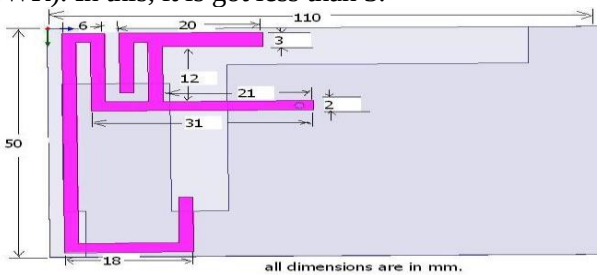

Figure.1. Proposed Mobile Antenna Design Top view.

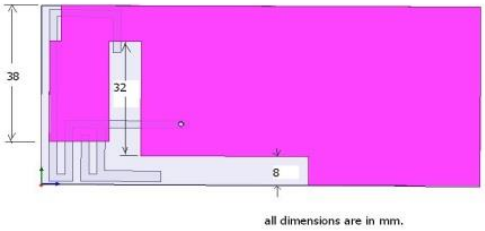

Figure.2. Proposed Antenna Ground View

3. RESULTS AND DISCUSSIONS

Before the measurement, the antenna is simulated for the parameters Return loss, VSWR, input impedance, efficiency. The antenna is fabricated and tested and the results are discussed here.

Simulated Results: Return loss in dB, VSWR, impedance were the results taken during simulation.

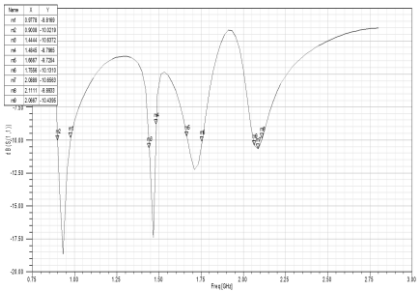

Figure.3. Graph of S- Parameter display For a Mobile antenna return loss is to be less than -6 dB

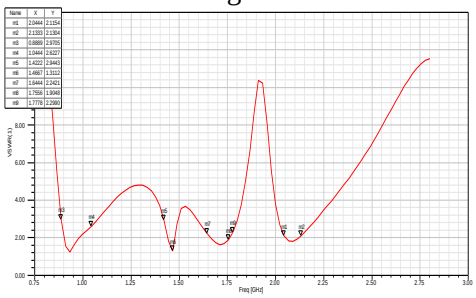

Figure.4. VSWR Display

As per the antenna details given in table I, antenna is designed and simulated in HFSS software package. The results are shown in fig.3-12.

Impedance graph is given in figure 5. It gives resistance and reactance values close to 50 ohms and zero.

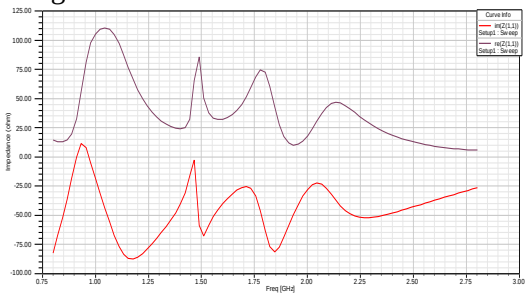

Figure.5. Impedance Display

Table.1. Proposed antenna details

Description	Values
Return loss for resonant frequencies	<6dB
VSWR	<3
thickness of substrate	1.6mm
Dimension	50mm x110mm
dielectric constant	4.4
impedance	close to 50 ohms
Feed used	Coaxial feed

Figure 6 shows the radiation pattern at 0.9 GHz. At 1.44 GHz the radiation pattern is shown in figure 7. Radiation pattern of 1.71 GHz is given in figure 8. Radiation pattern at 2.11 GHz is reported in figure 9.

