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Design of Omnidirectional Single Band Bent F-Shaped Microstrip Antenna for Wireless Applications

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Abstract-The design of the antenna is a bent F-shaped structure with single band. It has minimal return loss, better gain and efficiency. This antenna has a better gain and return loss at 7.568 GHz. The gain of the antenna is 3.298 dB at 7.568 GHz. It is a narrow band antenna with return loss of -19 dB. The radiation characteristics of the antenna is Omnidirectional. This F-shaped structured antenna has an exact impedance matching 50.82 ohm. The F-shaped structured antenna represents antenna with two different arm length. This antenna is designed using FR4 dielectric substrate with permittivity 4.4.The thickness of the substrate is 0.8 mm. The antenna is simulated using CST software.

Keywords: - F shaped antenna, FR4 material, c-band, single band, microstrip patch.

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I. INTRODUCTION

The key idea of the project is to design a single band microstrip antenna which can provide better gain and efficiency at 7.568 GHz and used for various applications. A number of attempts were made to increase the gain of the antenna by changing the port and the patch dimensions. The gain of the antenna is 3.298 dB with return loss of -19 dB. The substrate material used is FR4 glass epoxy with copper lossy in it. The thickness of the substrate is 0.8 mm. The permittivity of the substrate is 4.4.The structure of the antenna is F-shaped where the ground is a copper material. The significance of the project is to remove the middle stub of the antenna which makes the difference from the base paper. Though the cost is effective it has a good performance. The main advantage of using this antenna is its small size and light weight. This antenna has Omnidirectional radiation characteristics. The proposed model is microstrip antenna with two stubs working in a single band for better coverage quality. The simulation is performed with the help of CST software. The antenna has a small size with the structure of about 20×20 mm^2.

II. ANTENNA DESIGN

The proposed structure of the antenna has a gain of 3.298 dB, return loss of -19 dB at frequency of about 7.568 GHz. The thickness of the substrate FR4 is 0.8 mm with permittivity of 4.4 and loss tangent of 0.018. The antenna structure consist of a rectangular ground plane, a bent fork- shaped element with two arms of different lengths and a microstrip feed-line. The modified feeding structure is used to minimize the degradation of the radiation pattern which is caused due to the unsymmetrical fork-shaped element. An SMA connector is used for the connection of the feed-line for signal transmission.

III. EXISTING SYSTEM

'Design of an Omnidirectional Triple Band Bent-Fork Shaped Microstrip Monopole Antenna for Multi-band Applications' (2015)[2], the design of a microstrip monopole antenna working under triple band is presented in this paper. This proposed antenna has a bent F-shaped structure .It consists of three arms of different lengths in order to improve the input matching quality of the antenna at all operating bands .This antenna has 10 dB return loss. It is spread in the frequency ranges of 1.7-2.3 GHz, 5.1-5.7 GHz, 7.7-8.3 GHz with efficiency of about %30, %11.1 and %7 respectively. The antenna is simple and small in structure with dimension of 20×20 mm^2.This antenna is used for supporting PCS / Bluetooth, WLAN and X-band applications

A stepped feed-line is employed. The antenna has Omnidirectional radiation characteristics at its different frequency bands of operations.

