A Novel Design of Double M-Structure Rectangular Mircostrip Patch Antenna for Wireless communications

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Abstract

The approach is used to design a double M shape fed microstrip antenna, which is usually formed of four strips. This manner of designing is that mirror image designs are employed to improve the performance. The performance of a basic patch cannot be influenced by any single structure that does not have a mirror image. In this study, the two M-shaped structures are employed, and the results are in good agreement. These are some examples. These antennas have a variety of uses in today's world, including wireless communication. The experimental results suggest that, even though the proposed antenna has a low profile, low cast, and simple design, it may be used to improve the performance that has been obtained thus far. In order to assess the effectiveness of the offered solution, proposed antenna, the antenna is simulated through the simulation tool Zealand IE3D. The analysis of the antenna for different physical parameter values has been done by varying one of them and keeping improve result of a performance. It is carried out here to study the flexibility in designing of layer patch antenna.

Keywords*—Rectangular Mircostrip Patch Antenna, Bandwidth, VSWR, Return Loss, Ground Plane, FR4, Resonant Frequency*

1.Introduction

The development of the various types of antennas, for the different applications, is making wireless communication become a part of everyone's life. The technology is spreading throughout the world in many different applicationsIn recent years, advancements in communication systems have necessitated the creation of low-cost, light-weight, low-profile antennas capable of retaining excellent performance over long periods of time wide spectrum of frequencies [1]. In future the development of the personal communication devices will aim to provide image, speech and digital data communications at any time, and all around the world. It indicates that the future communication terminal antennas must meet the requirements of multi-band or wideband operations to sufficiently cover the possible operating bands. The performance and properties of the fabricated antenna was measured and compared with simulation results. Furthermore, we have highlighted the best FR4 to use for various applications such as antenna size reduction and other mode modification-related applications. A rectangular patch antenna array built on a FR4 substrate was compared to a similar array built on a regular FR4 substrate [2].In modern wireless communication systems, micro strip patch antennas are commonly used in the wireless devices. So,The antenna's shrinking has become a critical issue in lowering the overall size of the communication system. In today's wireless communication systems, there are a variety of options. micro strip patch antennas are commonly used in the wireless devices. The demand in commercial and military wireless systems is due to capabilities of proposed Antenna such as low weight, low profile, low cost, easily combined with design and technology, and relatively simple fabrication. All these antennas can also fabricate using IE3D simulation software and get sharp characteristics. Proposed RMPA can be widely used in many wireless communication systems because of their low profile and light weight.

In its most fundamental form, a mircostrip Patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side. The path of antenna is generally made of conducting material such as copper or gold and can take any possible shape. The radiation of patch and the feed lines are usually photo etched on the dielectric substrate.

Important parameters of any type antenna are impedance bandwidth and return loss. The bandwidth impedance depends8 on parameters related to the patch antenna element itself and feed used. The bandwidth is limited to a few percent [3]. So it is a disadvantage of basic microstrip patch antenna. The rectangular microstrip patch antenna made on FR4 improves the bandwidth and return loss in significant way. IE3D is a software package for the electromagnetic analysis and design, use to design the FR4 based rectangular microstrip patch antenna.

In this paper, we consider one modified design of antennas for single frequency. To improve the results, some types of ground structure are also utilized for minimizing the return loss and for increasing the bandwidth of the antenna [4].

2.Simulation of Simple Antenna Structure

The design parameters and results for a T-shaped rectangular microstrip patch antenna in IE3D software are explained and the results obtained from the simulations are easily demonstrated. The microstrip patch design is achieved by using different type probe feed technique. These numbers of patches were studied because they are having high bandwidth and gain. For conventional and popular probe-fed microstrip antennas with a thick substrate, the major problems are associated or present with impedance matching is the large or greater probe reactance owing to the required long probe pin in the very thick substrate layer. To solve this type of problem, a variety of designs with modified probe feeds have been reported. One design method is to cut an M slot in rectangular patch [4]. The radiating patch can be very high above the ground plane for this design and a long probe pin, it is not required. This type of behavior makes good impedance matching over a wide bandwidth.

The geometry of the proposed antenna is shown in figure 1 A rectangular patch of dimensions L x W separated from the ground plane using substrates a foam substrate (εr1) of thickness h1. The M-shape is located at mid of center of the patch antenna. The location and area of the slots on the patch can be specified by parameter W. The width and length of the slots are denoted by W and L. The rectangular patch is fed using 50Ω transmission probe [6].