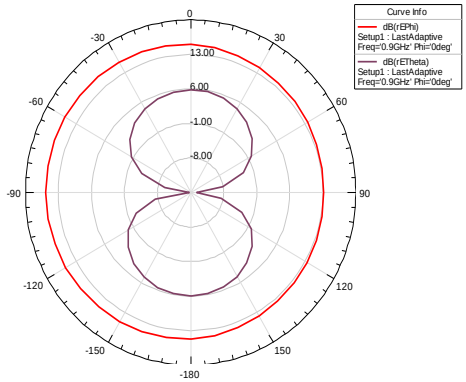

Figure.6. Radiation Pattern for 0.9 GHz

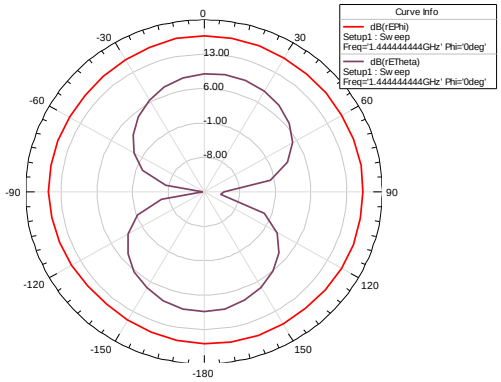

Figure.7. Radiation pattern at 1.44 GHz Black Colour line shows elevation angle and Red colour line shows azimuth angle

Antenna efficiency is recorded in figure 10. This graph shows more than 65 percent and 90 percent. This graph shows theta versus radiation efficiency.

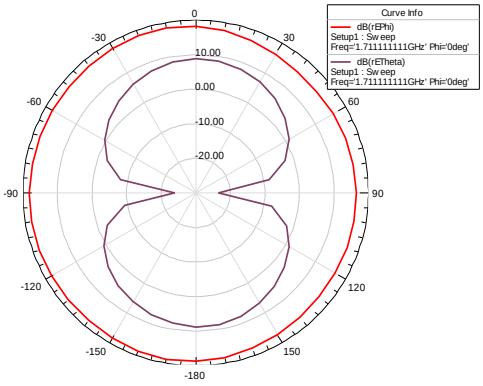

Figure.8. Radiation pattern at 1.71 GHz Black Colour line shows elevation angle and Red colour line shows azimuth angle

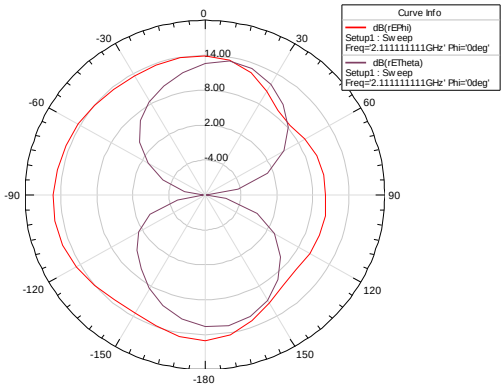

Figure.9. Radiation pattern at 2.11 GHz Black Colour line shows elevation angle and Red colour line shows azimuth

The three dimensional radiation pattern is shown in figure 11. Current distribution in the antenna is shown in figure 12. The red colour shows the maximum gain. This antenna is made on FR4 material on one side of the surface and other side as ground surface. The front view is shown in figure 13.

he antenna thickness size is 1.6 mm. The connector is attached at the ground surface at the feed point is shown in figure 14.

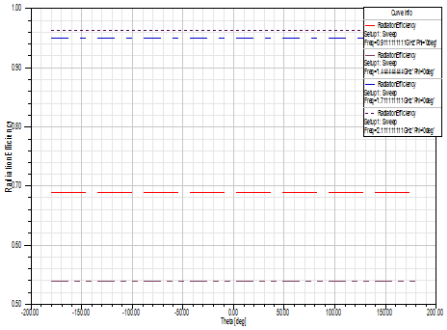

Figure.10. Radiation efficiency

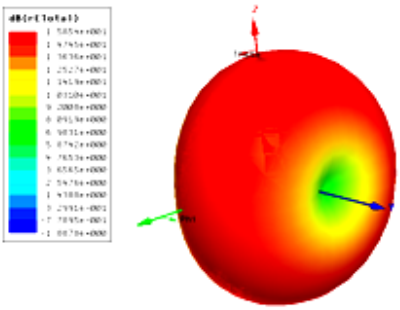

Figure.11. Three dimensional radiation pattern view

Figure.12. Current distribution in the proposed antenna.

