TRI-BAND F SHAPED SLOT IN THE PATCH ANTENNA DESIGN FOR WIRELESS COMMUNICATIONS

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Abstract : A tri-band F-shaped slot in the patch antenna designed in this paper. The proposed antenna covers the frequency band of Bluetooth, Wi-Fi and Wi-max applications. The Size of the proposed F-shaped patch antenna design is about 20mm x 30mm. Initially the antenna is designed for Bluetooth application later on introducing a slot in the patch will radiate more than single frequency band and it can be easily optimized to Wi-Fi and Wi-max applications. The optimizations done with respect to adjusting the position, shape, size of the slot and stub modifications. Structural modifications of the F-shaped patch antenna were simulated by using CAD FEKO. The details of Tri-band Patch antenna are studied and presented

***IndexTerms* - Antenna, Patch, F Shaped Slot, Stub, ISM, Bluetooth Band, Wi-Fi, Wi-Max**

I. Introduction

Microstrip antenna plays a major role in wireless communication as well as it is also used in mobile phone market. It also has certain advantages such as low profile (low power, small size and low cost), conformal to planar and non-planar surfaces, easy fabrication by today's modern manufacturing technology, mechanically strong when placed on rough surfaces. The recent development in the design of patch antenna has introduced many interest for the researchers in the field of wireless and mobile communications [1]-[5].

Patch antenna can cover multiple number of frequency bands because of thin planar structures, which will be applicable for mobile phones [6]-[10]. The optimized frequency can be obtained by proper patch dimensions. The number of frequency band can be increased by introducing the slot in the patch antenna. The slot has been etched out from the radiating patch through which it covers Wi-Fi and Wi-Max frequencies [11]-[15].

Several solutions has been implemented to achieve the desired multiband radiating properties of a multi antenna system [16]-[18]. However in order to improve the desired performance, the patch antenna have to be designed properly [19]-[21].

In this paper, we present a tri-band F-shaped patch antenna for wireless communications. The structure of the design is depend on creating a F-shaped slot on the patch to obtain tri-band resonance characteristics. The proposed design antenna covers the 2.45 GHz, 5.8 GHz and 8.79 GHz frequency bands. The distance is set as 2.4mm between the ground plane and patch antenna. F-shaped slot are inserted in the patch plane and the radiation characteristics is based on the physical parameters which includes the change in length and width, their stub positions, number of slots were introduced in the patch. The resonance frequency varies with respect to change in slot width, length and their feed pin position.

The structure of the paper is described as follows. Section II deals with the structure of antenna design with slots in the patch. Section III displays the results of return loss(dB) for each structure, gain(dB) with distribution of field component. Conclusion of the work is provided at the final section.

II. Analysis And Design

The geometry of the proposed patch with design parameter is illustrated in the Fig.1. The structure consists of patch, ground plane and substrate in between them. The ground plane and patch are connected through stub. The detailed dimensions of the proposed patch are given in Table I.

TABLE I. DETAILED DIMENSIONS OF PROPOSED ANTENNA

Parameters	L_p	W_p	L_g	W_g	L_1	L_2	L_3	L_4	L_5	L_6
Values (mm)	30	20	50	30	12	10	11	5	3	1

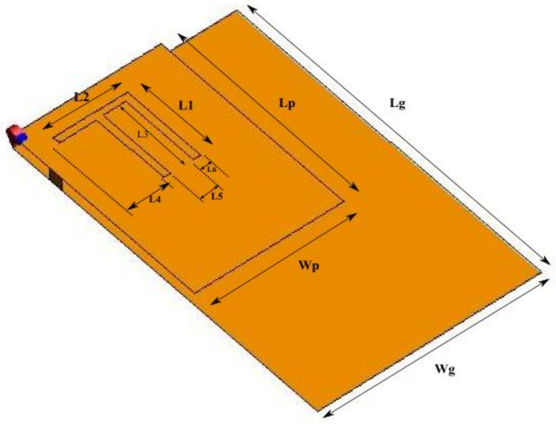


Fig.1 Patch Structure

Design Approach of Rectangular Micro-Strip Patch Antenna

. The patch width is calculated using

$$W = \frac{1}{2fr\sqrt{\mu0\varepsilon0}}\sqrt{\frac{2}{\varepsilon r+1}} = \frac{v0}{2fr}\sqrt{\frac{2}{\varepsilon r+1}} \quad (1)$$

