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COMPACT F-SHAPE ANTENNA FOR C-BAND APPLICATIONS

[1]M.KALYANI, [2]K.VASU BABU

Department of ECE,

VVIT college

[1]kalyanimopidevi@gmail.com

[2]vasubabuece@gmail.com

Abstract:-**Design of compact F-Shape antenna provides a small, low profile planar single band microstrip antenna. The main aim of this communication is to obtain a single band antenna that operates at C-Band and used for radars. The designed antenna has a compact size of 40×25 mm^2. The proposed antenna consists of F-Shaped slot radiators and a defected ground plane. Since only two F-shaped slots are etched on either sides of the radiator for single-band operation, the radiator is very compact in size and simple in structure. The antenna shows a single band at 8.704GHz. To validate the proposed design, an experimental prototype has been fabricated and tested. Thus the simulation results along with the measurements show that the antenna can operate over C-Band.**

Index terms:-**Compact F-Shaped antenna, single band.**

I. INTRODUCTION

Electronic gadgets such as mobile devices, hand held computers and smart phones are widely using wireless networks [1] and various frequency bands for internet access. In general the L-Band operates with in the frequency 1-2GHz which can be used for Bluetooth, S-Band operates with in the frequency 2-4GHz used for WLAN/WiMAX[10] networks, C-Band operates with in the frequency 4-8GHz used for radars and X-Band operates with in the frequency 8-12GHz used for satellite communication. These are having the features such as simple feeding, low profile, low manufacturing cost and easy to integrate. The federal communication commission (FCC)-specified spectrum for WLAN [1] is centered at 2.4, 5.2, and 5.8 GHz and for WiMAX at 2.5, 3.5, 5.5 GHz. A number of microstrip antennas with different geometrics have been charecterised to reduce the size and enhance the bandwidth for WLAN/WiMAX [10] applications. A substrate, ground plane [4] and a microstrip feed [4] on which some slots are etched to achieve singleband operation [1]. Longer arm of the patch and F-Shaped slots are used for compactness. Inverted L-Slot is used for triple band operation. An F-Shaped microstrip slot antenna with both open ended and short ended slots connected by a metal to a microstrip line is exploited for radars, multiple input and multiple output (MIMO) [7]. A monopole antenna with two rectangular corners cutoff and two inverted L-Slots are etched for triband operation [7]. The previous designed antennas with different measures exhibit triple band operation but in comparison the proposed antenna occupies the smallest area and has simpler geometry to realize the required operating bands. The proposed antenna consists of two F-Shaped slots of the same size that are etched on a rectangular patch to operate multiband operation [4].

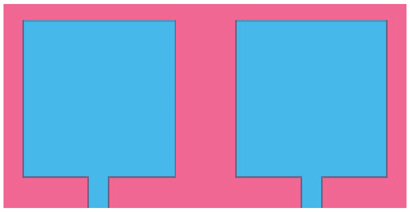
The F-Shaped slots are etched on the left and right sides of the radiator with very compact size and simple structure.

Many other antenna shapes are designed with different frequencies such as single F-shape[3] with 2.7GHz frequency, UWB antenna[8] was designed with 4.3GHz frequency, UWB MIMO antenna with the frequency 4.5GHz similarly H [6], F and circular designs.

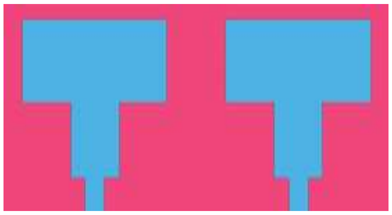
II. ANTENNA CONFIGURATION AND DESIGN APPROACH

The proposed antenna is fabricated on the FR-4 dielectric substrate of thickness 1.4mm, relative permittivity of 4.4 and dielectric loss tangent of 0.02. The overall size of the proposed antenna is only $40\times25mm^2$. the antenna is composed of a rectangular shape radiator with two F-Shaped slots of equal size formed by dimensions L2, L3, L4, W2, W3, W4, and W5. Computer simulation technology(CST), microwave studio(MWS), Ansoft's HFSS commercial software are used to optimise the parameters for triple-band operation of the proposed compact antenna and the dimensions listed in table 2.

