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Design and Bandwidth Enhancement of Double 'T' Slot Loaded Microstrip Patch [MSP] for Broadband Applications

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Abstract: In this paper, a compact size rectangular patch antenna is designed, analyzed and fabricated. The bandwidth enhancement of microstrip patch [MSP] antenna is done by cutting 'T' slots into the dimension calculated rectangular patch. The designed microstrip patch antenna is suitable for the use of many broad band applications. The operating frequency band of designed microstrip patch antenna is (2.18-3.3GHz) with 40.87% fractional bandwidth .The gain has been improved up to 4.18dBi, directivity 4.25dBi and efficiency 99.94 %. The proposed double 'T' slotted MSP is suitable for L and S-band operations. The proposed double 'T' slotted microstrip patch [MSP] antenna is simulated using IE3D Zealand simulation software based on method of moments. The antenna is fed by 50Ω microstrip line feed.

Keywords: Calculated ground plane, Calculated microstrip patch [MSP], Enhanced bandwidth, IE3D simulator, 50Ω microstrip line feed.

1. Introduction

Broadband devices are mainly practiced in our daily lives such as mobile phone, radio, laptop with wireless connection and MSP antennas play a important role in these devices [1]. In this paper the purpose of new design antenna presents to enhance the bandwidth of a compact rectangular slot shaped MSP antenna for many broadband applications such as military, wireless communication, satellite communication, global positioning system (GPS), RF devices, WLAN/WI - MAX application etc [2], [3]. The major drawbacks of MSP antennas in basic form are narrow bandwidth and low gain [4]. Then many techniques are used to enhance bandwidth and gain of MSP antennas. By using thick substrate with low dielectric constant and compact slotted patch can enhance the bandwidth and gain of antennas up to greater extent [5].
The MSP antenna have some good features such as low cost, low profile, light weight, high efficiency, easy to manufacture and implement with circuits [2], [5], [6]. The design structure components of antenna become small in size and have low processing cost [3].

In this paper method of moments is used to analysis the rectangular MSP antenna. The design resonant frequency of rectangular MSP antenna is 2.1GHz with 50Ω microstrip line feed. MSP antenna is characterized by using thickness (*H*), dialectic constant (ε_r), and length (*b*,*d*), width (*a*,*c*) of ground plane and patch. The performances of design MSP antenna such as radiation pattern, return loss, directivity, VSWR and gain are simulated by using IE3D software.

2. Antenna Design

The mathematical formula is used to calculate the dimensions of ground plane and micro strip patch in the form of length and width.

2.1 Width Formula of Rectangular MSP Antenna [7], [8].

$$W = \left(\frac{c}{2 f_r}\right)\left(\frac{\varepsilon_r + 1}{2}\right)^{-0.5}$$

Where c = 3×10^8 ms^{-1}, ε_r =4.2, f_r =2.1GHz

2.2 Formula of Effective Dielectric Constant [8], [9].

$$\varepsilon_{eff} = \left(\frac{\varepsilon_r + 1}{2}\right) + \left(\frac{\varepsilon_r - 1}{2}\right)\left(1 + \frac{12W}{H}\right)^{-0.5}$$

At H=1.6mm

2.3 Formula of Length Extension of Antenna [7], [8].

$$\Delta L = .412H\left(\frac{\varepsilon_{eff} + .3}{\varepsilon_{eff} - .258}\right)\left(\frac{\left(\frac{W}{H}\right) + .264}{\left(\frac{W}{H}\right) + .8}\right)$$

2.4 Length Formula of Rectangular MSP Antenna [10], [14].

$$L = \left(\frac{c}{2 f_r \sqrt{\varepsilon_{eff}}}\right) - 2\Delta L$$

2.5 Length and Width Formula of the Ground Plane of Antenna [3], [7].

$$L_g = L + 6H$$

$$W_g = W + 6H$$

3. Antenna Design Specifications

The design of proposed antenna is shown in Figure1. The proposed antenna is designed by using glass epoxy substrate which has a dielectric constant 4.4 and the design frequency is 2.1 GHz.
Height of the dielectric substrate is 1.6 mm and loss tangent *tan* δ is 0.0013. Antenna is fed through a line feed which is energized by 50Ω Microstrip feed line. All the specifications are given in the table1. (All lengths are in mm and frequency in GHz).

Table 1: Parameters for Antenna Design.

Sr.No.	Parameters	Value
1.	Design frequency fr	2.1
2.	Dielectric constant ξr	4.4
3.	Substrate height	1.6
4.	Loss tangent , *tan* δ	.0013

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Table 2: Designed Structure parameters

Sr.No.	Parameters	Value
1.	Ground plane width , a	53
2.	Ground plane length , b	42
3.	Patch width , c	43.4
4.	Patch length , d	32.4
5.	e	20
6.	f	8.2
7.	g	21.4
8.	h	15
9.	i	10
10.	j	12
11.	k	5
12.	l	13.4
13.	m	3.2
14.	n	4.7

The calculated design of a compact double ‘T’ slotted Microstrip patch antenna is shown in Figure 1.

