Design of a Square Shape U Slots Multiband Antenna

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Abstract**—** This paper introduce about the formation of Square shape U slots multiband antenna for the operation of various wireless applications. This antenna adequate to support four distinct frequencies as 2.4 GHz, 4.6 GHz, 6 GHz and 6.9 GHz. All four frequencies are coming under the different wireless bands such as GSM, Bluetooth, WiFi, WiMAX, WLAN, Wireless broad band and some navigation applications. Multiband can perform the multiple operations so this paper consist of design of a square shape u slots multiband antenna with a rectangular patch. This paper also consist of design results of Return loss S_{11}, VSWR measurement, polar plot of gain and radiation pattern and Surface current. Formation done on CST Simulation Software.

Keywords**—***Frequency bands; Impedance matching; Multiband operations; Square shape slots; Wireless applications; U slots.*

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I. INTRODUCTION

The aim of wireless communications hold up information trafficking between people and devices is the communications marginal of the next few decades. Antennas are basic component of any communication system. Many methods have been devised for making a single antenna structure operated on a number of bands [1]. For this method a multiband antenna is proposed. Multiband antennas has been design to operate on various frequency bands for example GSM (900-1900 MHz), GPS (1227-1575 MHz), Bluetooth (2400 MHz), WiFi (2400-2500 MHz), WiMAX (3800-4800 MHz), WLAN (5100-5800 MHz), and LTE (Long Term Evolution) which operates on different frequencies as 2400 MHz and 7 GHz. These antennas generally include competent designs where both part of the antenna is operated for different bands. Hence multiband antennas provide multiple frequencies at multiple bands [2].

II. FORMATION OF ANTENNA

For the operation of number of bands in wireless applications multiband antennas are used with multiple frequencies. In the figure 1 the formation of multiple square shape U slots are designed for multiple operations in multiband antenna. Single U slot perform single band operation, whereas four U slots perform multiple operations and broaden the bandwidth. Each U slot operates at different frequency bands according to their shapes and sizes. This structure is symmetric in both x and y axis [3]. Therefore the cross polarization factor is cancelled out. The resonance frequency of the multiband U slot antenna is further reduced by partially shorting the edge. The bandwidth of the compact multiband antenna can be increased by using thicker substrate. By increasing the resonant frequencies of the slots and the patch, we can secured broaden bandwidth.

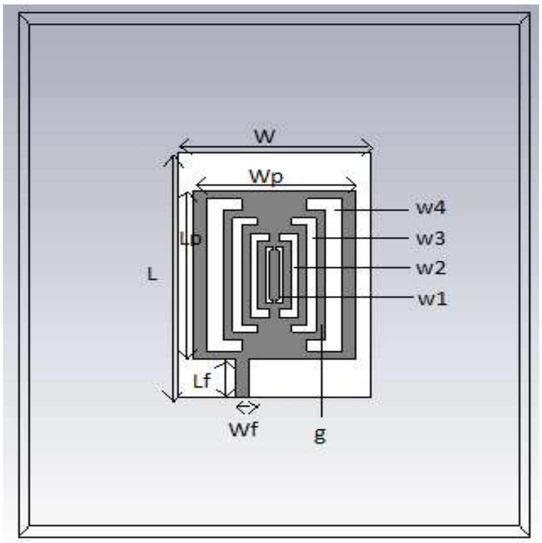

Fig. 1: Design of a square shape U slot multiband antenna

III. SIMULATION AND MEASURED RESULTS

In the formation of U slots, four square shapes has been used for the multiband operation. This propose design has been fabricate on FR4 substrate having dielectric constant of 4.4 and loss tangent 0f 0.0024 the overall size of antenna is $0.2497\lambda \times 0.1309\lambda$ length (L) and width (W) with respect to center frequency and 1.6 mm thickness. The length (Lp) and width (Wp) of the patch is 22 mm × 18.5 mm with PEC material. A simple strip line feed is used having dimensions Lf and Wf 5 mm × 1.5 mm. Each slot having a gap of 1 mm as a separation. This design also consider four slots as, width of first slot is 0.5 mm, width of second slot is 0.75 mm, width of third slot is 1 mm, width of fourth slot is 2 mm, length of the largest or fourth slot is 20 mm and length of the smallest or first slot is 7.5 mm. A single square shape is cut vertically in the middle part according to suitable width and gap. In this sequence four squares are cuts then arranged according to their length and width. The dimensions of the slots are

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chosen such that its resonance frequency is close to that of the rectangular patch with a slot [4].