The Figure1 depicts the simple proposed antenna's geometry (a). A rectangular microstrip patch with dimensions of L x W was from its ground plane by a substrate (l1) with a thickness of h1. In the centre of the different patch is a different shape. The 'W' can be used to specify the placement of the slots on the patches. W and L are the width and length of the slots, respectively [7]. A 50 output feed probe is used to feed the square patch are as follows:-

i. **Length (L)**: The two sides were chosen to be 45.66mm in length each.
ii. **Width (W)**: The two sides were chosen to be 35.12mm in length each.
iii. **Frequency of operation (FO)**: The transmitters' frequency response must be chosen carefully. For our design, we chose a resonance frequency of 2 GHz.
iv. **Substrate low dielectric (r)**: The dielectric material that we used for our design has a refractive index of 4.432. Because it decreases the size of the transmitters, a high dielectric constant substrate was used.
v. **Height of dielectric material (h)**: It is critical microstrip patch antennas used in cellular system are not too bulky. As a result, the dielectric substrate has a height of 1.6mm.
vi. **Length (L) and Cutting Width (w)**: 5 mm and 10 mm were chosen as the length and width, respectively.

3.Mircostrip Patch Antenna Design

The sequential designing steps of Mircostrip patch Antenna design are as follows:-

Step 1:Calculation of Width (W)

The Mircostrip patch antenna's width is specified as,

$$\frac{1}{2Fr\sqrt{(\mu\varepsilon)}}\sqrt{\left(\frac{2}{(\varepsilon r+1)}\right)}=\frac{C}{2Fr}\sqrt{\left(\frac{2}{(\varepsilon r+1)}\right)} \tag{1}$$

Replacing c = 3.00e+008 m/s, εr = 4.4 and FO = 2.0 GHz

Step 2:Computation of Effective dielectric constant (εreff):

The effective dielectric constant is,

$$\varepsilon ff=\frac{\varepsilon r+1}{2}+\frac{\varepsilon r-1}{2}\left(\frac{1}{\sqrt{1+\frac{12h}{w}}}\right) \tag{2}$$

Step 3: Computation of the Effective length (L_{eff})

The effective length is,

Replacing E_{eff} = 4.40, c = 3.00e+008 m/s and FO = 2.0 GHz

Step 4: Computation of the length extension (ΔL)

$$L_{eff} = \frac{C}{2 f_0 \sqrt{\varepsilon_{reff}}} \quad (3)$$

Step 5: Computation of actual length of patch (L)

The actual length is obtained by,

$$\Delta L = 0.412h \frac{(\varepsilon_{ref} f + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (4)$$

Step 6: Computation of VSWR

$$L = L_{eff} - 2\Delta L \quad (5)$$

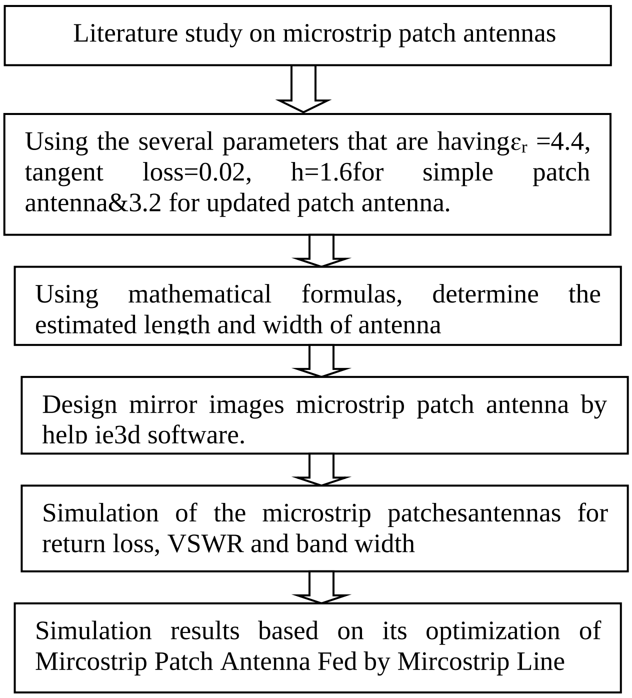
Step 7: Computation of Return Loss

$$VSWR = \left(\frac{1+|\Gamma|}{1-|\Gamma|}\right) \quad (6)$$

The return loss is calculated as follows,

$$RL = 10\log_{10}(\Gamma)\,dB \quad (7)$$

4.Methodology



By the help this calculation, similarly dimensions of modified antenna can be calculated.
The software used to model and simulate the Microstrip patch antenna is Zeland IE3D. IE3D is a full-integrate wave electromagnetic simulator which is based on the method of moments. It analyzes 3D and multilayer structures of general geometrical shapes. It has been widely used in the design of MICs, RFICs, patch antennas, wire antennas, and other RF or wireless antennas [8]. It can be used to calculate or simulatedand plot the all the parameters like VSWR and Return Loss.

