Efficient Design of Horn Shaped Slotted Patch Antenna

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Abstract-- *Horn-shaped slotted patch antenna is a multiband antenna which is design for operating in multiple bands of cellular frequencies. In multiband antenna one part is active for one band, while another part is active for different band. The main advantage of multiband antenna is that, when interference or noise is present in one band, it cannot affect other band that means other band works properly. Multiband horn-shaped slotted patch antenna is designed at multiple frequency operation with improved band isolation and reduction in size. Here, p-type silicon wafer is used as a substrate to minimize substrate conductivity losses, because it has high dielectric constant of 11.9. It improves the antenna radiation efficiency by using four slots in a rectangular patch giving appropriate antenna parameters such as multiband performance, enhanced efficiency and bandwidth. HFSS (High Frequency Structure Simulator) version 13.0 software has been used to design a horn-shaped slotted patch antenna.*

Keywords-Horn-shape, Slots, Patch antenna, Return loss

I. INTRODUCTION

The rising importance of wireless communication and multimedia services increasing the efforts to the design and implementation of microstrip patch structures. A patch antenna is advantageous because of its low cost, small size, ease of fabrication, and it can be easily integrated into many commercial transceiver systems. Microstrip patch antenna elements radiate efficiently as devices an microstrip printed circuit boards. The microstrip patch antenna is an excellent candidate for portable wireless devices.

As patch antenna establishes its physical effect on a dielectric substrate having effective electrical and magnetic properties, so selecting a correct substrate is important as well. The change in substrate material will affect the performance of the antenna in all aspects as per the output parameters are concerned. There are such materials with dielectric constants higher than 10. The patch size is smaller for higher dielectric constant. However, higher dielectric constant also reduces bandwidth and radiation efficiency. Also by using different types of slots in different position on the patch we can get improved antenna results.

II. LITERATURE SURVEY

In recent years microstrip printed slotted patch antenna has been mostly studied. Its performance be improved by changing inner structure. It has wide applications in advanced communication system [2-4]. Several years ago multifunction applications such as multiband communication as well as miniaturization are required [5]. Multiband slotted patch antenna are useful when one has to deal simultaneously with data uplink and downlink in satellite communication. By cutting different size of slots in patch we are able to achieve dual and triband operation [6-8].

III. NUMERICAL STUDY

Now it is the time to articulate the research work with ideas gathered in above steps by adopting any of below suitable approaches:

Based on simplified formulation that has been described, it’s just a practical based design procedure of rectangular patch antenna. Here notations used are dielectric constant of substrate (εr), the resonant frequency (fr), and the height substrate (h).

By specifying εr, fr (in Hz) and h, width (W) and length (L) can be determined by using the following step wise procedure.

1. For getting good radiation width of patch is *(W).*

$$W = \frac{1}{2 f_r \sqrt{\varepsilon_0 \mu_0}} \sqrt{\frac{2}{1+\varepsilon_r}} \qquad (1)$$

2. The effective dielectric constant of microstrip antenna using

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-\frac{1}{2}} \qquad (2)$$

3. By using *(W)* determine extension of length *ΔL* using

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$$\frac{\Delta L}{h}=0.412\frac{\left(\varepsilon_{eff}+0.3\right)\left(\frac{w}{h}+0.264\right)}{\left(\varepsilon_{eff}-0.258\right)\left(\frac{w}{h}+0.8\right)} \quad (3)$$

4. The length of patch is now determined by solving

$$L=\frac{1}{2f_r\sqrt{\varepsilon_{eff}}\sqrt{\varepsilon_0\mu_0}}-2\Delta L \quad (4)$$

Design of implemented horn shaped slotted patch antenna given in section IV, using above design procedure for the following frequencies.

f_r = 0.8GHz, 2.1GHz, 2.3GHz, 2.45GHz. ε_r=11.9 (silicon). VSWR is defined in terms of the input reflection coefficients as:-

$$VSWR=\frac{1+|\Gamma|}{1-|\Gamma|} \quad (5)$$

The Γ is a measure of reflected signal at the feed point of the antenna. It is defined in terms of input impedance of the antenna.

IV. DESIGN OF ANTENNA

The horn shape slotted patch antenna is one type of microstrip antenna which was designed to achieve operation in multiple frequency bands. Here, 2 inch p-type silicon (Si) wafer with high dielectric constant (11.9) is used as a substrate to minimize conductivity losses, thereby improving the antenna radiation efficiency.

Sr. No.	**Parameters**	**Values**
1	Radius of substrate	25mm
2	Height of substrate	1.6mm
3	Material of substrate	silicon
4	Length of patch	35mm
5	Width of patch	26mm
6	Material of patch	Gold
7	Length of feed line	16mm
8	Width of feed line	1.6mm
9	Length of slot	2mm
10	Width of slot	0.5mm
11	Dielectric constant of silicon	11.9

The design of the horn-shaped patch antenna was carried out using the high frequency structure simulator (HFSS) tool. The 3D geometry proposed four-band linearly polarlized asymmetrical patch antenna with four thin slots along with relevant dimensions as shown in Figure 1.