Length and Width of the substrate in terms of λ is calculated by following formulas

Width of the substrate is calculated by

$$W = \frac{c_0}{2f_r}\left(\sqrt{\frac{2}{\epsilon_r+1}}\right)$$

Length of the substrate is calculated by

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

Where, L_{eff} is the effective length of substrate

ΔL is the extended length of substrate

Dielectric constant of substrate is calculated by

$$\epsilon_{reff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left[1+\frac{12h}{w}\right]^{-1/2}$$

L_{eff} and ΔL are calculated by

$$\Delta L = h\times 0.412\frac{(\epsilon_{reff}+0.3)(\frac{w}{h}+0.264)}{(\epsilon_{reff}-0.258)(\frac{w}{h}+0.8)}$$

$$L = \frac{c_0}{2f_r\sqrt{\epsilon_{reff}}} - 2\Delta L$$

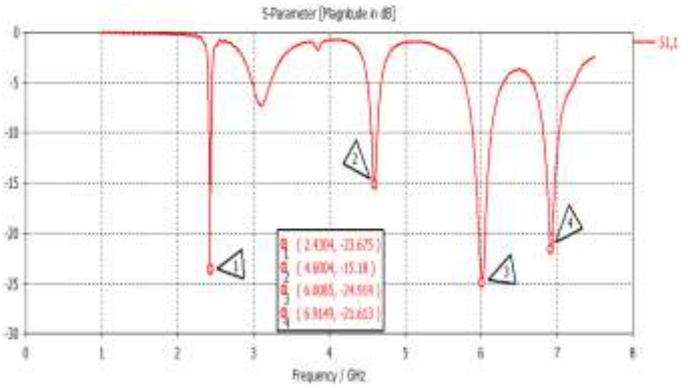

Fig. 2: S parametes of multiband antenna

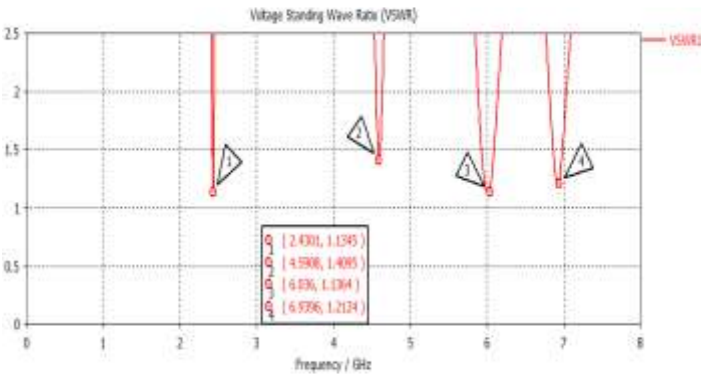

Fig. 3: VSWR measurement

The measured VSWR plots of this antenna is shown in figure 3, the frequency range for VSWR <2. Four different frequencies show the different surface current for the multiband rectangular patch antenna. In this paper the reflection coefficient (s_{11}) shows the antenna output response for the different frequency bands and minimum losses at a particular point.

TABLE I.

S. No.	Parameters of the multiband antenna		
	Name of the dimensions	Symbols	Units (mm)
1.	Width of the substrate	W	22
2.	Length of the substrate	L	34
3.	Width of the patch	Wp	18.5
4.	Length of the patch	Lp	22
5.	Width of the feed	Wf	1.5
6.	Length of the feed	Lf	5
7.	Gap between slots	g	1
8.	Width of first slot	w1	0.5
9.	Width of second slot	w2	0.75
10.	Width of third slot	w3	1
11.	Width of fourth slot	w4	2