Fabrication of Proposed Antenna: The photograph shows the fabrication of proposed antenna both front and bottom view. Female connector is attached to the antenna at the ground layer side.

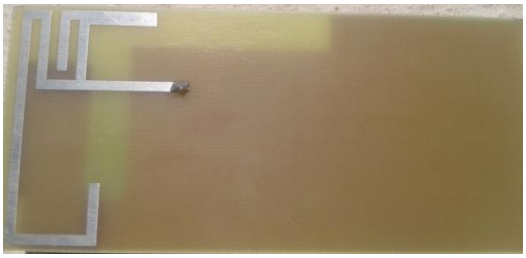

Figure.13. Proposed Mobile Antenna front view

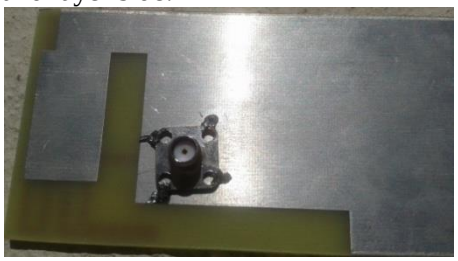

Figure.14. Proposed Mobile Antenna bottom view.

The fabricated antenna is then measured under the vector network analyzer.

SMA Connector female type is used here for connecting the transmission line to antenna.

Measured Results: Figure 15 shows the measured return loss graph. it gives from 500 MHz to 2500 MHz range. The measured results of S-parameter, VSWR and Smith chart are provided here after the prototype antenna is fabricated. S-parameter display, VSWR display, Smith Chart display are the measured results shown in figure 15-17. The impedance measurement is shown in the Smith chart graph. VSWR is achieved less than 3 for the resonant frequencies and it is shown in figure 16.

Figure.15. Measured S-Parameter display. For a Mobile antenna return loss is to be less than -6 dB

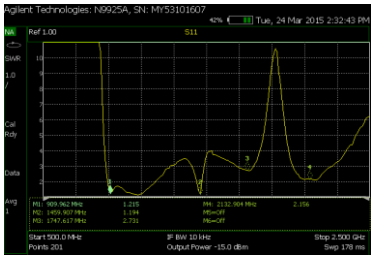

Figure.16. VSWR display For a Mobile antenna return VSWR should be in between (1:3)

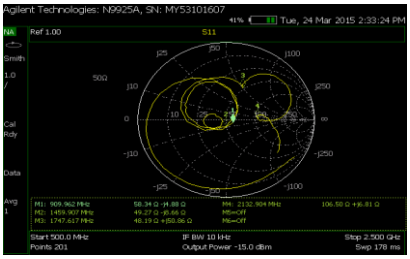

Figure.17. Smith chart display

Figure 17 shows the Smith chart display of measured results from the fabricated antenna.

Discussions: Our project is mobile antenna design for four bands with reasonable radiation characteristics and it is compared in table II.

Table.2.Resonant frequencies comparison

Band	Range of frequencies	Simulation Result	Measured Result
GSM	(880-960) MHz	925 MHz	909.96 MHz
GNSS	(1430-1480)MHz	1460 MHz	1459.90 MHz
DCS	(1710-1780) MHz	1725 MHz	1747.61 MHz
UMTS	1920-2170 MHz	2085 MHz	2132.90 MHz

This antenna is suitable for wireless communication applications.

4. CONCLUSION

A new internal multi band micro strip patch antenna for mobile applications is proposed. Antenna is designed, simulated with HFSS software, fabricated on FR4 substrate with overall dimension of 50x110mm^2 and measured with vector analyzer. This antenna can be used in GSM, DCS, GNSS, UMTS bands. The simulation results of radiation parameters such as S-parameter, VSWR, and impedance are compared with measured results. Good agreement is obtained between them. Gain improvement is the future work in this research.

5. ACKNOWLEDGMENT

The authors are thankful to Dean, Head of the Electronics and Communication Engineering, AVIT, Chennai and B.S.Abdur Rahman University, Chennai, India.

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