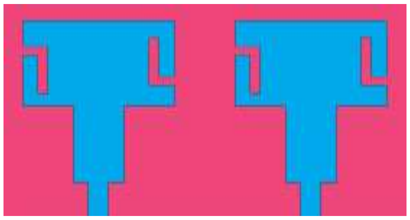
The antenna design evolution process to achieve the triple band operation for WLAN/WiMAX applications shown in the fig:-1. The antenna design starts by a conventional rectangular patch and ground plane. From the fig:-2 it can be observed that a single resonant mode formed at about 8.8GHz (antenna 1).



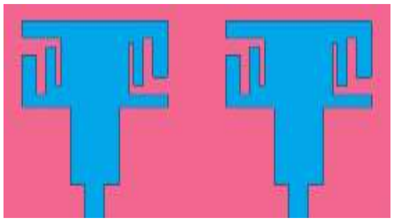
Antenna # 1



Antenna # 2



Antenna # 3



Antenna # 4

Fig: 1 Step by step process of proposed antenna

The antenna 2 shows the resonating frequency at 7.2GHz due to the modification of the radiating patch by etching two L-shaped slots each on either boundaries of the patch. Antenna 3 indicates that inclusion of an additional L-Shaped slot on the radiating patch of the antenna provides another additional resonance. From fig:1 we can observe that a patch is designed as F-Shape like two f shapes are inserted in a single patch for to design a compact f shape with in the range $40\times25mm^2$.

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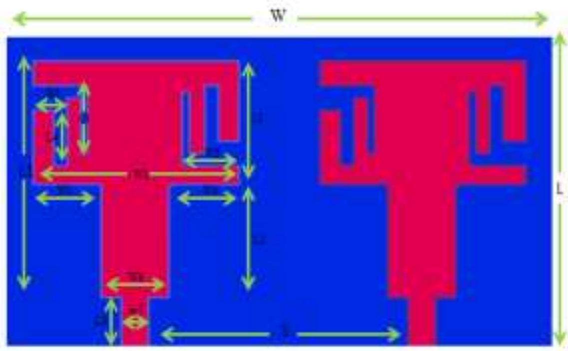

Fig: 2 compact F-Shaped Antenna

To study the operating principle and differences obtained during different steps can be observed in fig: 3. we can observe 4 different waveforms each colour indicating different antenna design. Initially a patch with a strip is simulated with the frequency range of 8.7GHz. Further second antenna is designed using two rectangular slots in the patch are removed and simulated and the frequency 7.2GHz is obtained.

Symbol	Dimensions (mm)	Symbol	Dimension (mm)
W	40	W7	2
L	25	L1	19
W1	15	L2	10
W2	3.5	L3	5.5
W3	5	L4	4.5
W4	5	L5	9
W5	2.5	S	19
W6	5	Ls	4

Fig: 3 Dimensions of the proposed design

Parameters used to design the compact F-Shape antenna is shown in fig: 2

The L-Shaped slots are removed from the patch and the obtained frequency observed is 4.3GHz. Finally the compact F is designed i.e two f shapes in a single patch with the frequency 8.704GHz. These waveforms are the comparisons of design at different steps.

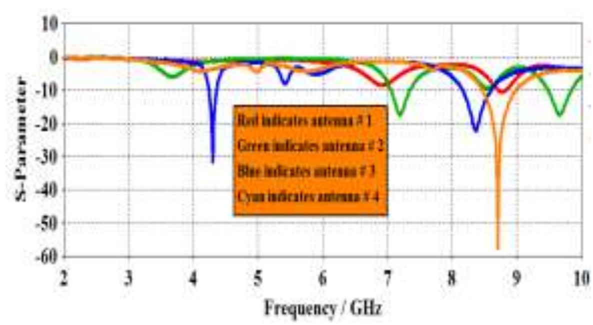

Fig: 4 Returnloss of different antennas (step by step)