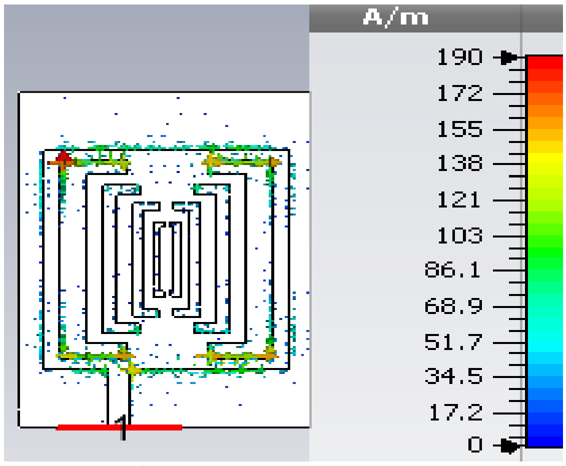

Fig. 4: Surface current for 2.4 GHz

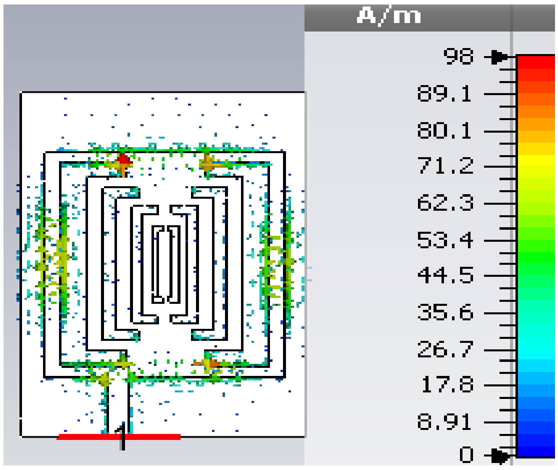

Fig. 5: Surface current for 4.6 GHz

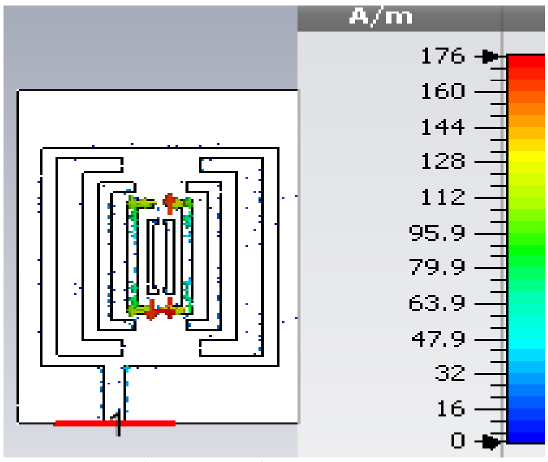

Fig. 6: Surface current for 6 GHz

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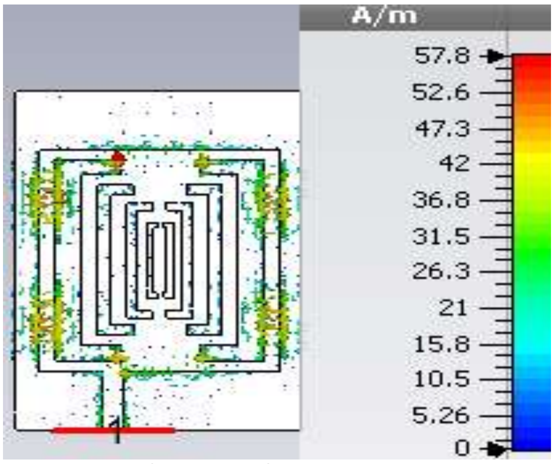

Fig. 7: Surface current for 6.9 GHz

Antenna gain is the combination of directivity and electrical efficiency. Radiation pattern of the slotted multiband antenna at four different frequencies with major lobe, minor lobe, back lobe, side lobe is shown below. Major lobe represents the direction of maximum radiation.