Proposed architecture of simple rectangular microstrip patch antenna is as follows:-
The configuration of proposed antenna is shown in figure 1. The proposed dimension of L & W and is printed on a substrate of thickness h=1.6 and relative permittivity =4.4. The print is etched on ground substrate.

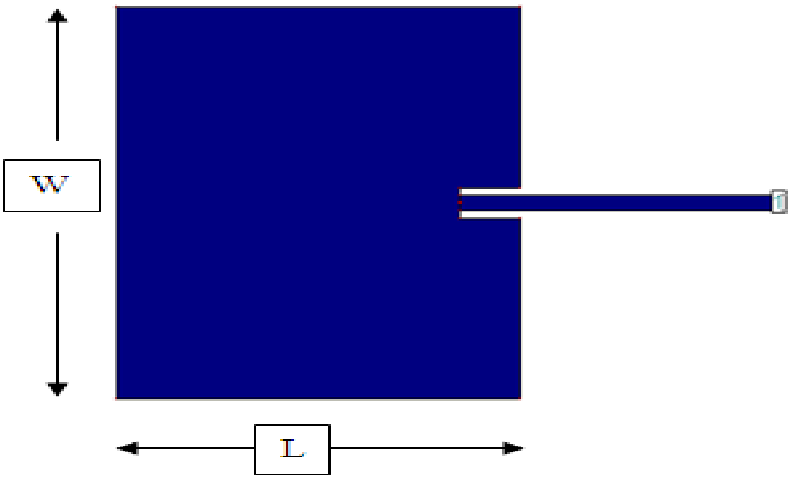


Fig. 1: Simulated geometry of Simple Patch Antenna

The slot is fed by a 50Ω microstrip line. The basic rectangular microstrip line fed printed antenna design for exciting having an operating frequency at around 2 GHz, the dimension of determined by where c is called as the speed of light in the air, h is called the effective dielectric constant and L is the length of Simple Rectangular Microstrip Patch Antenna Fed by Microstrip Line. A microstrip patch antenna is designed for the resonant frequency 2 GHz [9]. The length of the patch is 35.44136mm and its width is 45.6435 mm. The length of the microstrip line is 35.44136mm which used for the feeding purpose. For the designing of this antenna we took a both sided copper PCB. On the lower side of PCB copper field acts as the ground for this antenna and the on the upper side of the PCB we designed the patch of giving dimensions mentioned in table 1. The whole geometry is simulated and raised practically using a dielectric substrate of height 1.6mm and having a dielectric constant 4.4mm and Loss tangent of the material is should be 0.02. Microstrip feeding technique is used for providing the feed to the antenna.

Table 1: Summary of Design Parameters of Simple Patch Antenna

Frequency	2GHz
Length	35.44mm
Width	45.64mm
Cut width	5.0 mm
Cut depth	10 mm
Path length	32.82 mm
Path width	3.009 mm
Return loss	-26.16 dB
VSWR	1.132

5.Results Analysis

- **Parameter Display and Bandwidth Calculation**

The simulation is done by varying feeding positions and s-parameter is studied for each simulation and tabulated by taking each case. Thus the enhanced bandwidth of rectangular microstrip patch is obtained at probe feed position (1, 0).

