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Analysis and Design of Various Noval Microstrip Patch Antenna

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Abstract- In today's modern communication industry, antennas are the most important components required to create a communication link. Microstrip antennas are the most suited for aerospace and mobile applications because of their low profile, light weight and low power handling capacity. They can be designed in a variety of shapes in order to obtain enhanced gain and bandwidth, dual band and circular polarization to even ultra wideband operation. This paper provides a detailed study of the design of probe-fed Rectangular Microstrip Patch Antenna to facilitate effects of changing the feed point. By this paper we conclude that in the same patch we can take different feed points and same patch can be used for various applications. The main aim of this paper is to design various MSA for and analyze there results. For this first we simulate the results in IE3D and then we test these results practically after designing the hardware of the patch. In testing we find that our designed Microstrip antenna is very useful in Bluetooth technology for communication. The design parameters of the antenna have been calculated using the transmission line model and the cavity model. For the simulation process IE3D electromagnetic software which is based on method of moment (MOM) has been used.

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Deepak [α] & Dhaynendra Parashar [σ]

Abstract- In today's modern communication industry, antennas are the most important components required to create a communication link. Microstrip antennas are the most suited for aerospace and mobile applications because of their low profile, light weight and low power handling capacity. They can be designed in a variety of shapes in order to obtain enhanced gain and bandwidth, dual band and circular polarization to even ultra wideband operation. This paper provides a detailed study of the design of probe-fed Rectangular Microstrip Patch Antenna to facilitate effects of changing the feed point. By this paper we conclude that in the same patch we can take different feed points and same patch can be used for various applications. The main aim of this paper is to design various MSA for and analyze there results. For this first we simulate the results in IE3D and then we test these results practically after designing the hardware of the patch. In testing we find that our designed Microstrip antenna is very useful in Bluetooth technology for communication. The design parameters of the antenna have been calculated using the transmission line model and the cavity model. For the simulation process IE3D electromagnetic software which is based on method of moment (MOM) has been used.

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I. Introduction

Communication between humans was first by sound through voice. With the desire for slightly more distance communication came, devices such as drums, then, visual methods such as signal flags and smoke signals were used. These optical communication devices, of course, utilized the light portion of the electromagnetic spectrum. It has been only very recent in human history that the electromagnetic spectrum, outside the visible region, has been employed for communication, through the use of radio. One of humankind's greatest natural resources is the electromagnetic spectrum and the antenna has been instrumental in harnessing this resource.

Many wireless service providers have discussed the adoption of polarization, diversity and frequency diversity schemes in place of space diversity approach to take advantage of the limited frequency spectra available for communication [1-10]. Due to the rapid development in the field of satellite and wireless communication there has been a great demand for low cost minimal weight, compact low profile antennas that are capable of maintaining high performance over a large spectrum of frequencies. Through the years, microstrip antenna structures are the most common option used to realize millimeter wave monolithic integrated circuits for microwave, radar and communication purposes[11-35]. Compact microstrip antennas capable of dual polarized radiation are very suitable for applications in wireless communication systems that demand frequency reuse and polarization diversity.

a) Aim and Objective

The main aim of this paper to provide the very efficient bandwidth and return loss. For achieving this we designed many Microstrip antenna and obtained good results. If bandwidth is good then it can be used to any type of application. In here my work defines that at different feed points [41, 42] we can get a useful bandwidth where we can use the different devices. The performance comparison is based on, return loss, and bandwidth at all four different feed points in first MSA. In second patch we have simulate the patch at 4GHz, 5GHz, and 6GHz frequency and we find wideband width. And in third patch [37, 39] describe the phenomena of dual band.