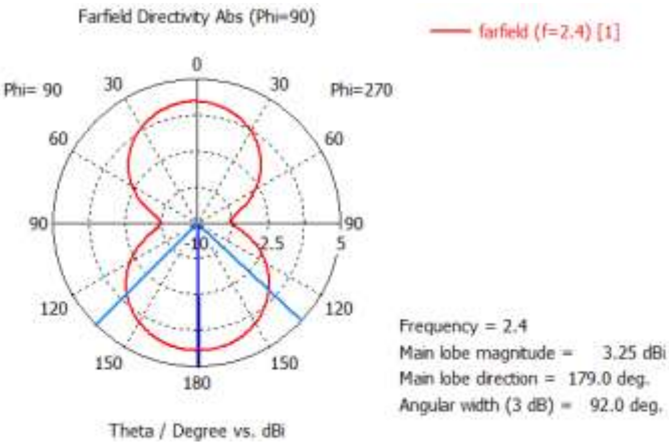

Fig. 8: Radiation pattern at 2.4 GHz

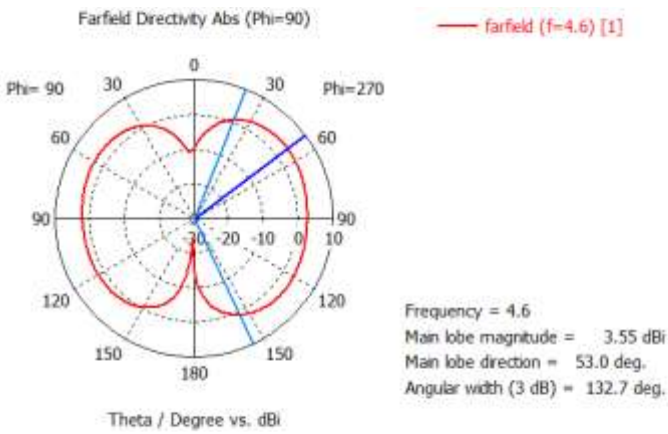

Fig. 9: Radiation pattern at 4.6 GHz

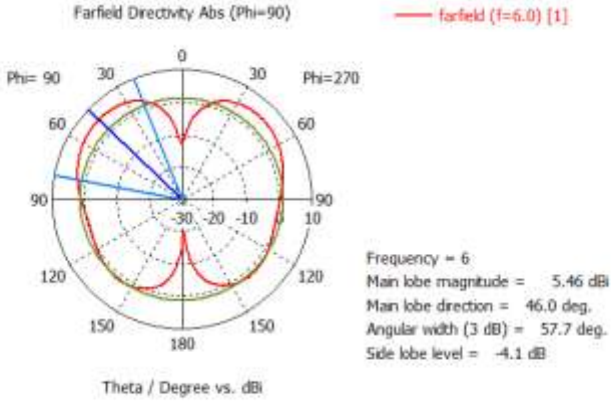

Fig. 10: Radiation pattern at 6 GHz

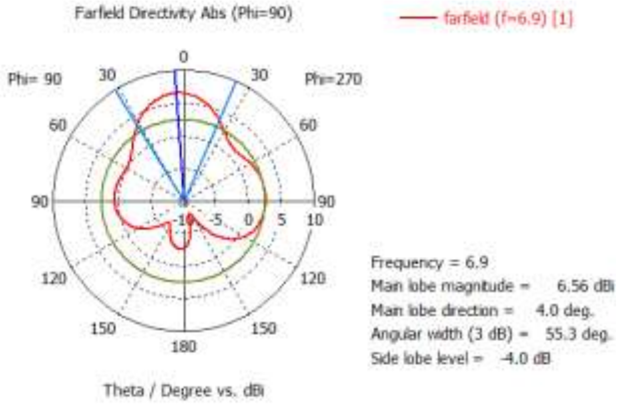

Fig. 11: Radiation pattern at 6.9 GHz

IV. CONCLUSION

In this paper a square shape multiband antenna with a simple strip line feed is investigated. The simulated results obtained using CST simulation. The secured result shows the multiple operations at resonant frequencies. Square shape u slot, modifiable feeding technique, and dimensions of the multiband antenna made it possible in the received frequency bands of 2.4 GHz, 4.6 GHz, 6 GHz, and 6.9 GHz in various wireless applications such as GSM, Bluetooth, WiFi, WiMAX II, WLAN, and wireless broadband. Reflection coefficient (S_{11}), VSWR pattern, Surface current and gain were analyzed.

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