Enhancing the Antenna Parameters using High Frequency Simulation Structures in Mobile Phones

Manish Kumar, Abhai Chaturvedi

Department of Electronics and Communication, GLA, University, Mathura (281406), India

E-Mail: manish.kumar@gla.ac.in

Abstract

Now-a-days, the uses of antenna based devices are rapidly increasing. Among those antenna based devices mobile phones and Wi-Fi routers are the important modules which play the crucial role in every individual's life. As the technologies & usage of it are rapidly increasing and to meet the satisfaction of the end users all the providers are looking to elaborate their signal strength and other parameters. So, as to increase the strength of the signal the antennas should be capable of meeting it. In this paper, we would like to present the Microstrip patch antenna design of parasitic slot structure with an operating frequency of 7.5 GHZ and comparison of some their parameters with the other antenna structures. For this design, we use high frequency simulation structure (HFSS) software; the antenna is based on the FR4_epoxy substrate with tangent lass of 0.0018 and dielectric constant of 4.4(approx.). After simulation, the performance characteristics such as return loss (S_{11}), gain, directivity, radiation pattern, VSWR are recorded and compared also.

Keywords: Microstrip patch antenna, HFSS, FR4_epoxy substrate.

1. Introduction

In the field of communications antennas will play a very crucial role in the transfer of signals or data from transmitter to the receiver. There are different types of antennas such as parabolic reflector, patch antenna, slot antenna, and folded dipole antennas. Among these each type of antennas have their unique properties and usage. In communication antenna design, microstrip patch antennas are well suited for the ease. Micro strip patch antennas have more advantages than the conventional antennas. In this design, we use rectangular shaped micro strip patch antenna (MSPA) which has the advantages such as inexpensive, less weight and other prominent advantage is that it is easily made conformal to the surface of the design. The study on MSPA has made great progress in the recent years. As with new developments, there has been increase in the demand for high data rates, high bandwidth utilization. Other parameter which has great importance is that the size of the MSPA. The increase in bandwidth should not affect the size of the antenna that is designed. There two important standards such as Wi-Fi (WLAN) and Wi-MAX. For these wireless communication purposes we required to have efficient antennas with reduced in size. Because, the reduced size of the antenna should not affect the performance and efficiency of that antenna.

Primarily, the microstrip patch antenna consists of three important layers namely, the radiating patch, substrate and the ground plane which is present on the opposite side of the radiating patch. Here the radiating patch is generally made of conducting materials such as copper or gold and this can be of different possible shapes. Radiating patch and the feed line are on the one side of the substrate for the better performance of the designed antenna. The thickness of the dielectric substrate which has the low dielectric constant is to be considered since it provides better efficiency, more bandwidth and effective radiation pattern.

In this paper, we wish to demonstrate the parasitic slot patch antenna for dual band operation and details of the antenna design are described and prototype of the proposed antenna bandwidth enhancement haven been designed and tested.

2. Design Procedure

As said earlier, this microstrip patch antenna has three important layers. Middle layer is named as substrate, which is made of FR4_epoxy material with a dielectric constant value of 4.4 and height of the substrate is 1.6 mm. The lower layer constitutes the ground plane, which covers the entire bottom part of the rectangular substrate with values (sides) of 16 mm X 18 mm. Finally, the other layer is called as the patch which is placed on the top surface of the rectangular substrate. The rectangular patch has the values of its sides as 9 mm X 12 mm. This patch is now get separated into two patches with other rectangle patch whose values are 9 mm X 0.5 mm and these separated patches are named as main patch and parasitic patch. Because, the patch is excited directly by using a feed line with 50 ohm input impedance and the parasitic patch is excited indirectly by getting the radiation from the main patch. Now, other two slot structures are made, one on the main patch and other on the parasitic patch by considering different shaped structures. Here, we considered to have 6 arm polygon shapes on the main patch and a rectangular structure on the parasitic patch. For the design of rectangular microstrip patch antenna the following parameters are to be considered such as dielectric constant (ε_r), operating or resonating frequency (f_r) and height (h).