II. Dimensions Calculation of 1st Proposed Antenna

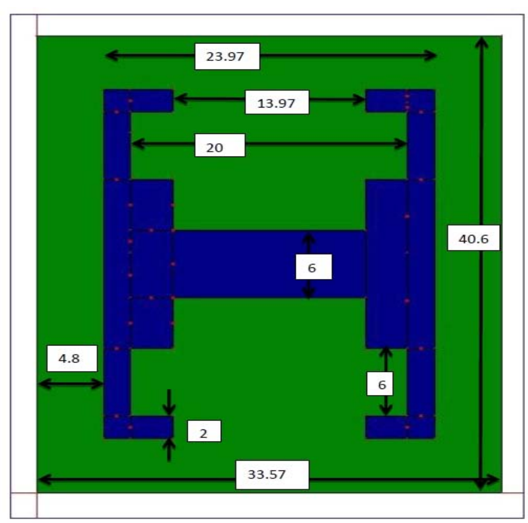

Figure 1 : Top view of Proposed Microstrip Patch Antenna

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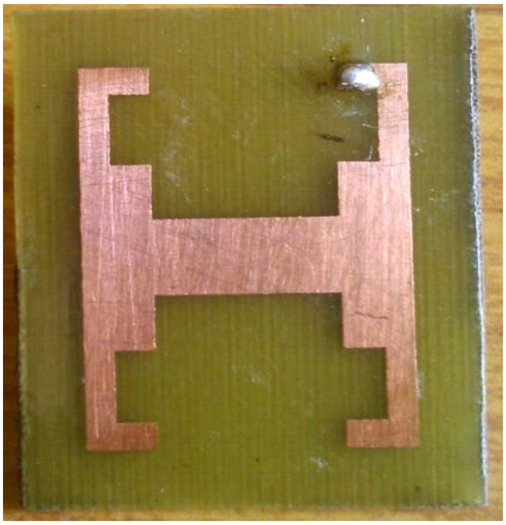


Figure 2 : Hardware of Proposed Microstrip Pa Antenna

a) Calculation of the Width (W)

The width of the Microstrip patch antenna [36] is given by equation (1) as:

$$W = \frac{c}{2f_r\sqrt{\frac{\varepsilon_r+1}{2}}} \quad (1)$$

Substituting c = 3e8 m/s, ε_r= 4.2 and f_r= 3 GHz, we get:

$$W = 0.03100 \text{ m} = 31.00 \text{ mm}$$

b) Calculation of Effective dielectric constant (ε_{reff})

Equation (2) gives the effective dielectric constant as:

$$\varepsilon_{reff} = \frac{\epsilon_r+1}{2} + \frac{\frac{\epsilon_r-1}{2}}{\sqrt{\left[1+12\frac{h}{w}\right]}} \quad (2)$$

Substituting ε_r= 4.2, W = 31.0 mm and h = 1.6 mm we get:

$$\varepsilon_{reff} = 3.86$$

c) Calculation of the Effective length (L eff)

Equation (3) gives the effective length as:

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

Substituting ε_{reff}=3.86, c = 3e8 m/s and f_r= 3 GHz we get:

$$L_{eff} = 25.44\text{mm}$$

d) Calculation of the length extension (ΔL)

Equation (4) gives the length extension

$$\text{as:}\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)} \quad (4)$$

Substituting ε_{reff}= 3.86, W = 31.0 mm and h = 1.6 mm we get

$$\Delta L = .7421 = 7.421\text{mm}$$

e) Calculation of actual length of patch (L)

The actual length is obtained by re-writing equation (5) as:

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

Substituting L_{eff}= 25.44 mm and ΔL = 7.421 mm we get:

$$L = 23.97 \text{ mm}$$

f) Calculation of the ground plane dimensions (L_g and W_g)