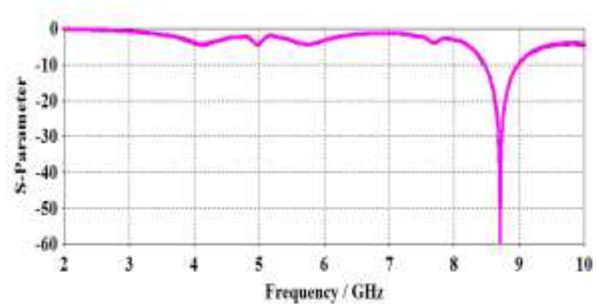

Fig: 5 S11 comparison of proposed antenna

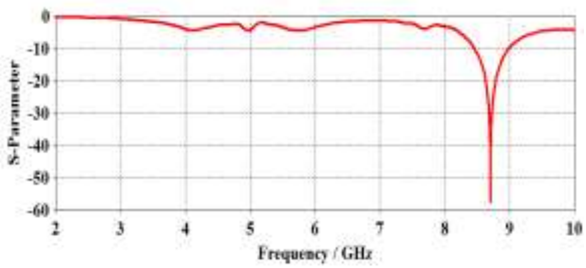

Fig: 6 S11 of the proposed antenna

From figure 4 we can observe the obtained s11 with in the frequency range of 8.704GHz. Here s11 indicates the returnloss of the designed antenna.

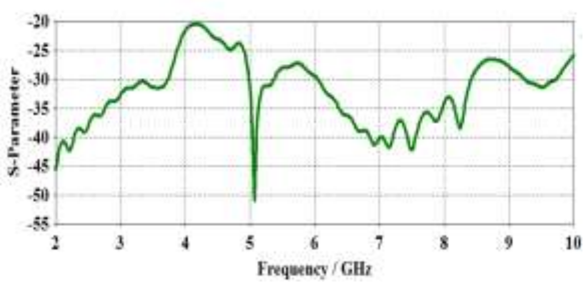

Fig: 7 S12 of the proposed antenna

From the above graph we can observe the mutual coupling of the proposed antenna with different frequency. Mutual coupling of the design is indicated with the s-parameter S12 shown in figure 5.

Figure.5 indicates the mutual coupling of the proposed antenna. Here different waveforms are compared by changing the distance between two f shaped patches. The distance between the patches can be observed in the below figure: 6.

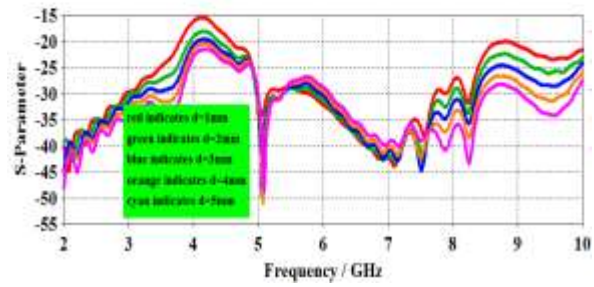

Fig: 8 Distance comparison of proposed antenna

The results obtained from the distance comparison are shown in figure: 6. Here each and every colour indicates the variation in distance such as red indicates at a distance of 1mm with the frequency -20.1 dB, green indicates at a distance of 2mm with frequency -22.5 dB, blue indicates at a distance of 3mm with frequency -24.5 dB, cyan indicates at a distance of 4mm with frequency -26.4 dB and magenta indicates at a distance of 5mm with frequency -28.1 dB.

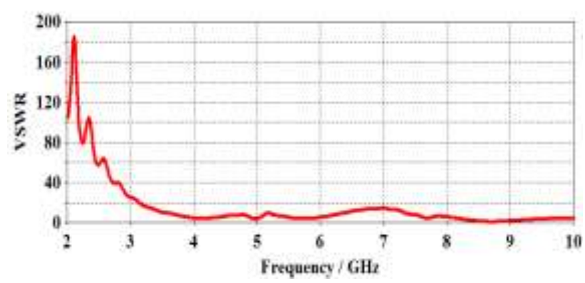

Fig: 9 VSWR of proposed antenna

Voltage standing wave ratio of the proposed antenna is 1.002GHz throughout the entire frequency band. VSWR must be less than 2GHz.