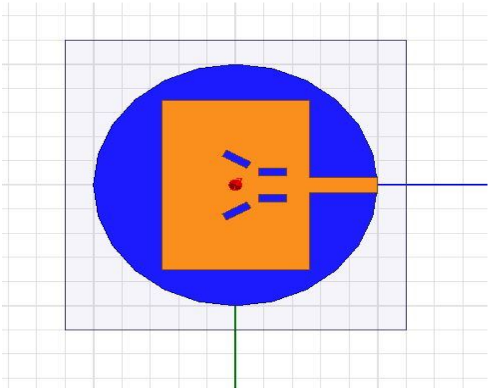

Fig. 1.Design of horn shaped antenna structure

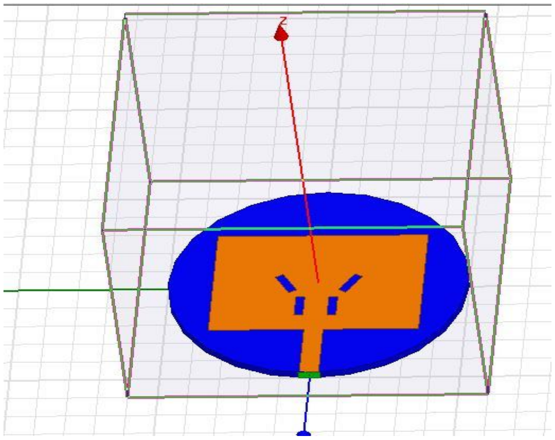

Fig. 2.Side view of horn shaped antenna structure enclosed in rectangular radiation box

V. RESULTS

The important parameter of horn-shaped slotted patch antenna.

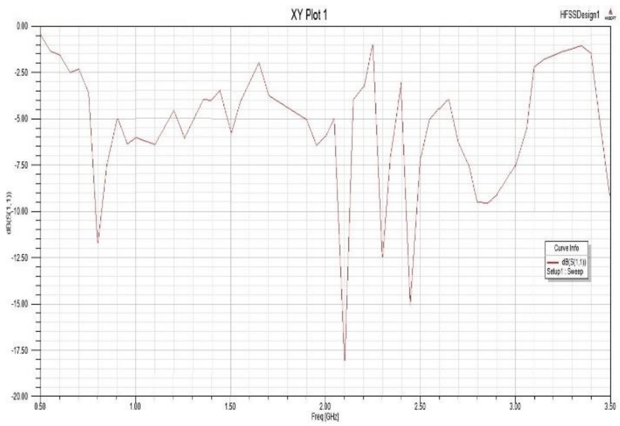

Fig. 3.Return loss of horn shaped slotted patch antenna

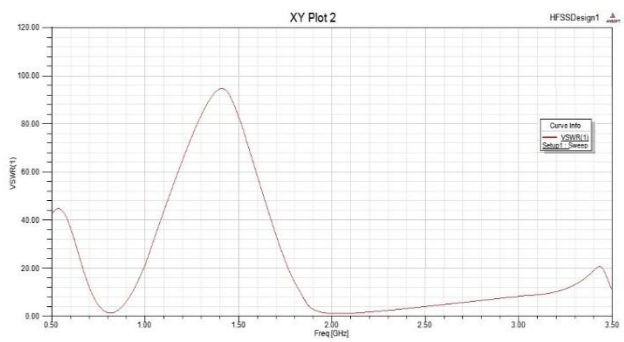

Fig. 4.VSWR of horn shaped slotted patch antenna

Fig 3 shows the return loss characteristics of horn-shaped slotted patch antenna. fig. 4 shows the VSWR (voltage standing wave ratio) of horn-shaped slotted patch antenna. The antenna resonated in four different frequencies such as 0.9GHz, 2.1GHz, 2.3GHz, 2.45GHz. The results shown in observation table.

Sr No.	Frequency (GHz)	Return Loss (dB)	VSWR
1	0.8	-12	1.9
2	2.1	-18	1.2
3	2.3	-12.5	1.5
4	2.45	-15	1.8

VI. CONCLUSION

The microstrip patch antenna is used in various applications such as high performance communication system. They have few drawbacks. One of them is low bandwidth. To increase the bandwidth or to improve the other parameters we use the different types of slots. In horn-shaped slotted patch antenna having frequencies are 0.8GHz, 2.1GHz, 2.3GHz and 4.5GHz indicating antenna working in multiband which are cellular frequencies. Hence this antenna is applicable for cellular communication such as 2G (GSM), 3G (UMTS), 4G(LTE), Bluetooth and Wifi.

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