The transmission line model is applicable to infinite ground planes only. However, for practical considerations, it is essential to have a finite ground plane. It has been shown by [9] that similar results for finite and infinite ground plane can be obtained if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery. Hence, for this design, the ground plane dimensions would be given as:

$$L_g = 6h + L = 6(1.6) + 23.97 = 33.57\text{mm} \quad (6)$$

$$W_g = 6h + L = 6(1.6) + 31 = 40.6\text{mm} \quad (7)$$

g) Result of 1st Proposed Antenna by Simulation

The software used to model and simulate the microstrip patch antenna is ZelandInc's IE3D software. IE3D is a full-wave electromagnetic simulator based on the method of moments. It analyzes 3D and multilayer structures of general shapes. It has been widely used in the design of MICs, RFICs, patch antennas, wire antennas, and other RF/wireless antennas. It can be used to calculate and plot the S_{11}parameters, VSWR, current distributions as well as the radiation patterns. An evaluation version of the software was used to obtain the results for this thesis. For simplicity, the length and the width of the patch and the ground plane have been rounded off to the following values: L = 23.97 mm, W = 31 mm, L_g= 33.57 mm, W_g= 40.6 mm

Now when we take the first feed point at X=25.575 Y= 35.075 then we found the simulation result given below.

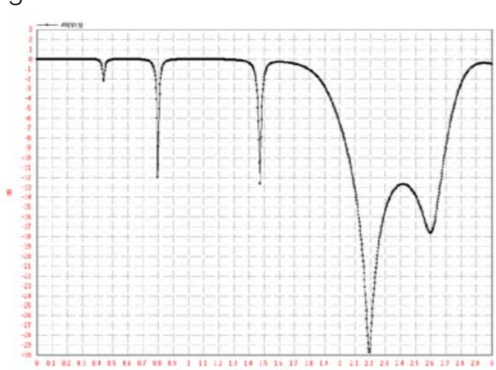


Figure 3 : Return Loss V Frequency Result at 1st FeedPoint

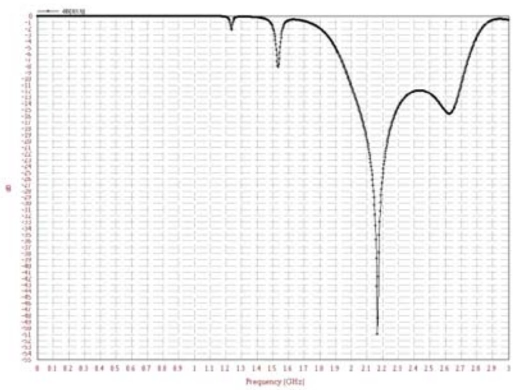


Figure 4 : Return Loss V Frequency Result at 2nd Feed Point

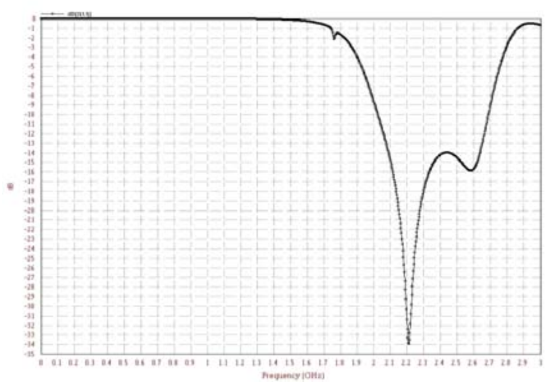


Figure 5 : Return Loss V Frequency Result at 3rd Feed Point

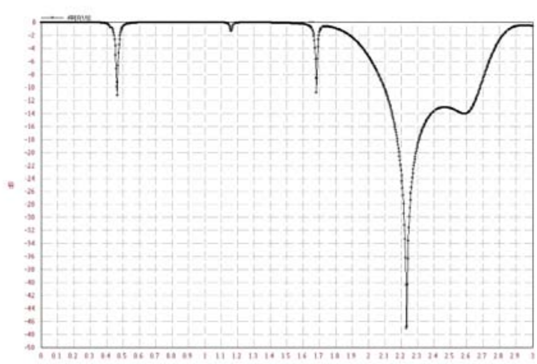


Figure 6 : Return Loss V Frequency Result at 4th Feed Point

From the simulation results of 1st feed point we are shown that return loss is below –10 db is maximum at frequency 2.2GHz is -30db.We can calculate the bandwidth for this patch at 1st feed point by given equation

$$B.W(\%) = 100\frac{F_{max} - F_{min}}{\frac{F_{max} + F_{min}}{2}} \quad (8)$$

F_{max} and F_{min} are frequency is maximum and minimum frequency at below -10db .In here F_{max}= 2.691GHz F_{min} = 2.054 we get B(%) = 26.84%.