II.I. Parameters involved in the patch antenna design formulas are

The width of the microstrip patch antenna is given by

$$W = \frac{c}{2fr}\sqrt{\frac{2}{(\epsilon_r + 1)}}$$

The effective dielectric constant (ε_{reff}) is given by

$$\varepsilon_{reff} = \frac{\epsilon r + 1}{2} + \frac{\epsilon r - 1}{2}\left(1 + 12\frac{h}{W}\right)^{-1/2}$$

The effective length is given as

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}}$$

Length extension (ΔL) is given by

$$\Delta L = 0.412h = \frac{(\epsilon reffec. + 0.3)(\frac{W}{h} + 0.264)}{(\epsilon reffec. - 0.258)(\frac{W}{h} + 0.8)}$$

Finally, the actual length of the patch is given by

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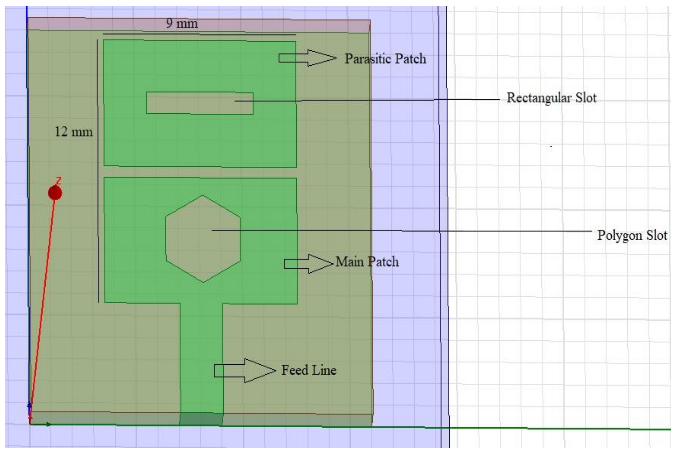
$$L_{eff} = L + 2\Delta L$$

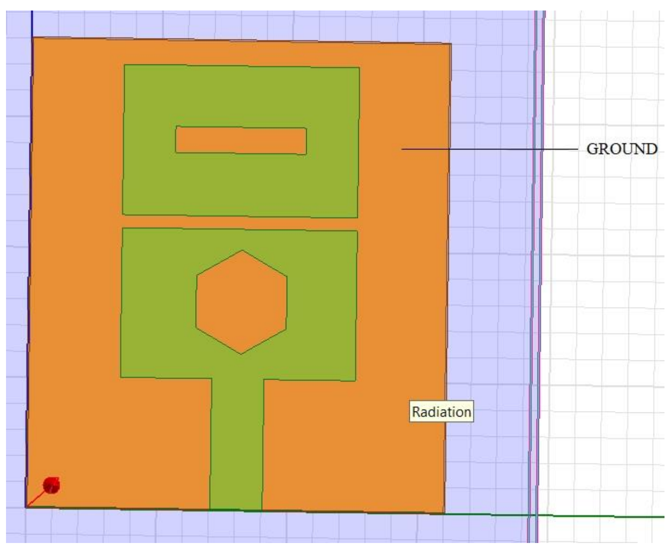
The parametric values are calculated by the use of design equations and the same are tabulated in below table 1.The geometrical structure is designed by the HFSS simulator and the structure of the designed (proposed) parasitic slot antenna is represented in the figure 1.

Parameter	Value
Frequency (f_r)	7.5 GHz
Substrate Height (h)	1.6 mm
Dielectric Constant (ε_r)	4.4
Length (Lp)	9 mm
Width (Wp)	12 mm

Table 1: Proposed Antenna Values



(a) Top View of the Proposed Structure



(b) Bottom View of the Structure

Figure1. (a) Top View, (b) Bottom view of the proposed structure

3. Simulation Results

A. S-Parameter (S_{11})

The result of the s-parameters will gives us the information about the return loss of the antenna. The below graph represents, that the proposed structure of the antenna have the dual band width with values less than -10dB at 8.43GHz and 15.14GHz.