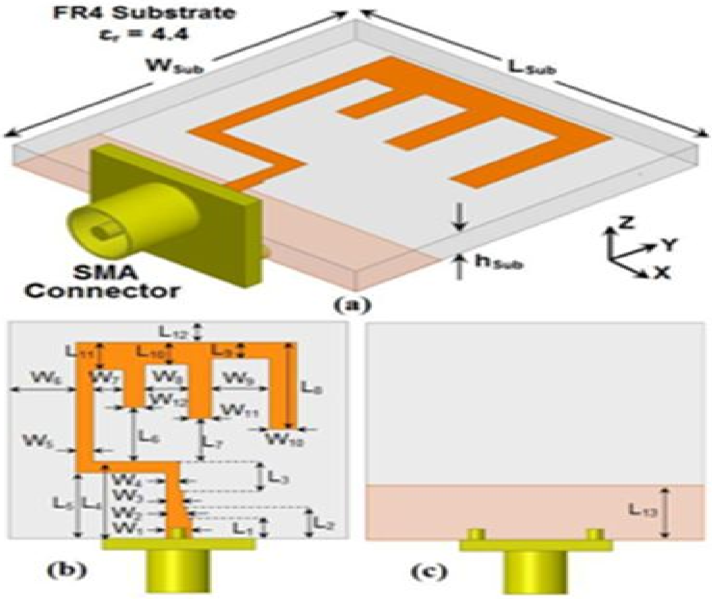

Fig.1. Bent Fork Antenna

This antenna structure consists of a truncated rectangular ground plane, a modified stepped microstrip feed-line, a modified bent fork-shaped radiating element which itself consists of three arms with different length creates three distinguishable resonance. A SMA connector is connected to the feed line for signal transmission.(a)side view,(b)top view,(c) bottom view

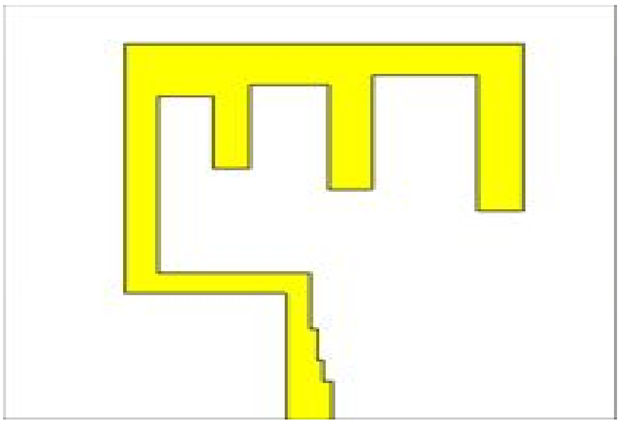

Fig.2.With two folded arms and a microstrip stub between them as a radiating structure

There are three frequency bands in fig.2(1) 1.7-2.3GHz,(2) 5-5.9GHz,3) 7.6-8.3GHz Which support PCS, Bluetooth, WLAN, X-band.

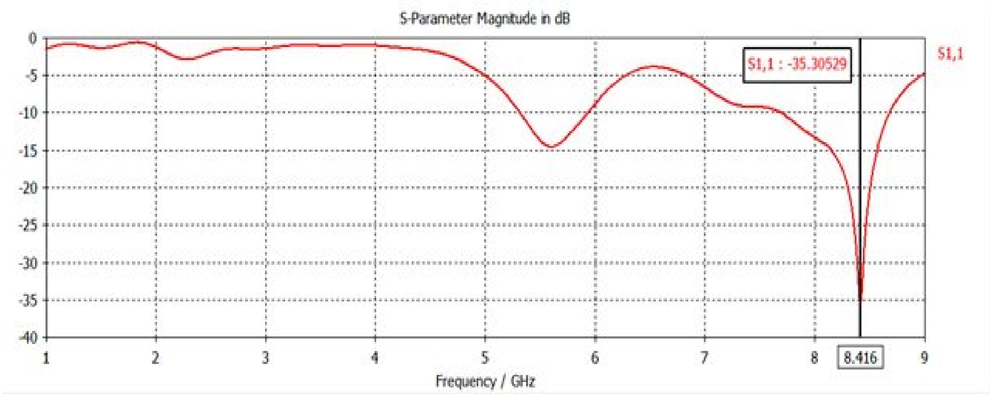

Fig.3.Simulated frequency response of the antenna

The simulated result explains us the following:
The return loss is -35 dB which operates at frequency of about 8.416 GHz .$S_{1,1}$ represents one input port and one output port. It is a narrow band antenna. The minimum frequency is 1GHz and the maximum frequency is 9 GHz.