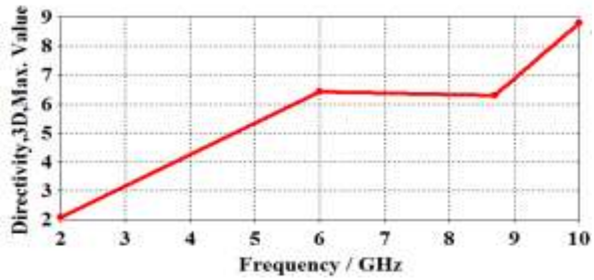

Fig: 10 Directivity of proposed antenna

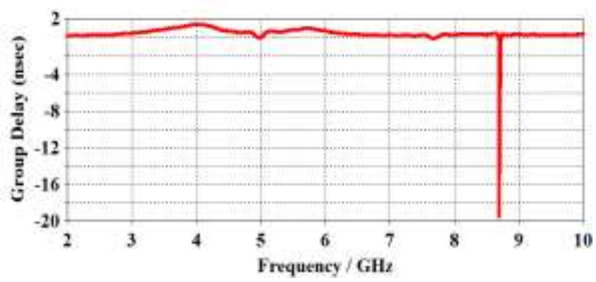

Fig: 11 Group delay of proposed antenna

Group delay is a measure of phase distortion. Group delay is the actual transit time of a signal through a device under test as a function of frequency. When specifying group delay, it is important to specify the aperture used for the measurement. Group delay can be observed with in the frequency range of 8.704GHz.

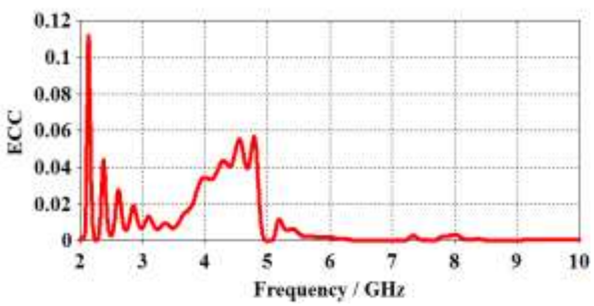

Fig: 12 Envelop correlation coefficient of proposed antenna

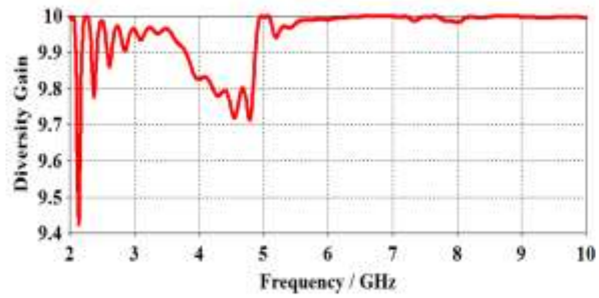

Fig: 13 Diversity gain of proposed antenna

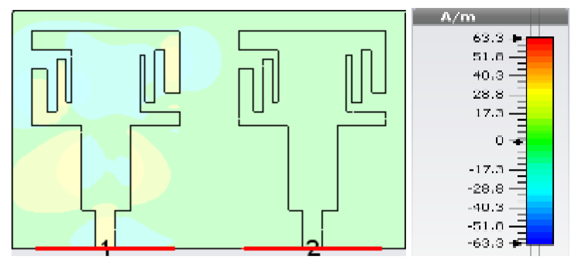

Fig: 14 Electric field of the proposed antenna with resonance

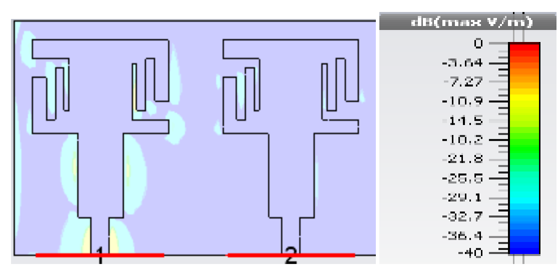

Fig: 15 magnetic field of proposed antenna with resonance

E- Field H- Field

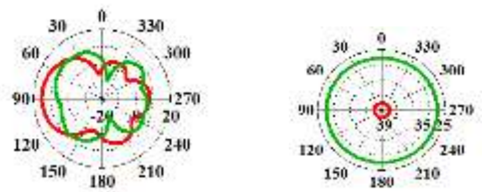

Fig: 16 Radiation pattern of the proposed antenna at 8.704GHz

The radiation characteristics of the proposed design is studied its operating frequency is 8.704GHz. Radiation patterns observed at both E-plane and H-plane

CONCLUSION

The compact F-Shape antenna for C-Band applications is designed and simulated with the frequency 8.704GHz. This band can be used for radars communication. SISO and MIMO for the proposed antenna using microstrip patch, FR-4 (Lossy) substrate and ground plane are designed and analysed using CST 2014 software. Other parameters such as gain, S_{12} and VSWR also have been improved. The returnloss (S_{11}) of the proposed structure is -57.31dB and mutual coupling coefficient S_{12} is -26.49 dB.The VSWR of the proposed structure is less than 2 over the entire band of operating frequency.

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