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Bandwidth Enhancement and Analysis of Designed Rectangular Microstrip Patch [MSP] Antenna using Compact Rectangular Slotted Technique for Wideband 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 rectangular 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 1.456-3.104GHz with 72.28% fractional bandwidth .The gain has been improved up to 4.28dBi, directivity 4.33dBi and efficiency 99.54 %. The proposed rectangular slotted MSP is suitable for L and S-band operations. The proposed rectangular 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.

Key words: 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 2.2GHz 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. Mathematical Formula To Calculate The Dimensions Of Microstrip Patch [Msp] Antenna

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]

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

Where c = 3×10^8 ms^{-1}, ε_r =4.2, f_r =2.2GHz

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

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

H=1.6mm

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

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

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

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

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

$$L_g = L + 6H$$
$$W_g = W + 6H$$

3. Antenna Design Specification

Calculated dimensions of ground plane is constructed by using resonant frequency (f_r), dielectric constant (ε_r), substrate thickness (H) and loss tangent (*tan* δ) and 50Ωmicrostrip line feed is fed into patch. Calculated dimensions are obtained by formula and compact rectangular slotting is done on the rectangular patch.

Table 1: Antenna Design Specifications

Sr. no.	Antenna Parameter	Data
1.	Resonant frequency (f_r)	2.2GHz
2.	Substrate thickness (H)	1.6mm
3.	Dielectric constant (ε_r)	4.2
4.	Loss Tangent (*tan* δ)	.0013

4. Antenna Design Procedure

Using the above equations and geometrical parameters, dimensions of antenna is calculated. In the design of antennas first calculate the dimensions of ground plane and patch then antenna is constructed by using dimensions after that slots cut into the microstrip patch.

Table 2: Calculated Antenna Dimensions in mm

S.No.	Parameters	Value
1.	**Ground plane width , a**	**51.1**
2.	**Ground plane length , b**	**40.6**
3.	**Patch width , c**	**41.5**
4.	**Patch length , d**	**31**
5.	**e**	**19**
6.	**f**	**18.4**
7.	**g**	**16.8**
8.	**h**	**7**
9.	**i**	**7.2**

10.	**j**	**9.7**
11.	**k**	**20.2**

The calculated design of a compact rectangular slotted microstrip patch antenna is shown in Figure 1.

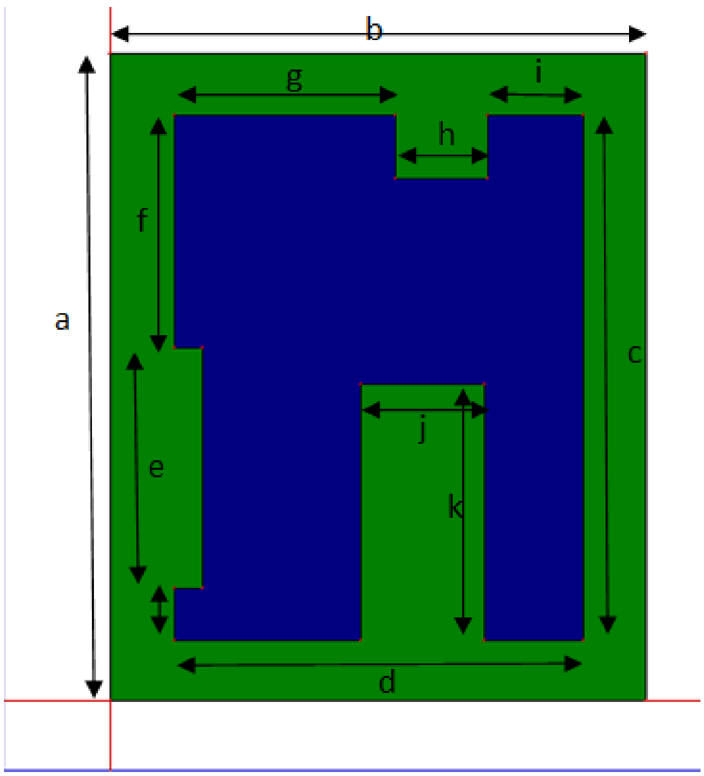

Figure 1: Geometry of Proposed Antenna

5. Simulation Result And Discussion

In Figure 2, The simulation performance of design MSP antenna is analyzed by using IE3D software at define resonant frequency of 2.2GHz and antenna successfully obtained 1.8GHz resonant frequency at peak point of return loss. The plotted graph of return loss Vs frequency is taken at the maximum frequency of 3.5GHz which is shown in Figure 2,The enhances bandwidth 1648MHz (72.28% fractional bandwidth) of design antenna is obtained at calculated resonant frequency of 1.78GHz.