Similarly for each feed point we can calculate the bandwidth of the patch.

Now form the above results we conclude that the proposed antenna give the various results at different feed points ,and all the results are useful for communication field without changing any other parameter we have found the useful results at all the feed points.

Table 1 : Performance table at different feed point

Feed points	1	2	3	4
X	24.575	7.75	8.525	24.875
Y	35.075	35.25	5.875	5.875
Return Loss	30	51	34	47
Bandwidth	26.84%	31.25%	28.69%	25%

At the 2nd feed point we have getting the best results in all others the feed points.

i. *Testing Result of 1st Proposed Antenna*

At the above 2.1 we have seen the simulated result of the patch using IE3D software. Now in this section we are shown the actual tested results of patch. Due to various losses and effects simulated results and actual testing results have some variations.

Figure 7 : Setup for Testing of a Patch

Figure 8 : Results at 2nd feed point

From the above given table we can see that return loss is goes below -10 db at frequency 2.10GHzand the maximum return Loss is obtained at frequency 2.32GHz is-41db. Return loss again goes above -10db at frequency 2.65GHz.

So from here we can calculate the bandwidth of patch at second feed point, because we test these patch at second feed point.

$$\text{Band width (\%)} = \frac{2.65-2.10}{\frac{2.65+2.10}{2}} \times 100 = 23.15\%$$

In the simulation we have find out these bandwidth is 31.25% between frequency 1.979 GHz to 2.71GHz and return loss is -51db.But as we already consider that due to various effects these results can be vary. But if we optimized then we can get more effective results.

In the given table comparison is shown between simulated and actual testing results

Table 2 : Comparisons between Simulated and Testing Results

Specifications	Testing Results	Simulation results
Return Loss	-41	-51
Band width (%)	23.15	31.25

h) Inverted T Shape Microstrip Antenna[43,44,45]

As we know the main drawback of microstrip patch antenna is its narrow bandwidth but it can be improved by various techniques. In here we are taking a patch and we simulate it 4GHz, 5GHz and 6GHz frequency and we observe that when we goes to higher frequency its bandwidth is improved. And at 6GHz we also obtained dual bandwidth. So our main work in here to improve the bandwidth of the patch by allocating the feed point at same location.

From the above formulas in we can calculate the W and L of the patch for different frequencies, table 4.4 are given below for the W and L.

Table 3

	4Ghz	5Ghz	6Ghz
W_g(mm)	32.856	28.205	25.104
L_g (mm)	27.404	23.686	21.197
W_e(mm)	23.256	18.605	15.504
L_e(mm)	17.804	14.085	11.597

In this work we are having the three same type of patch, but for each patch W and L are change because frequency for each patch are change. But in here we are shown the entire patch at 4GHz, 5GHz and 6GHz