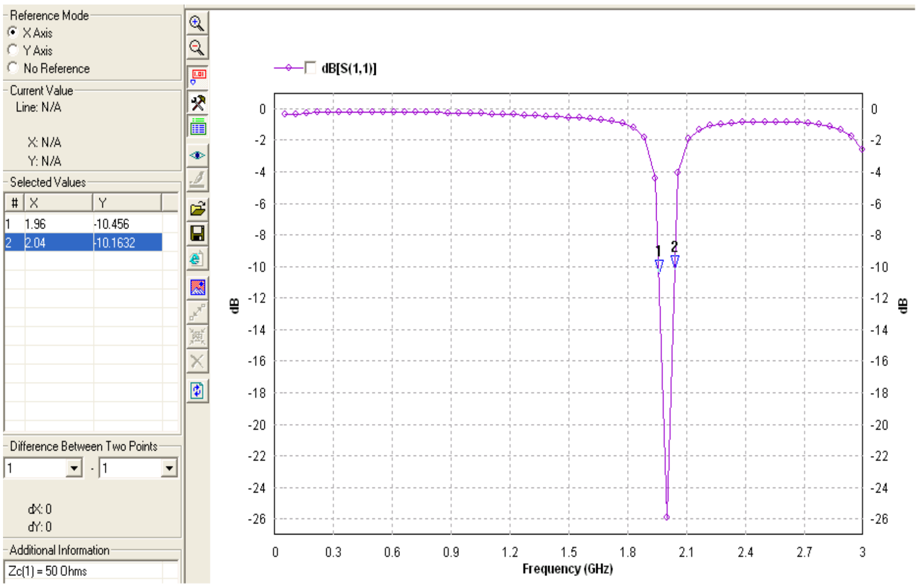


Fig. 2: S11 parameter Display

The simulation is done by varying feeding positions and s-parameter is studied for each simulation results by taking each case. Thus the enhanced bandwidth of T-shape rectangular microstrip patch is obtained at probe feed position (1, 0).

At feed point :(1, 0) as shown in table 2.

Table 2: Feed Points

Frequency	F_1=1.96 GHz	F_2=2.04 GHz
Bandwidth	Bandwidth= (f_2-f_1) *100/ F_c	Bandwidth= 9%

- **Bandwidth Calculation:**

The bandwidth calculation at feed position (1, 1), maximum bandwidth is achieved. From the figure 2, frequency f1 is taken as 1.96 GHz and frequency f2 is taken as 2 GHz. Therefore the bandwidth is obtained after doing calculation as shown in figure 3.3 as 9%.

- **Return Loss:**

The return loss at feed position (1, 1),we have getreturn loss from the figure 2,the return loss is obtained -26db.

- **VSWR:**Less than 2,

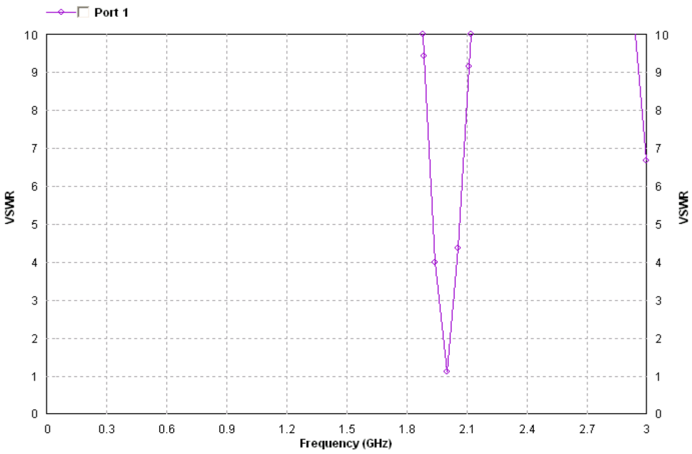


***Figure 3**: VSWR for Simple Patch Antenna*

- **Designing of M shape Rectangular microstrip patch antenna(RMPA)**

Figure 3 depicts the proposed RMPA transmitter. The suggested L&W dimension is printed on a substrate with a height of h=1.6 and a comparative capacitance of 4.4. On a base substrate, the print is scratched. A 50-microstrip line feeds the slot. Figure 1 shows the basic square microstrip line fed printing transmitter layout.The working frequency for exciting is around 2 GHz, and the size is determined by Figure 1 depicts a Square Microstrip Patch Antenna fed by Microstrip Line, wherein c is velocity of sound in air, is efficient relative capacitance and L is length of the Rectangular Microstrip Patch Antenna[9] [10]. The resonance frequency of a microstrip patch transmitter is 2 GHz. The patch is 35.443mm in length and 45.656mm in width. The microstrip line has a length of 32.822mm and is used for feeding. We used a double-sided copper PCB to design this transmitter. The bottom layer for this transmitter is a copper field on the lower side of the PCB, and we constructed a perfect mirror T- patch with the given size on the upper side of the PCB. Using a dielectric with a thickness of 1.6mm and a dipole constant of 4.4mm, the entire geometry is modeled and increased effectively [11]. The material's loss tangent is 0.02. The feed to the transmitter is provided via the microstrip feeding method.