2. An effective dielectric constant of the patch is

$$\varepsilon reff = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left[1+12\frac{h}{W}\right]^{-1/2} \quad (2)$$

3. The length of the patch stretched by ΔL on each side

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon reff+0.3)(\frac{W}{h}+0.264)}{(\varepsilon reff-0.258)(\frac{W}{h}+0.8)} \quad (3)$$

4. An effective length of the patch is given by

$$L_{eff} = L + 2\Delta L \quad (4)$$

5. The ground plane width (W_g) and length (L_g) are given by

$$W_g = 6h+W \quad (5)$$

$$L_g = 6h+L \quad (6)$$

Conventional Patch in FEKO

The dimensions of the patch and ground plane radiating at the dimensions of (Wp, Lp) = (20, 30) mm and (Wg, Lg) = (30, 50) mm. The separation between the ground plane and patch is 2.4mm. The patch with no slot radiates at the frequency of 2.45 GHz.

Slotted PIFA in FEKO

Introducing a single slot in patch antenna will give more than single frequency band. The resonant frequency for the lower operating band is chosen by design properties of the patch and the resonant frequency for the higher operating band is chosen by changing the size of the slot and fine tuning the position of the slot and stub. The slotted structure is shown in Fig.3. The patch with single slot radiates at the frequency of 2.48 GHz band and 8.21 GHz band respectively.

F shaped slot in Patch

The F shaped slot has been cut from the patch plane and the shape of the slot decided to obtain more number of frequency bands and the patch with F shaped slot in this design radiates at the frequency band of 2.37 GHz, 5.79 GHz and 8.78 GHz respectively. The F shaped slot in the patch has been shown in Fig.4

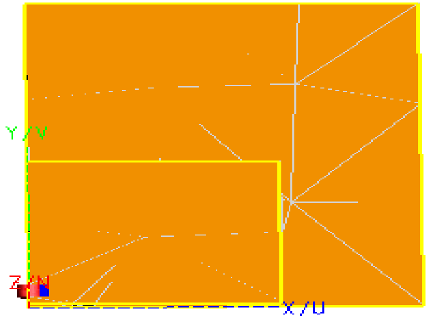


Fig.2 Conventional Patch Structure

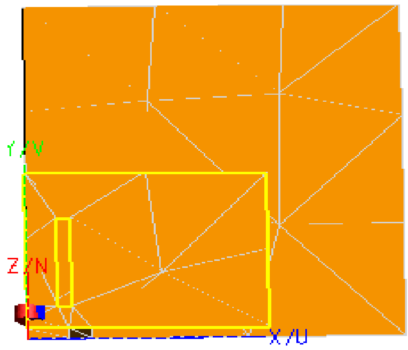


Fig. 3 Patch structure with single slot

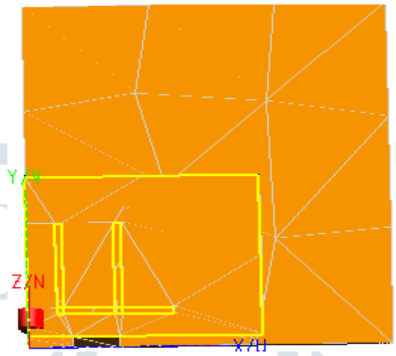


Fig. 4 Patch structure with F shaped slot

III. RESULT AND DISCUSSION

The proposed patch is designed and simulated by means of Method of Moment's. The proposed patch is simulated and tested upto 10 GHz, it covers the multiple frequency bands Bluetooth, Wi-Fi and Wi-Max applications. In this design the patches, ground plane, stub and edge feed are assumed to be perfect dielectric conductor. Initially, the patch antenna is designed for the resonant frequency of 2.45 GHz for Bluetooth application and it is shown in Fig 5. The return loss and bandwidth obtained was -27 dB and 0.65 GHz. Secondly, a narrow slot is cut out from the radiating element to reduce the corresponding inductance occured by the feeding probes. Introducing the slot resonantes another frequency at 8.21 GHz without affecting the first resonant frequency and it is illustrated in Fig. 6. Later on, another slot has been introduced and there parameteric effect is shown in Fig. 7. Finally, an F-shaped slot is cut out from the radiating patch and it introduces the third resonant freqeuncy at 5.8 GHz.