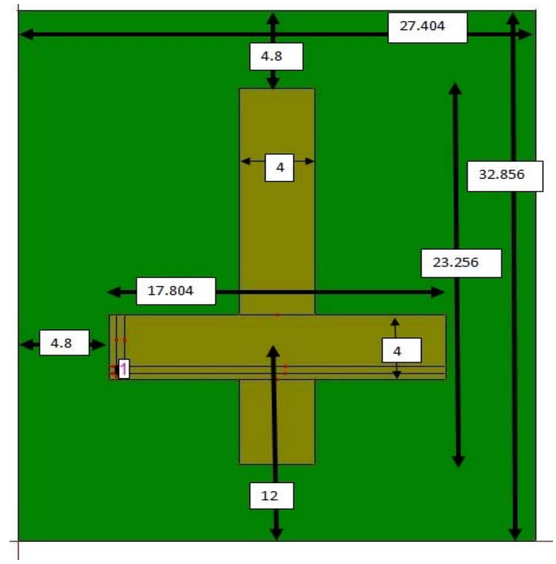


Figure 9 : Proposed patch at 4GHz

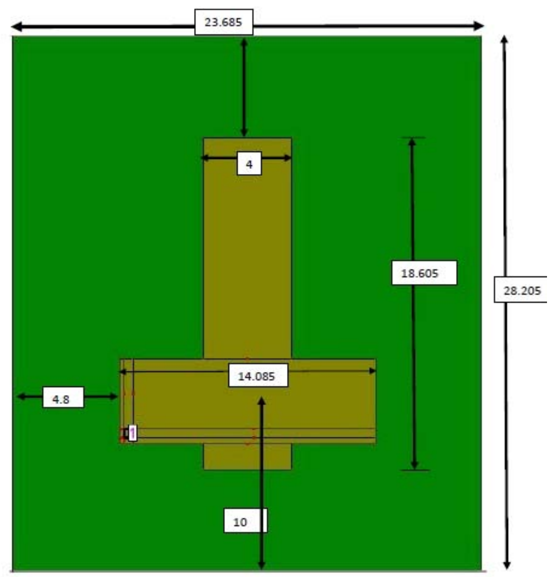


Figure 10 : Proposed patch at 5GHz

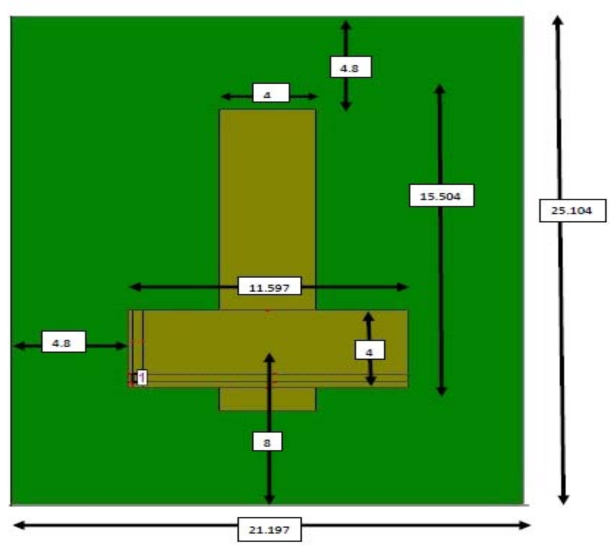


Figure 11 : Proposed patch at 6GHz

Figure 12 : Hardware of Proposed MSA

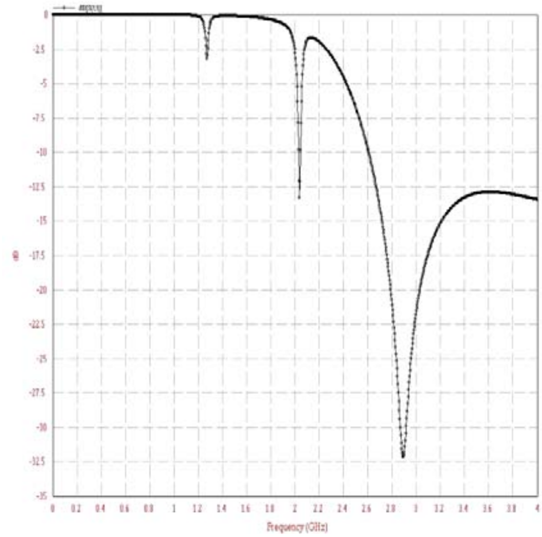


Figure 13 : Results at 4GHzFig.13 Results at 4GHz

i. *Results of Inverted T Shape Microstrip Antenna*

A proposed inverted T shapes patch is analyzed with a 4GHz, 5GHz, and 6GHz. This is found that by varying the operating frequency the size of patch changed [table.4.4] and a result is also changed [table.]. At 4GHz, 5GHz, 6GHz frequencies antenna parameters return loss, bandwidth are measured and compared.