- **Geometry & Designing**

A little compact T form and I shape microstrip patch transmitter is presented in this study. We used mirror image designs to improve the performance of this T-and I shaped microstrip patch transmitter. The efficiency of a simple patch cannot be influenced by any single structure that lacks a mirror reflection. In this study, the two structures in the shape of T and I have been utilized, and outcomes are very similar. The T and I forms can help with impedance matching. Figures 1 and 2 depict the suggested microstrip patch satellite's design[12]. The patch antenna is small in size of 45.644mm x 35.142mm (W x L) and is built on a FR4 substrate with a depth of 3.2mm and an absolute dielectric constant (r) of 4.4.

A microstrip line with a cut length of 5 mm and a cut length of 10 mm feeds the burner. A 50 microstrip line with such a frequency of 2GHz is printed on the partially grounded substrate as the excitation.

The redesigned first and second ground planes serve as an impedance matching component in square microstrip patch antennas, controlling the resistance bandwidth Where ‘ws’ stands for antenna width and ‘ls’ stands for antenna length.

The suggested transmitter may be configured to function at 2.0GHz frequency by selecting these variables. The findings of both simulations and experiments are also discussed. The Zeland IE3D model yielded the simulation results in this research.

- **Design parameters of M shape Microstrip Patch Antenna**

Co-ordinates 1st

The slot size is,

WEIGTH	WS1	WS2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13
	8.5.	8.5	15.5	15.5	8.5	8.5	-8.5	- 15.5	- 15.5	-8.5	-8.5	-8.5	8.5
LENGTH	LS1	LS2	LS3	LS4	LS5	LS6	LS7	LS8	LS9	LS10	LS11	LS12	LS13
	3.8	9.8	9.8	17.8	8.22	8.22	17.8	10.8	10.8.	3.8	3.8	8.8	8.8

Co-ordinates 2nd

The slot size is,

WEIGTH	WS1	WS 2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13
	8.5.	8.5	15.5	15.5	8.5	8.5	-8.5	-15.5	-15.5	-8.5	-8.5	-8.5	8.5
LENGTH	LS1	LS2	LS3	LS4	LS5	LS6	LS7	LS8	LS9	LS10	LS11	LS12	LS13
	-3.8	-9.8	-9.8	-17.8	-8.22	-8.22	-17.8	-10.8	10.8.	-3.8	-3.8	-8.8	-8.8

The inset feed used is designed to have an inset depth of 10mm, feed-line width of 5mm and feed path length of 32mm. A frequency range of 2 GHz is selected and 151frequency points are selected over this range to obtain accurate results.

The center frequency is selected where the return loss is minimized.The bandwidth can be calculated from the return loss (RL) plot. The bandwidth of the antenna can be said to be those range of frequencies over which the RL is greater than -10 dB (10 dB corresponds to a VSWR of 1 which is an acceptable figure). Using IE3D, the optimum feed depth is found to be at *Y0* = 10mm where a RL of -34.12 dB is obtained. The center frequency of 1.9620 GHz is obtained which is very close to the desired design frequency of 2 GHz as shown in figure 4(a).

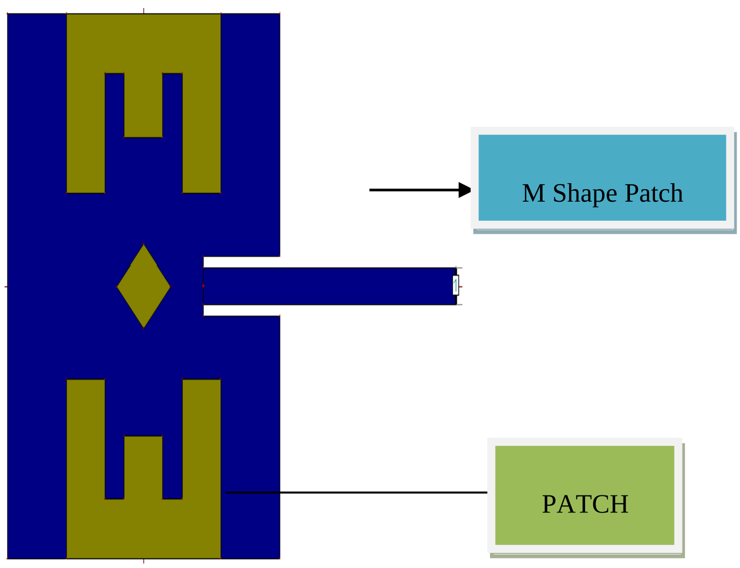


Fig. 4(a) Double M Shapes Rectangular Microstrip Patch Antenna

The bandwidth enhancement is due to much more vertical electrical current achieved in the patch through the M shape resulting in much regular distribution of the magnetic current in the slots. Figure shows the simulated current distribution of the proposed antenna at 2 GHz frequency. The use of M shape embedded on the microstrip patch shows as the most successful technique utilized by the use of mirror image double M shape approach [13]. This technique is confirmed by the simulation result shown in Figure 4 (b).