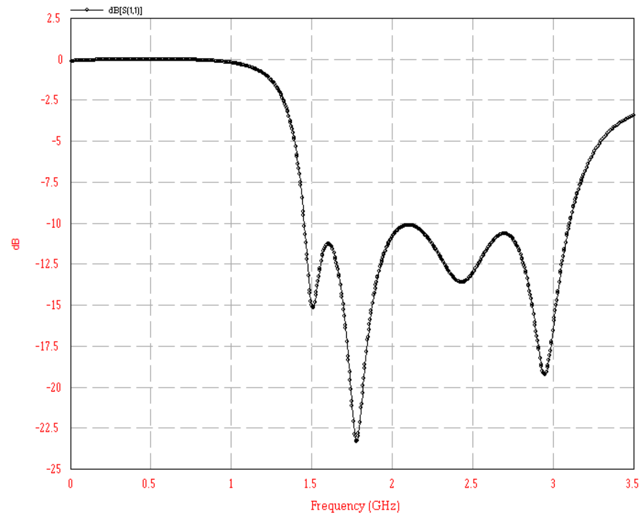

Figure 2: Return Loss vs. Frequency Graph

In Figure 3, the plotted graph of Gain Vs Frequency shows the total field gain of the MSP antenna and obtain maximum gain of antenna is 4.275dBi at frequency 2.95GHz.

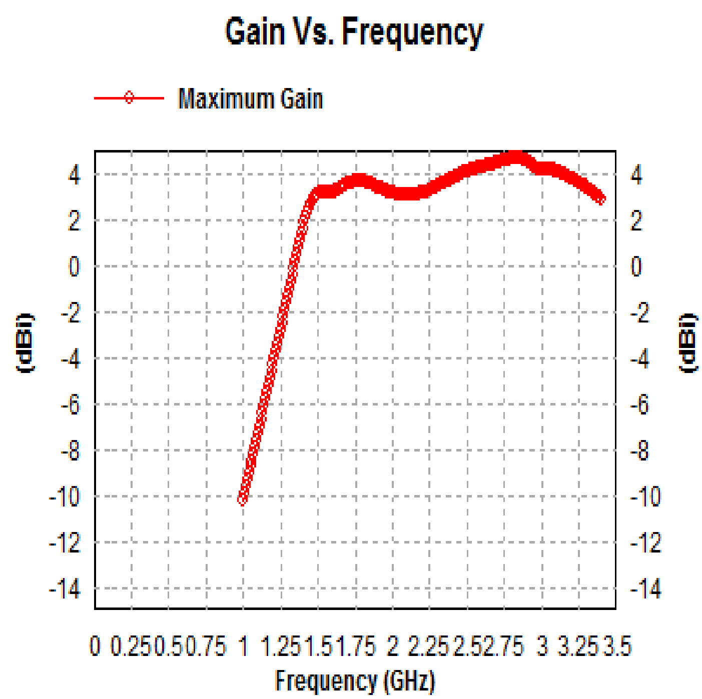

Figure 3: Gain vs. Frequency Plot

In Figure 4, the plotted graph of Efficiency Vs Frequency represents radiating efficiency and antenna efficiency. The obtain antenna efficiency in percentage is 99.54% at 1.78GHz

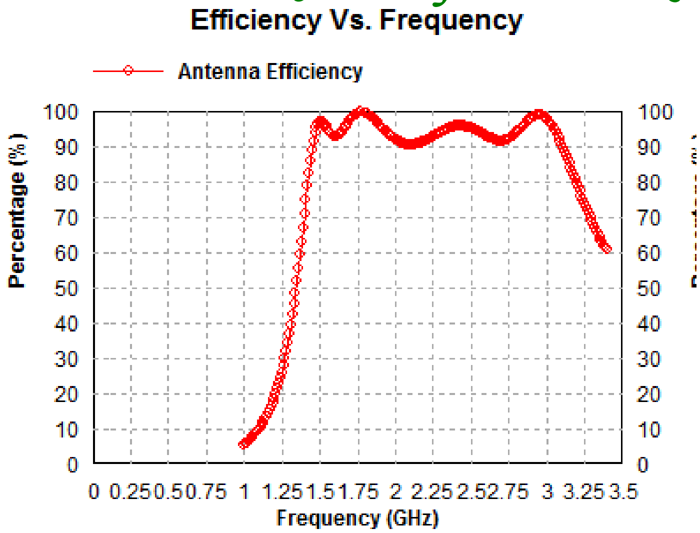

Figure 4: Efficiency vs. Frequency Plot

In Figure 5, the plotted graph of VSWR Vs Frequency represents that the bandwidth of design antenna is useful or not. The obtain VSWR is 1.146 at resonant frequency of 1.78GHz.

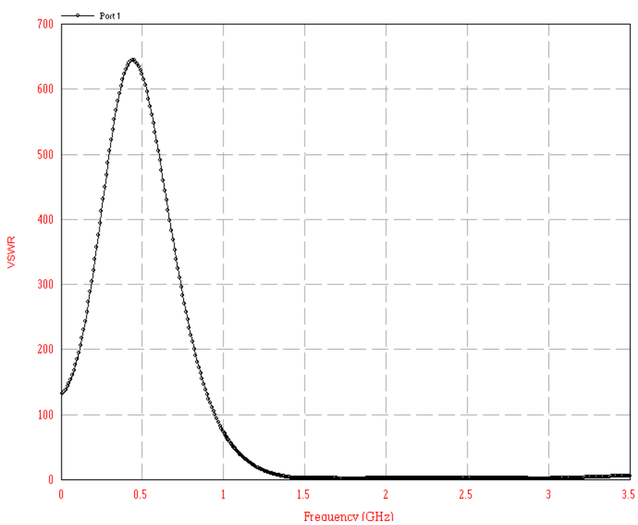

Figure 5: VSWR vs. Frequency Plot

In Figure 6, the plotted 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 1.78GHz and phi=0(deg), phi=90(deg).