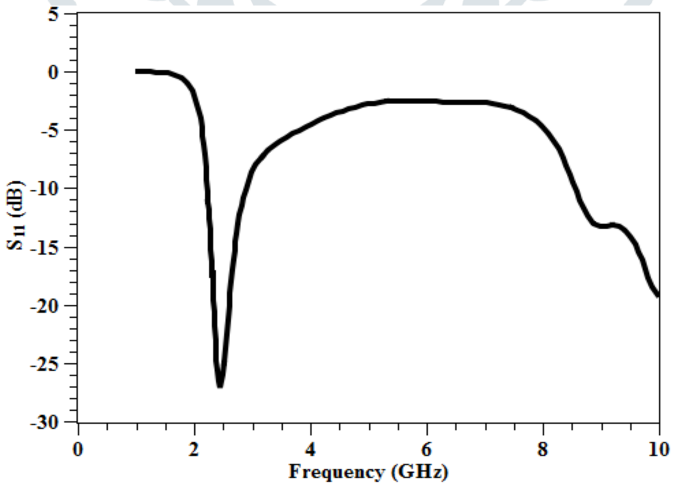


Fig. 5 Return Loss characteristics of radiating Patch

Simulation results of different structure has shown in Fig. 9. From the figure, it has been concluded that by introducing a slot in the patch creates an additional resonant frequency and there is a very minimum effect on return loss for lower resonating frequency at 2.4 GHz. The comparisons of resonant frequencies of Patch antenna are shown in the Table II