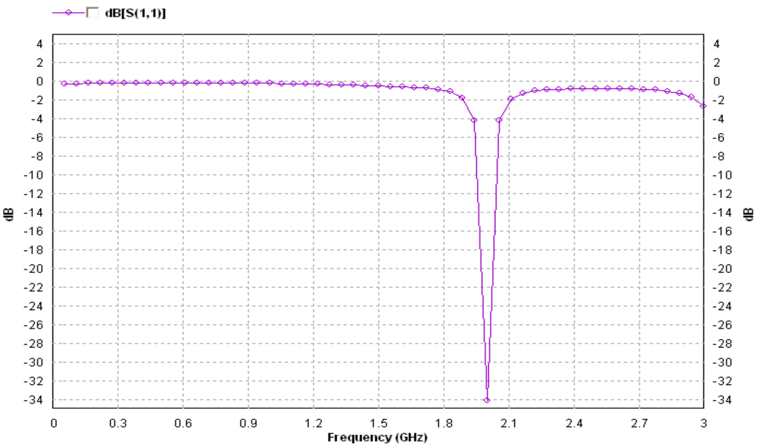


Figure4 (b)*: Simulation Results of Return Loss of M Shape Rectangular Microstrip Patch Antenna*

The graph of the VSWR versus frequency indicates that the value of the VSWR at all the four resonating dips is lesser than the 2 which indicates the good impedance matching capabilities of the given antenna at shown frequency ranges.

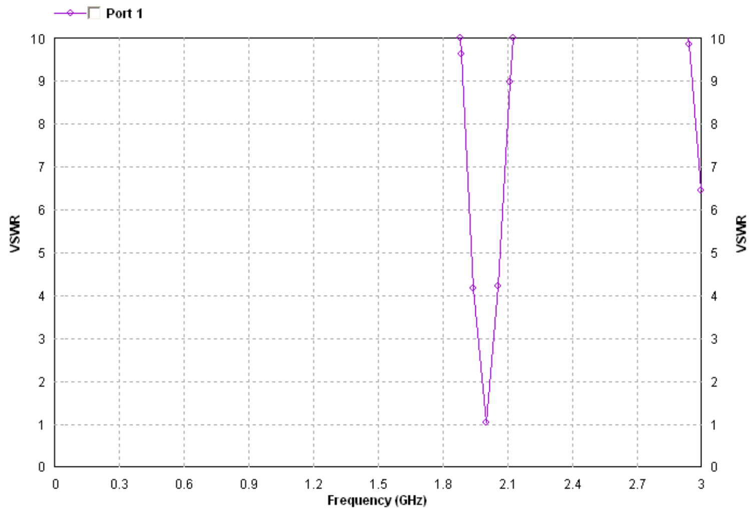


Figure 4(C): *VSWR for M Shape microstrip Patch Antenna*

The value of VSWR at 2 GHz is 1.051, 1.04, 1.03 and 1.021. That shown 4(c).The graph for impedance V/s frequency graph at each and every frequency point between 0 to 3GHz

5.Conclusion

The authors proposed antenna structure has been simulated using Zeeland's IE3D simulator. Figures of obtained results show the variation of return loss with frequency for the simulated microstrip patch antenna. In the process, the resonant frequencies for which minimum return loss occurs for various designs after the successful simulation of the proposed antenna and then a comparison is done between various simulated responses. The outcome of the return loss is -26db, and the VSWR is 1.141 in this simple RMPA design. Following that, it was discovered that the design of four modified antennas that give as an improve results. The graph of the VSWR versus frequency indicates that the value of the VSWR at all the five resonating dips is lesser than the 2 which indicates the good impedance matching capabilities of the given antenna at shown frequency ranges.

The simulated result of modified rectangular microstrip patch antenna with FR4 structure are shown Figure4 At 2GHz frequency simulated , when it is designed with FR4 structure at 3.2mm it shows return loss is -34.12dB and VSWR is 1.034 which shows significant reduction of return loss and VSWR using FR4 structure.

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