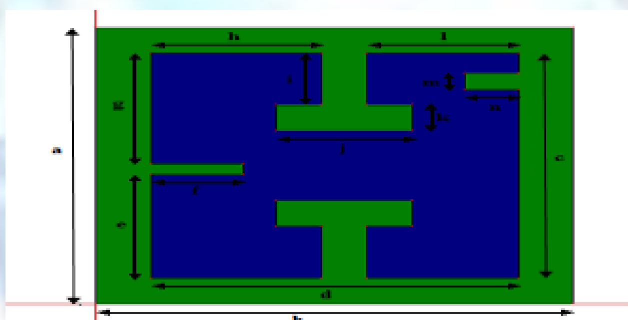

Figure 1: Geometry of Design Antenna and All Dimensions in mm.

IV. Simulation Result and Discussion

The simulation performance of design MSP antenna is analyzed by using IE3D software at define resonant frequency of 2.1GHz and antenna successfully obtained 2.35GHz resonant frequency at peak point of return loss. The graph of return loss Vs frequency is taken at the maximum frequency of 3.5GHz which is shown in Figure 2,The enhances bandwidth 1120MHz (40.87% fractional bandwidth) of design antenna is obtained at calculated resonant frequency of 2.35GHz.

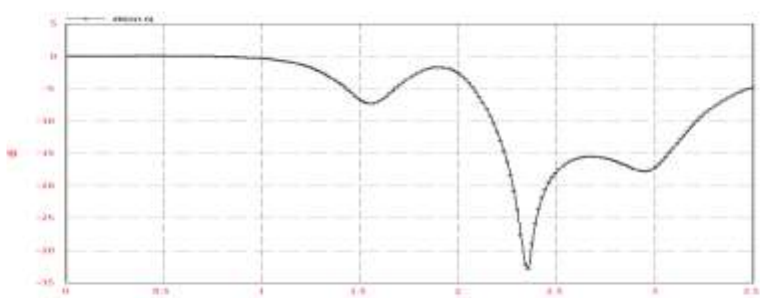

Figure 2: Return Loss vs. Frequency Graph

In Figure 3, the graph of Gain Vs Frequency shows the total field gain of the MSP antenna and obtain maximum gain of antenna is 4.18dBi at frequency 2.95GHz.

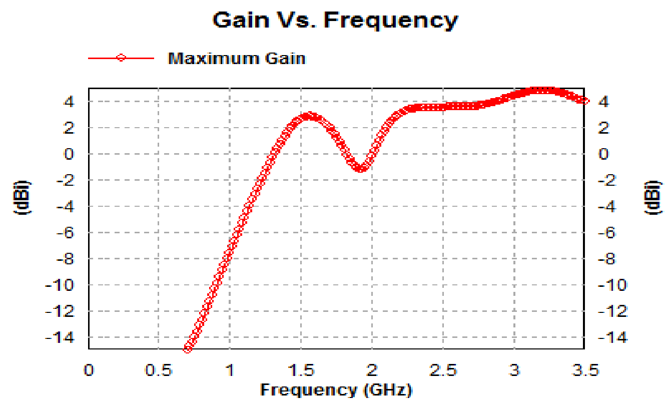

Figure 3: Gain vs. Frequency Plot

In Figure 4, the graph of Efficiency Vs Frequency represents radiating efficiency and antenna efficiency. The obtain percentage antenna efficiency is 99.9491% at 2.35GHz

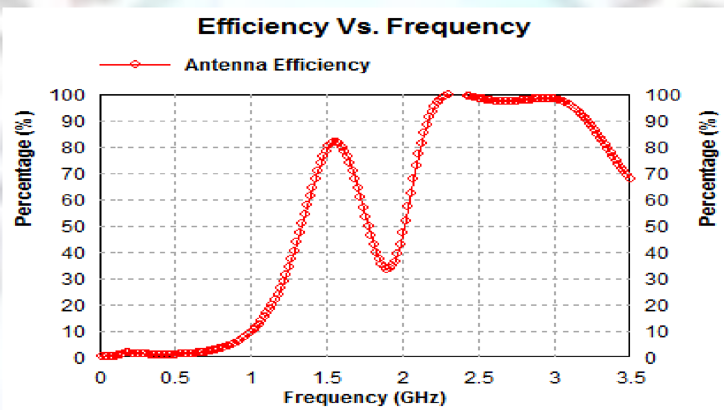

Figure 4: Efficiency vs. Frequency Plot

In Figure 5, the graph of VSWR Vs Frequency represents that the bandwidth of design antenna is useful or not. The obtain VSWR is 1.046 at resonant frequency of 2.35GHz.