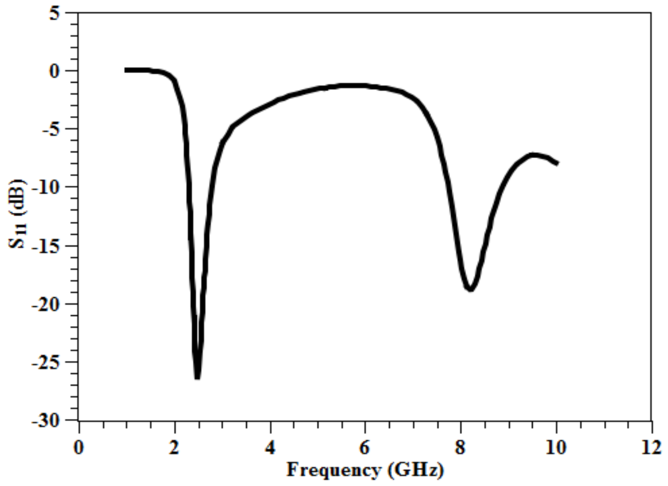


Fig.6 Return Loss characteristics of radiating patch with single slot

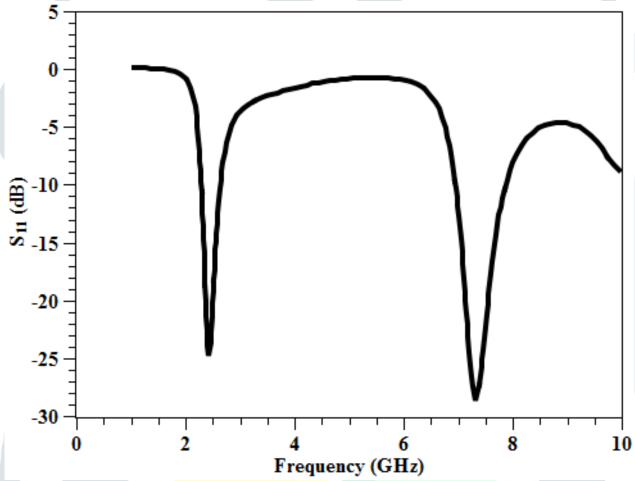


Fig. 7 Return Loss characteristics of radiating patch with dual slot

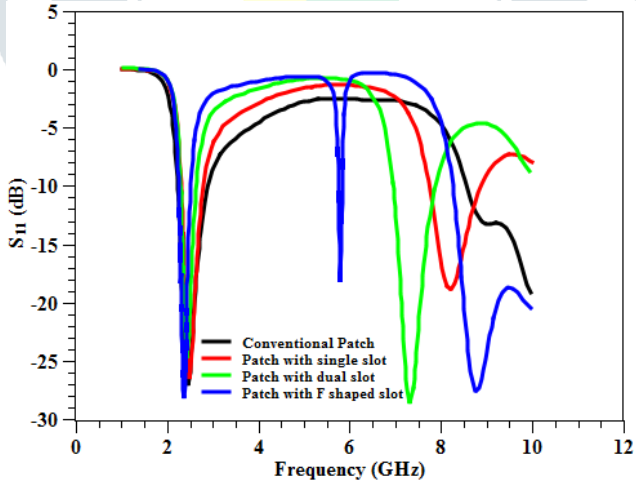
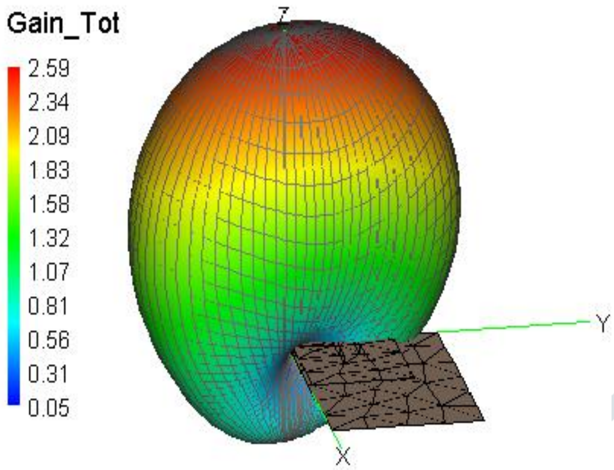


Fig. 9 Comparison of F-shaped Patch with single and dual slot

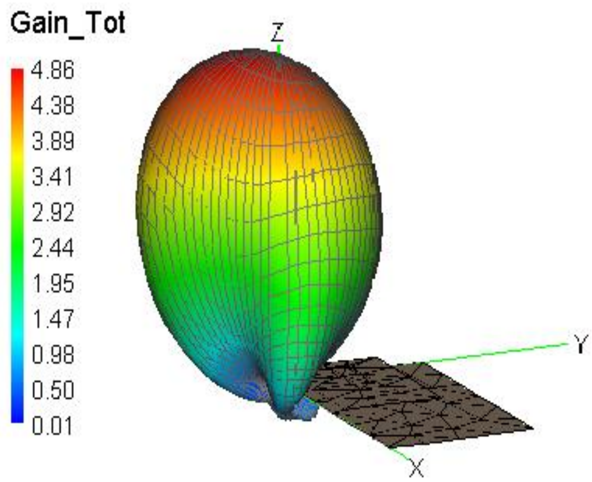
Table II. COMPARISON OF RESONANT FREQUENCIES

Sl.No	Antenna	Resonant Frequencies (GHz)
1	Patch antenna without any slot	2.45
2	Single slotted Patch Antenna	2.48, 8.21
3	Two slotted Patch Antenna	2.42, 7.43
4	F Shaped Patch Antenna	2.36, 5.8, 8.79

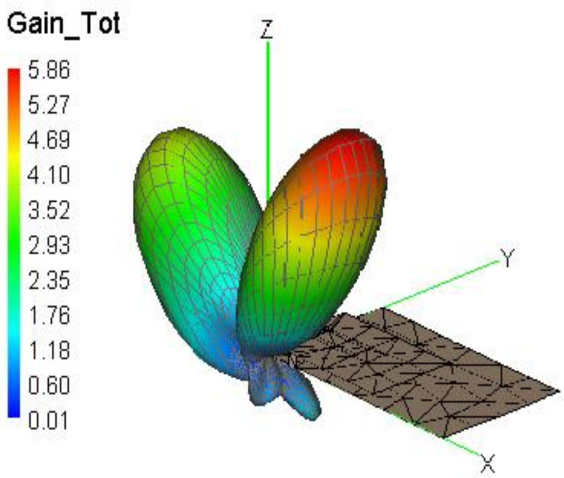
Figure 10 shows the 3 dimensional radiation characteristics with gain obtained at different resonant frequencies are 2.45 GHz (2.59 dB), 5.8 GHz (4.86 dB) and 8.79 GHz (5.86 dB). Through the radiation characteristics the antenna gain and directivity can be analyzed.



(a) 2.45 GHz



(b) 5.8 GHz



(c) 8.79 GHz

Fig.10. 3DRadiation patterns of the Patch antenna

IV. CONCLUSION

A compact Tri-band Patch antenna has been presented in this paper which covers frequency band of Bluetooth, Wi-Fi and Wi-Max applications for wireless communication. The resonant frequency obtained with the overall dimensions of 25mmx30mmx2.4mm and the design is simulated by using CAD FEKO tool. By varying the slot dimension and stub position the tri-band frequency can be extended to multi-band frequency.

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