IV. SUBSTRATE DESCRIPTION

FR4 stands for Flame Retardant 4 glass epoxy has a wide variety of electrical and mechanical applications. Mechanical support, heat conduction, electrical interconnection these are the purpose for the substrate.FR4 consists of a woven glass fiber mesh soaked in organic polymer(epoxy) with copper .it is commonly referred to as copper clad laminates. It is a common material for PCB (Printed Circuit Board).Thickness of the copper is 0.035mm. A thin layer of copper foil is laminated to one or both sides of FR4.The FR4 and copper thickness can both vary and so are specified separately. Its application includes construction of switches, standoff, washer, arc-shields. It is cheap and easily available material. It is not a good choice for antenna operating at higher frequency.

V. SOFTWARE DESCRIPTION

CST is Computer Simulation Technology .A powerful tool for 3D electromagnetic components. The CST products have been used to simulate are couplers, filters, antennas, PCBs, waveguides, sensors, electrical mechanics etc. It is efficient computational solution for electromagnetic design and analysis also able to choose the most appropriate method for the design and optimization of devices operating in a Wide range of frequencies. Other software for antenna simulation includes HFSS (High Frequency Structure Simulator) and ADS (Advanced Design System) compared to other software it takes less time to produce the output .HFSS and CST is used for design of small antenna .It is not opted for large geometric structures like reflector antenna.

VI. SIMULATION OF F-SHAPED PATCH ANTENNA

Microstrip or patch antennas are becoming increasingly useful because they can be printed directly onto a circuit board. F shaped antenna is fed by microstrip line feed. This simulation makes the antenna flexible in terms of generating resonant frequency and bandwidth. Microstrip antennas are becoming very widespread within the mobile phone market. Patch antennas are low cost, have a low profile and are easily fabricated.

1. **SUBSTRATE**:

The substrate material is FR-4 (LOSSY) normal material. Its permittivity is 4.4.The substrate dielectric constant has effect on the directivity, bandwidth and the efficiency of an antenna. After much research the 4.4 dielectric constant material is chosen as it serves the antenna radiation and its efficiency.

2. **GROUND**:

The ground plane material chosen is a hard drawn copper and it is a lossy metal too. Ground thickness is 0.036mm.The ground plane is an electrically conductive surface, connected to electrical ground .In printed circuit board, a ground plane is a large area of copper foil on the board which is connected to the power supply ground terminal and serve as a return path for current from different components on the board. The ground plane controls the radiation from spreading in different directions.

VII. DESIGN CALCULATIONS

Loss tangent = 0.018
Thickness h = 0.8 mm

Length of the substrate L_S is
$L_S = 2L$ =18.44mm (3.1)
Width of the substrate W_S is
Ws = 2W =24.1mm (3.2)
Height of the substrate H_S is
Hs =0.8mm (3.3)

The calculations for finding the length, width and height of the ground plane is given below.[1]

Length of the patch plane $L = L_{eff} - 2\Delta L$ =9.218mm (3.4)

Since the length of the patch has been extended by ΔL on each side, the effective length of the patch is now

Effective length is $L_{eff} = \frac{C}{2f_0\sqrt{\varepsilon_{reff}}}$ = 9.95mm (3.5)

The Width of the patch plane is found using,

$$W = \frac{C}{2f_0\sqrt{\varepsilon_r + 1/2}}$$

Width of the patch plane = 12.050 mm (3.6)

Length of the ground plane $L_g = 6H + L$ = 14.018mm (3.7)

Width of the ground plane $W_g = 6H + W$ = 16.85mm (3.8)

Length of the substrate $L_s = 6H + L$ = 18.436mm (3.9)

Width of the substrate $W_s = 6H + W$ = 24.1mm (3.10)

The extended incremental length of the patch ΔL is found using,

$$\Delta L = \frac{0.412(\frac{W}{H}+0.264)(\varepsilon_{reff}+0.3)}{(\varepsilon_{reff}-0.258)(\frac{W}{H}+0.8)} = 0.366\text{mm} \quad (3.11)$$

Effective dielectric constant of the patch is found using,

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1 + 12\frac{H}{W}\right)^{\frac{1}{2}}$$

Effective dielectric constant =3.968 (3.12)

Dielectric constant $\varepsilon_r = 4.4$

Frequency of operation = f = 7.568GHz

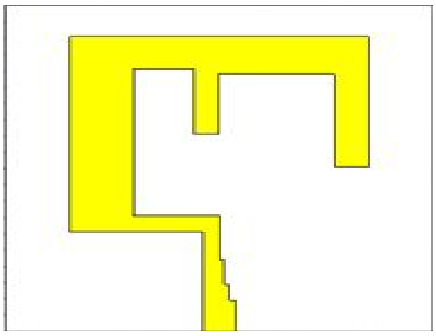

Fig.4. Structure of the antenna – F-shaped with two stubs

The antenna consists of two stubs with the middle stub removed from the bent fork antenna.