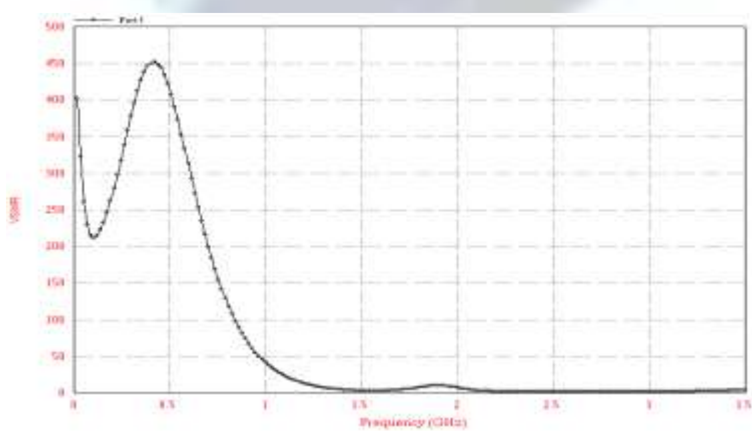

Figure 5: VSWR vs. Frequency Plot

In Figure 6, the graph of 2D radiation pattern of antenna represents radiating all power in one direction therefore design antenna has unidirectional radiation pattern. 2D radiation pattern of antenna is shown at resonant frequency 2.35GHz and phi=0(deg), phi=90(deg).

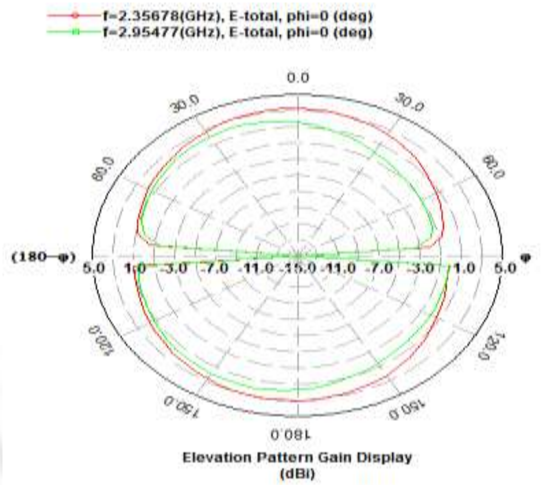

Figure 6: 2D Radiation Pattern of Antenna

In Figure 7, the graph of total field Directivity Vs Frequency represents the ratio of radiation intensity in a given direction from the antenna to the radiation intensity averaged over all direction [11]. The obtain directivity of antenna is 4.25dBi at frequency 2.95GHz.

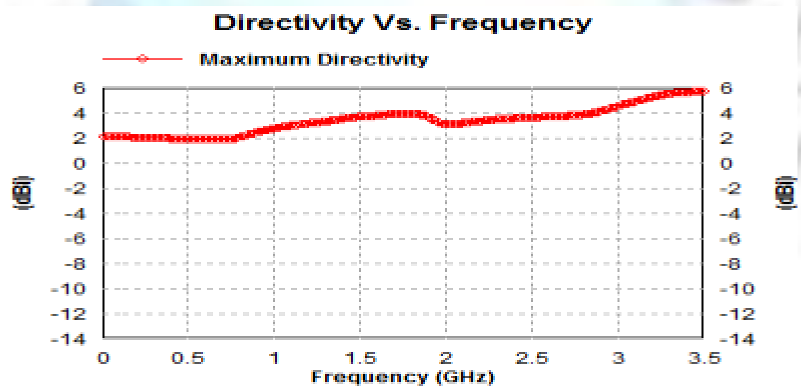

Figure 7: Directivity vs. Frequency Plot

In Figure 8, the graph of Axial-Ratio Vs Frequency represents the ratio of the major axis to the minor axis of the polarization ellipse and the resulting pattern shows an oscillating pattern [15].

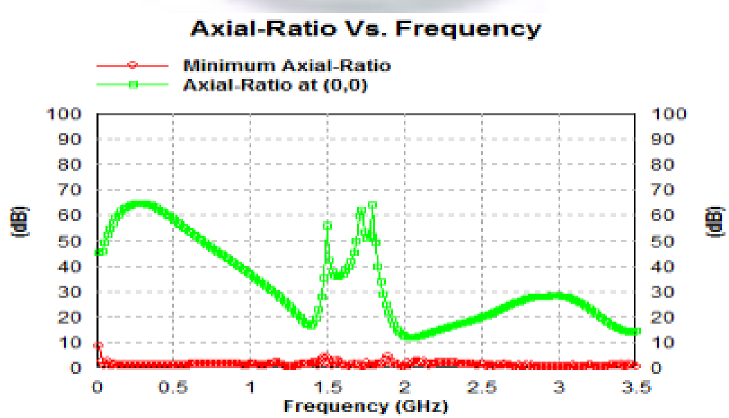

Figure 8: Axial-Ratio vs. Frequency Plot

VI. Acknowledgment

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Conclusion

In this paper, a compact double 'T' slotted rectangular microstrip patch [MSP] antenna with 50Ω microstrip line feed has been designed. The enhance bandwidth of design antenna is 1120MHz (40.87% fractional bandwidth), operating frequency range 2.18-3.3GHz and gain (4.18dBi), efficiency (99.95%), return loss (-32.93dBi) and VSWR (1.046) is obtained. The simulated result of design antenna shows good performance and thus can be used as various broadband applications such as missile, wireless, satellite, mobile communication, and military.

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