At 4GHz frequency we take a feed point at X= 5.425 and Y= 10.625, in here we are using a coaxial probe feed. From the results we conclude that the return loss is maximum at 4GHz And the minimum, return loss is at 6GHz.When we conclude the bandwidth of the patch then maximum bandwidth is 50%, obtained at 5GHz and minimum bandwidth is 42.42% at 4GHz (accept 1st band at 6GHz).The main important result in here is dual bandwidth is obtained at 6GHz, which can be used in various application.

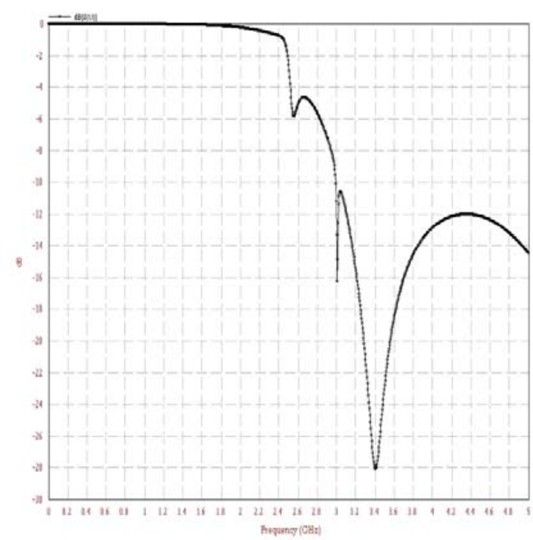


Figure 14 : Results at 5GHz

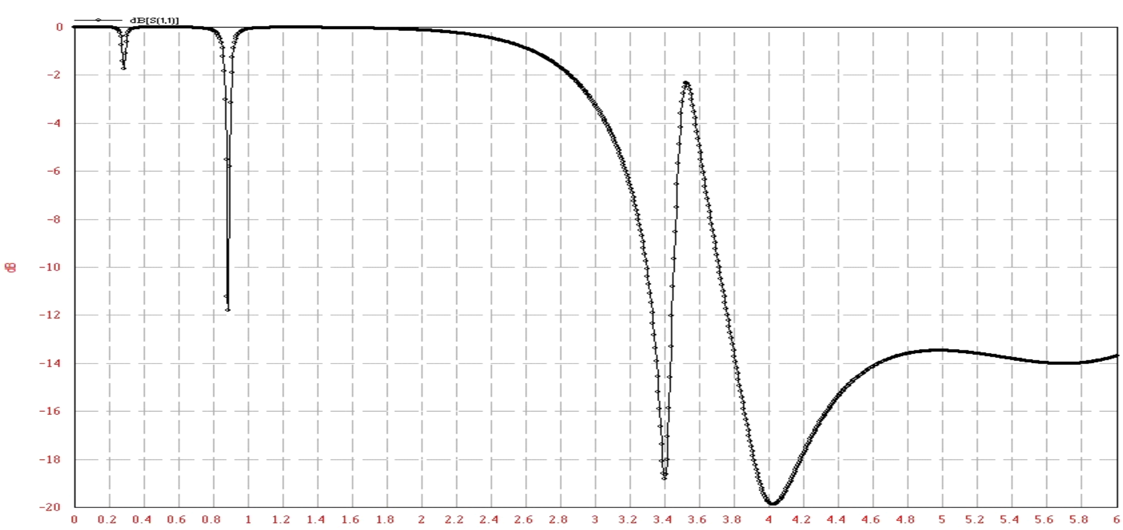


Figure 15 : Results at 6GHz

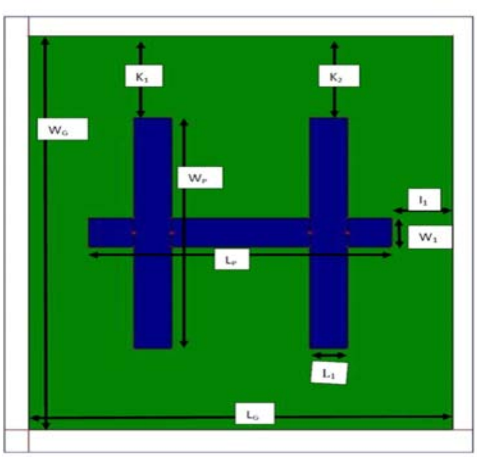
Investigated results of return loss, and bandwidth for patch with different operating frequencies are shown in Table 4.