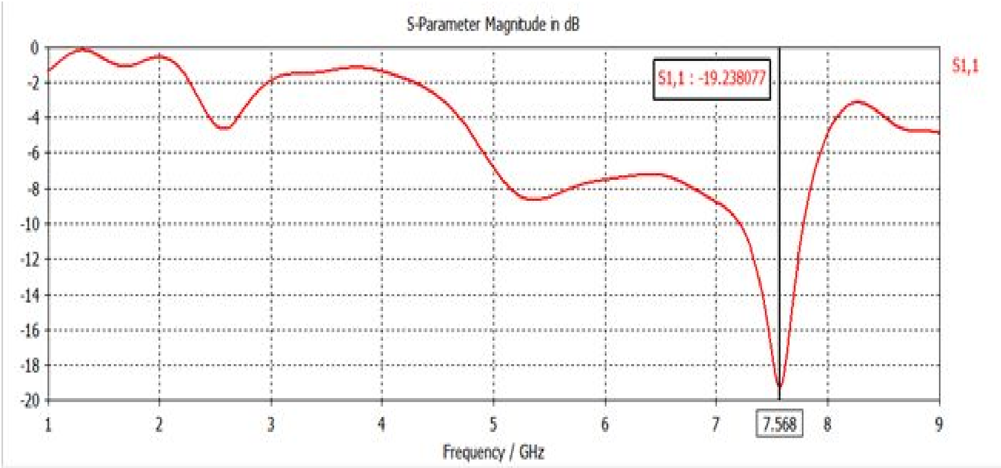

Fig.5 Simulated frequency response for single band antenna

The simulated results explain us that, the return loss is -19 dB which operates at frequency of about 7.568 GHz .$S_{1,1}$ represents one input port and one output port. It is a narrow band antenna. The minimum frequency is 1GHz and the maximum frequency is 9GHz.

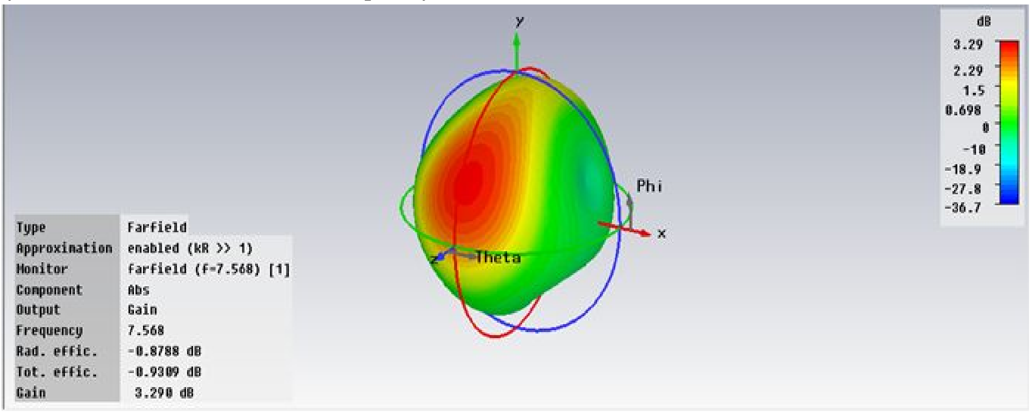

Fig.6.Radiation pattern of the antenna

With reference to the diagram, the red region depicts the radiation intensity of the antenna.