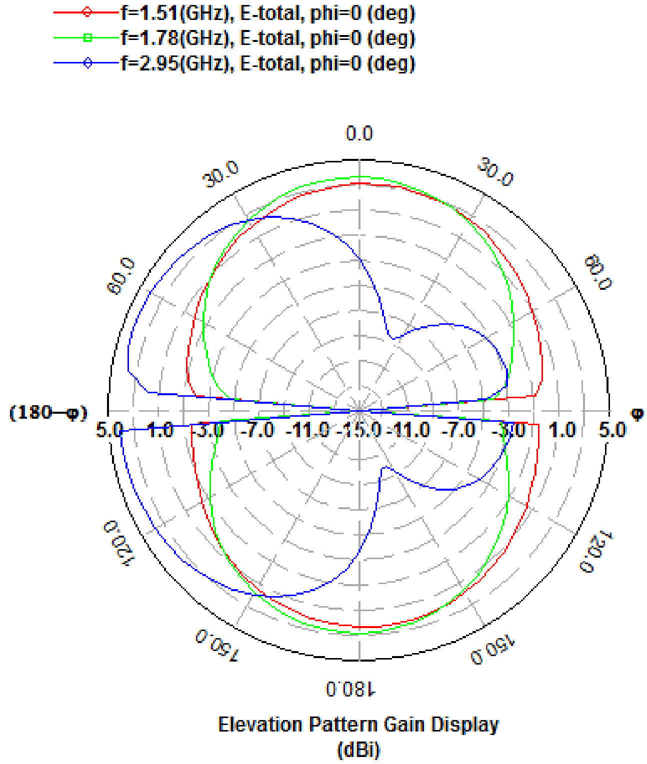

Figure 6: 2D Radiation Pattern of Antenna

In Figure 7, the plotted 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 4.327dBi at frequency 2.95GHz.

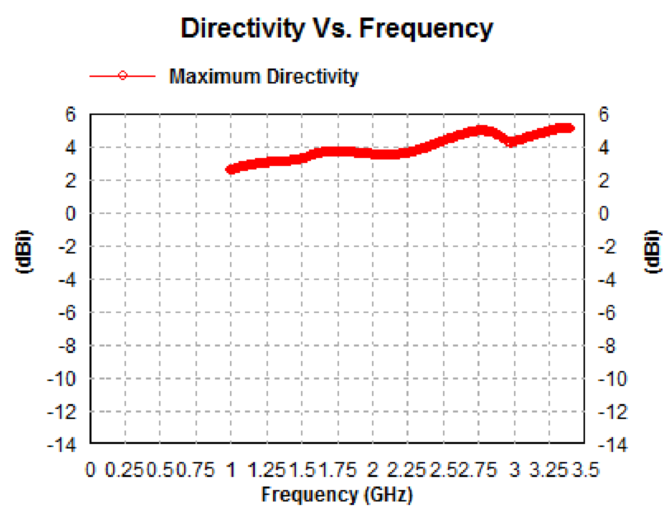

Figure 7: Directivity vs. Frequency Plot

In Figure 8, the plotted 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].

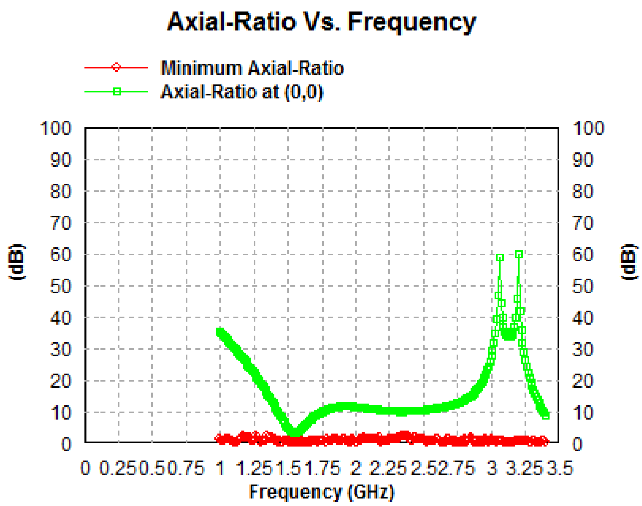

Figure 8: Axial-Ratio vs. Frequency Plot

6. CONCLUSION

In this paper a compact rectangular slotted rectangular microstrip patch [MSP] antenna with 50Ω microstrip line feed has been designed. The enhance bandwidth of design antenna is 1648MHz (72.28% fractional bandwidth), operating frequency range 1.456-3.104GHz and gain (4.275dBi), efficiency (99.54%), return loss (-23.37dBi) and VSWR (1.146) 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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