Specifications	4GHz	5GHz	6GHz
X(mm)	5.425	5.375	5.225
Y(mm)	10.625	8.65	6.5
Band	Single	Single	Dual
Band Width (%)	42.42	50	4.74 (1st Band)
			47 (2nd Band)
Return Loss	-32	-28	-19
			-20

In the above work we have found that by changing the operating frequency and keeping feed point area constant, it is seen that as bandwidth is improves. We are getting single band at 4GHz and5 GHz while as at 6GHz we obtained dual band of 4.74% and 47%. It suggests that the microstrip antenna performance can be upgraded by using the proposed inverted T shaped patch antenna. The main focus is our work, that we are not changing the feed point area. By our work compactness of microstrip patch antenna can be achieved.

i) H Shape Micro strip Patch Antenna

Now in this section we are designing Partially H Shape Dual Band Micro strip Patch Antenna .A single feed compact micro strip antenna for dual -band is presented in this paper. For the proposed antenna two resonant frequencies are obtained at 1.87GHz and 2.3 GHz respectively. The design and simulation of the proposed antenna is carried out using IE3D software. An extensive analysis of the return loss, Radiation pattern, gain, VSWR of the proposed antenna is presented. The simple configuration of the proposed antenna makes it suitable for the applications in various communication systems. The return losses of this dual band antenna are -26dB at 1.95GHz, and -20dB at 3GHz. The proposed antenna offers 10.63% bandwidth at 1.87-2.08GHz and 26.41% bandwidth at 2.3- 3 GHz.



Proposed 16 : Figure Antenna

Figure 17 : Hardware of Proposed MSA

All the dimensions are calculated as per given formulas in section 2.4.1. The calculated dimensions are given below in table.

Table 5 : Design Parameters of Proposed Antenna

Antenna Parameters	Dimension in mm
h	1.6
W_g	40.6
L_g	33.57
W_p	23.8
L_p	23.97
K_1& K_2	8.445
L_1	3
W_1	3
l_1	4.8

i. *Simulating and Testing Results of H Shape Micro strip Patch Antenna*

A prototype of the antenna has been tested by IE3D simulator, with the above given geometrical dimensions of the patch. The simulation returns loss of this antenna is presented in figure for two different distances.

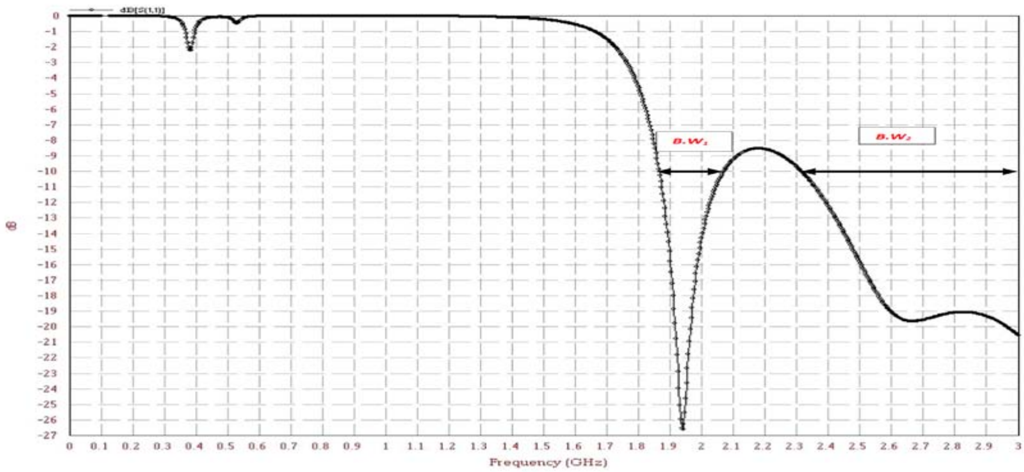


Figure 18 : Simulated Return Loss and Bandwidth of the Dual Band H shape Rectangular patch antenna