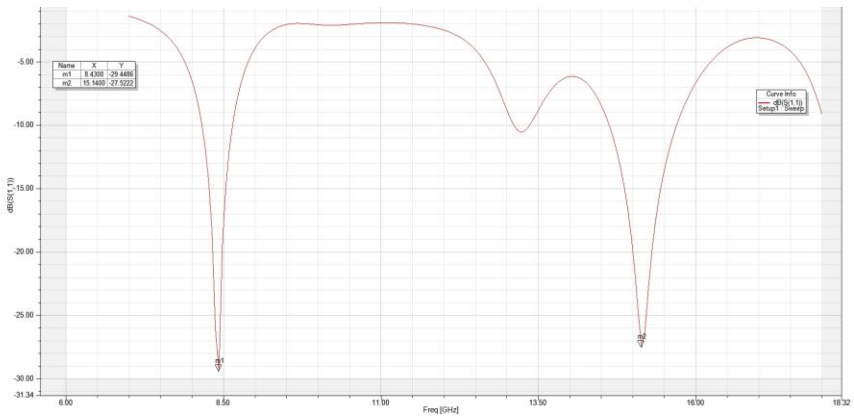


Fig.2: Frequency Vs S-Parameter (S_{11})

B. VSWR Plot

The below graph will represent the VSWR values of the designed antenna. The VSWR value lies in between 1 and 2 which indicate that the antenna is perfectly designed and working accordingly. Here, the VSWR values of the designed structure lies in between 1 to 2 at 8.43GHz and 15.14GHz.

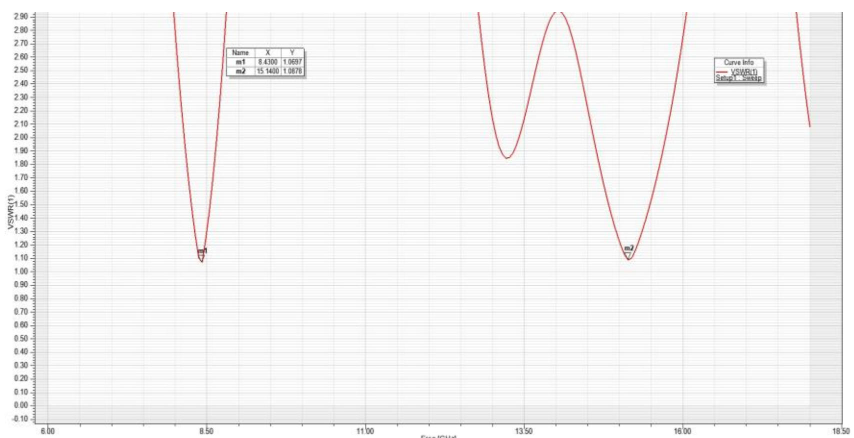


Fig.3: Frequency Vs VSWR

C. Radiation Pattern

The below graph represents, the value of radiation pattern measured on 360^0 chart. The measured radiation pattern at 360^0clearly shows that, the value we acquired is absolutely equal to the Gain of the antenna.