S.NO	SMITH CHART (OHM)	FREQUENCY/RETURN LOSS	GAIN (dB)	PATCH DIMENSION	PORT DIMENSION
1	66	5.784 / -14 dB	2.374	1.5(PATCH WIDTH)	0.75
2	66	5.89 / -16 dB	2.179	1.8(PATCH WIDTH)	0.5
3	61.78	5.89 / -16 dB	1.948	-	0.7
4	58.92	5.89 / -14 dB	2.11	-	0.9
5	56.9	5.842 / -14 dB	1.819	-	1.2
6	55.98	5.842 / -14 dB	2.048	-	1.5
7	53.97	5.752 / -14 dB	2.467	-	2
8	53.44	5.744 / -15 dB	2.453	-	2
9	53.05	5.712 / -15 dB	2.396	-	2.5
10	53.04	7.584 / -20 dB	2.739	4 to 6(FIRST STUB)	-
11	52.21	7.592 / -20 dB	2.674	-	2.8
12	52.06	7.596 / -20 dB	2.606	-	3
13	51.05	7.576 / -18 dB	2.438	-	3.5
14	50.5	7.576 / -19 dB	2.387	-	4
15	50.5	7.568 / -19dB	3.298	-	4

Tab1.Tabulation of values from the initial state to the final state

We initially got impedance as 66 ohm ,gain as 2.374 dB and then after changing the dimensions of the patch of the antenna we found the impedance to be 61.78 ohm and gain to be 1.948 dB. Then after changing the port dimension the impedance was 53.05 ohm with the gain of 2.396 dB. Again changing the patch dimension from 4 to 6 in the first stub of the antenna ,we got 53.04 ohm as impedance and gain as 2.739 dB. Thereafter, we changed the port dimensions for the successive calculations and finally reached the impedance of 50.5ohm with gain of 3.298 dB.

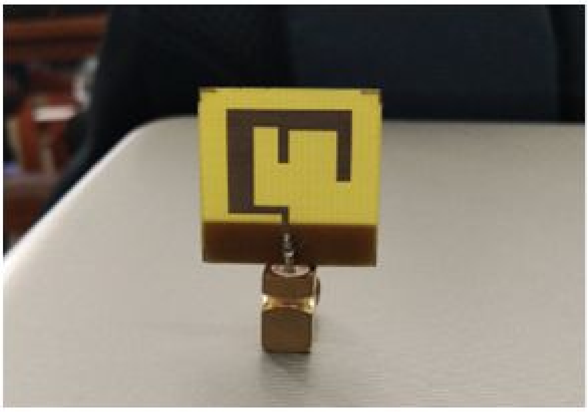

Fig.7.Fabricated antenna – Front side

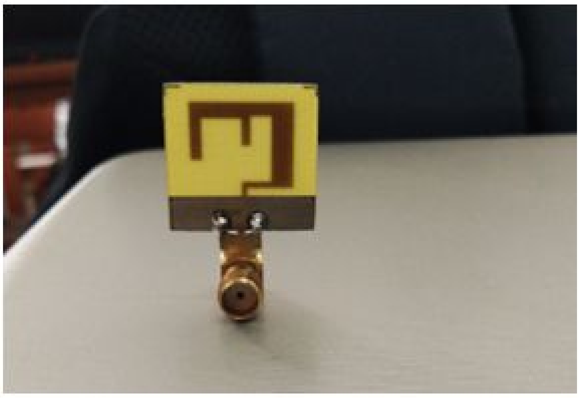

Fig.8.Fabricated antenna – Rear side

VIII. TEST RESULTS

The practical antenna results tested using network analyzer of Agilent technologies are shown below.