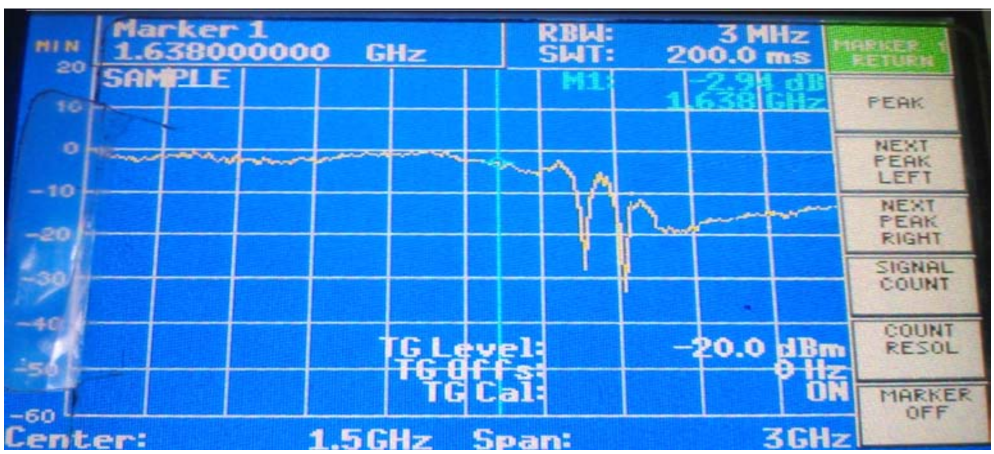


Figure 19 : Testing Results of Proposed MSA

Return loss is a measure of the reflected energy from a transmitted signal which is commonly expressed in positive dB. The larger the value the lesser is the energy that is reflected. From the figure we can see that dual band width is obtained. The first Band at frequency between 1.87GHz -2.08GHz, and the maximum return loss at here is –26db. From this band we can find out the 10.63% bandwidth by using fallowing equation.

The second band of this microstrip antenna, we are obtain at frequency range 2.3GHz- 3.0GHz and maximum return loss is here -20db and the bandwidth is 26.41%.The return loss should be -10db is satisfactory for this patch to provide better results.

But when we actually test this patch then we obtain some changes in results. The return loss of first band is obtained same as simulation but return loss of second band is goes to -32db.s

III. Conclusion

We have designed various novel wideband microstrip patch antennas. The characteristics of proposed antennas have been investigated through different parametric studies using IE3D simulation software. The proposed antennas have achieved good impedance matching, stable radiation patterns, and high gain. The work in this paper primarily focuses on the study of various results on the same patch which give the useful results, and the bandwidth can be used in various applications.

IV. Suggestions for Future Works

The proposed patch is simulated at 3GHz frequency and we seen that at all the feed points the return loss is below -10bd. At all the feed point we have obtain the bandwidth. This patch is simulated only on 3GHz, but if simulation is done at higher frequency then it may be possible theata wide bandwidth obtain and if this is possible then we can use the proposed antenna at any feed point. From this work we can prove that a single patch antenna can be used at much application.

From second patch it may be possible that feed point location is not changed but results can be improved when we goes toward higher frequency. In future if we design a patch at low frequency and bandwidth is satisfactory for applications then we can also attained satisfactory results at higher frequency at same feed point location .but due to limitations of testing in here we are only simulated results obtained from IE3D.

From last H shape patch we attained a dual bandwidth, we have seen that second band of result is goes below -10db at frequency 2.3GHz to 3 GHz. And this bandwidth can be improved if we simulate same H patch at higher frequency above to 3GHz. The bandwidth of this band can be improve in future, but due to limitations in testing for patch above 3GHz we are goes on above 3GHz.

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