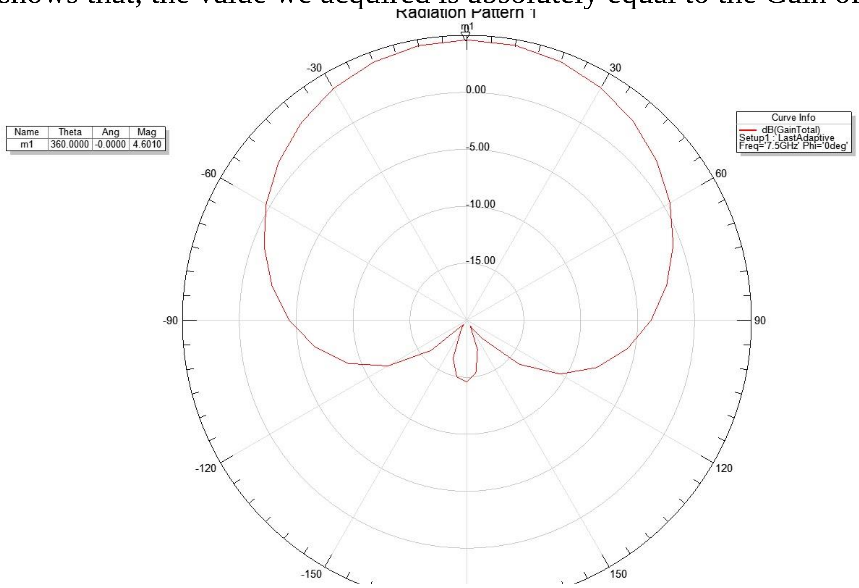


Fig.4: Radiation Pattern

D. Gain

In any antenna design, the performance of the antenna will be represented by its gain. The gain produced by the proposed (designed) antenna is represented in below figure.

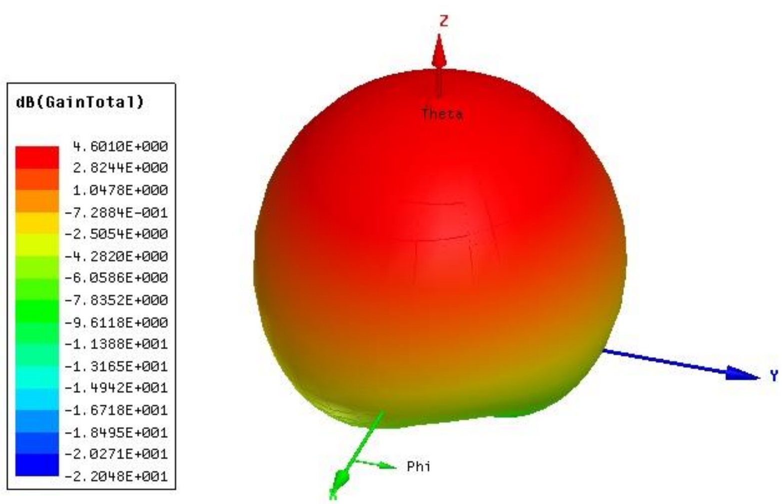


Fig.5: 3D Gain

E. Final Simulation parameters

The below table, represent the simulated results of the proposed (designed) structure. The proposed structure will provide good S_{11} values at dual bands, whose values are less than the -10dB with VSWR values in between 1 to 2. The other parameters values are also recorded in the table and compared the above values with the structure which are near to the proposed antenna structure and finally stated that the proposed antenna will provide the better results than the other compared structures.

Parameters	Values		Standard
Resonate Frequency	8.43 GHz	15.14 GHz	As per needed
Return Loss (S_{11})	-29.44	-27.52	Less than -10dB
VSWR	1.06	1.08	Less than 2
Gain	4.60		3-8
Directivity	4.70		3-8
Efficiency (η)	97.8%		70%

Table.2: Simulation Results

4. Conclusion

The designing of communication antennas in enhancement of antenna parameters were understood. The important parameters (such as S_{11}, Radiation Pattern, Gain, Directivity and Beam width) that affect design and applications were studied and their implications understood. The designed parasitic slotted antenna operated at the desired frequency was simulated (using HFSS) and the desired level of optimization was obtained. We also conclude that the antenna is a part of communication device and it requires continues evolution process. This paper proposed and designed an antenna which can operate at 8.43 & 15.14 GHz and these dual bands are considered in the UWB band. This proposed antenna will provide enhancement in the bandwidth and good return loss less than the -10dB at both the dual bands. This parasitic slotted microstrip patch antenna will serve as good option for bandwidth enhancement purpose.

5. References

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