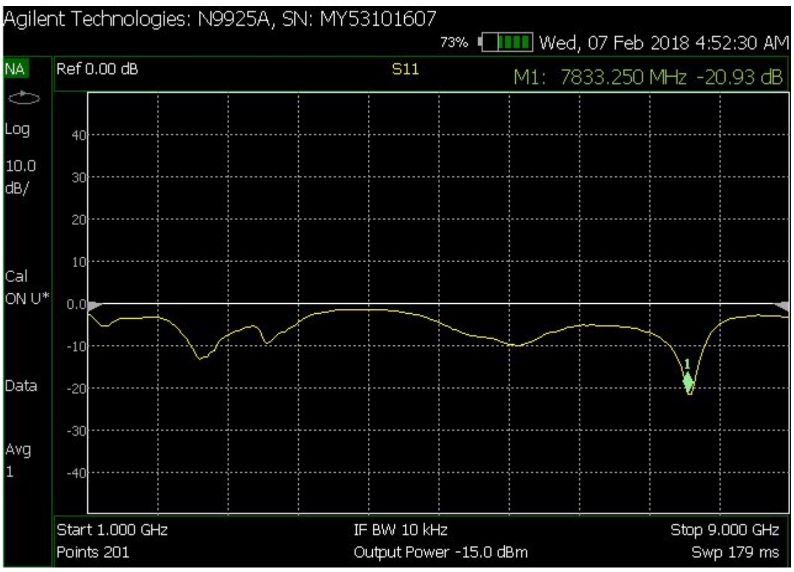

Fig.9.Return loss

The test results of the antenna states that antenna has a return loss of -20 dB. Return loss is defined as the loss of power in the signal due to the discontinuity in the transmission. It is the measure of energy reflected back at the port in the network. Return loss= input power/reflected power.

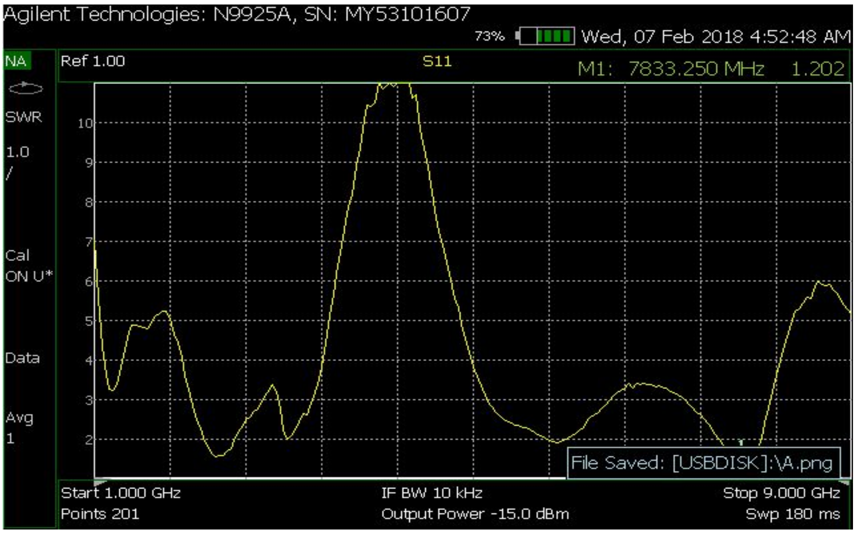

Fig.10.VSWR

The test results of the antenna states that antenna has a VSWR of below 2. The ratio of the maximum voltage to the minimum voltage in a standing wave is known as Voltage Standing Wave Ratio.

IX. CONCLUSION

The antenna is designed and simulated using CST software. It works well in frequency of about at 7.568 GHZ. It is much more appreciable since it is small in size. It is cheap and the substrate is easily available. It is simple in its structure . we have concluded that the antenna works well in this frequency which has return loss of -19 dB and gain of about of 3.298 dB. Hence it can be used for various applications.

REFERENCES

[1] Constantine A. Balanis (1982), 'Antenna Theory analysis and design' (2nd edition)

[2] J.Nourinia, P.Rezai, A.valizade and B.mohammadi (2015), 'Design of an omnidirectional triple band bent-fork shaped microstrip monopole antenna for multiband applications', *(ICEE), IEEE, CA, pp.546-549*.

[3] Ling Xu, Joshua le-Wei Li (2012), 'A dual band microstrip antenna for wearable application', *(ISAPE2012), IEEE, CA, pp.109-112.*

[4] R. Srividhya, S.Srinivasan (2016), 'A compact multiband partially reflective surface antenna for XBAND and WLAN applications', *(ICDCS), IEEE, CA, pp.23-27.*

[5] Dr.R.B.Waterhouse(2003), 'Microstrip Patch Antennas: a designer's guide, RMIT University