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Comparative analysis of Bandwidth Enhancement of a Rectangular Microstrip Patch Antenna using capacitive & Non Capacitive Coupled Feed

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***Abstract*— In the present Scientific, Technological scenario the use of Microstrip Antenna has raised tremendously because of its versatile features. So far as this paper is concerned, this paper presents a comparative study of a rectangular Microstrip patch antenna at Gigahertz (GHz) frequency using non contacting microstrip feed lines of length 14.5 mm and feed line of contacting length with superstrate. This means we created capacitive coupling between patch and feed line in the first case and in the later case Patch and Feed Line is connected well together. The results presented here are obtained using Ansoft High Frequency Structure Simulator (HFSS) 11.0 software which is based on full wave finite element method. In this designing a superstrate of thickness 5mm is also introduced to get the more precise results. Here it is very important to mention that the best performance of antenna i.e., below -10dB that we achieved in both Contacting and Non-Contacting cases, Bandwidth of 8% is obtained in contacting case and bandwidth of 6.4% is obtained when capacitive coupling is created between Patch and Feed Line. As a matter of course, we obtained resonance frequency of 17.2 GHz at solution frequency of 17.8 GHz.**

***Index Terms*- Rectangular patch, Superstrate, GHz, Port, Ansoft HFSS, electromagnetic spectrum, Microstrip feed line.**

1. INTRODUCTION

Antenna are the eyes and ears of wireless communication system and it enables the wireless communication possible up to best possible extent. In this hierarchy of Antennas, Microstrip antennas are employed tremendously well due to their light weight, small size, ease of fabrication with circuitry. However these antennas are less suited to modern communication as they efficiently resonate at single frequency and shows narrow bandwidthh and low gain especially at lower microwave frequencies. As they are compact in nature and hence are popular structures in modern wireless communication system. The performance of antenna is affected by patch geometry, substrate property and feed technique. In rectangular structure the mode TEz (where z is taken perpendicular to the patch) is supported by this shape on substrate with height ($h << \lambda$) very small as compared to wavelength. There are different model to analyze the Microstrip patch antenna. The basic model to analyze the patch antenna is the cavity model. This model provides the

method that the normalized field within the dielectric substrate can be found more accurately and does not radiate any power.
The effective dimension of antennas are greater than the actual dimension due to the fringing field between the patch and the ground plane. With the development of mobile and wireless communication system the demand for broad band, multiband patch antennas are desired.

The environmental factors like raining and thundering are the major part of our functionality as it can create the adverse affect over the antenna and can deteriorate the performance of antenna; particularly its resonance frequency/bandwidth wherever they are used for long duration. This is one of the reasons why superstrate (cover) are often used to protect microstrip antenna. So in a Nutshell it can be said that superstrate not only plays a vital role in return loss and bandwidth enhancement but also protect antenna from these natural calamities. Now this paper continues in the following manner : Section 2 extensively presents the formulae for the design and the design of antenna for Contacting and Non-Contacting cases. Section 3 shows the simulated results and in section 4 we will conclude our work with its applications.

2. SIMULATION MODELS OF DESIRED ANTENNA CONFIGURATIONS

The desired Microstrip patch antenna consists of a rectangular patch and different lengths of feed line. In this designing configuration we only vary the length of feed line. We kept the dimensions of substrate, superstrate, ground plane, patch and boundary as it is in both the cases. The dimension of ground plane and substrate is 64mm ×74mm with substrate having thickness of 3mm. The substrate is having material of RT duroid 5880 and the Superstrate is having FR4_epoxy with dielectric constant ε_r

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=4.4 & dielectric loss tangent tan δ= 0.02. The Dimension of rectangular patch is 26mm×38mm. Simultaneously we used feed line of dimension of length 14.5mm which is termed as non contacting case and it is of length 15 mm for contacting case, with the constant width of 1.25mm in both the configurations. A superstrate of thickness 5mm is also used above the patch.

To get ourselves more concerned with the design we are showing the following formulae that we used for the determination of dimensions of Substrate, Patch and ground plane.

2.a Rectangular Microstrip Patch Antenna Design Formulae

Dimensions for Patch :
Width of the patch (W) :

$$W=\frac{c}{2 f_o \sqrt{(\varepsilon r+1)/2}}$$

Where c is speed of light
f_o is solution frequency
ε_r- Relative Permitivity of dielectric

Length of the Patch (L) :

$$L = L_{eff} - 2\,\Delta L$$

where L_{eff} is the effective length of patch
Δ L is the length extension for patch

Ground plane dimensions :
Length of ground plane :

$$L_g = 6h + L$$

Where h is height of substrate
L is length of patch

Width of the ground plane :

$$W_g = 6h + W$$

We calculated our results using following basic formula.

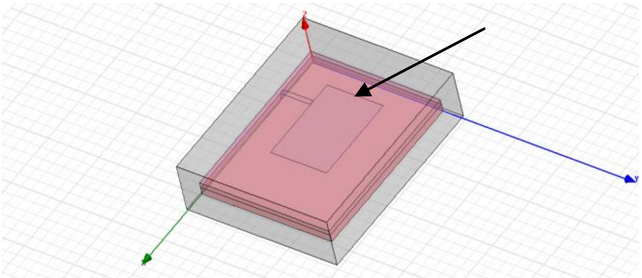
$$Percentage\ Bandwidth = f_H - f_L/2f_c * 100 \quad \text{...............(i)}$$

$$Impedencee\ Bandwidth = f_H - f_L \quad \text{..................... (ii)}$$

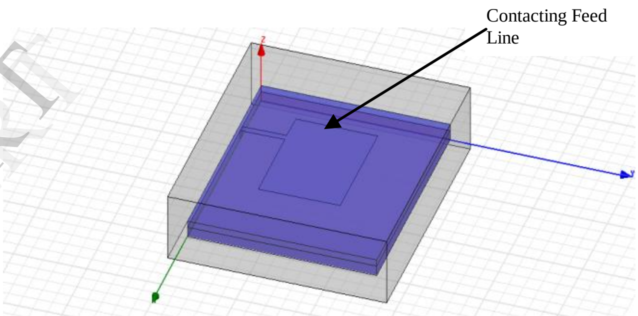
We calculated all the parameters by using the above mentioned formulae. The

2.b Case I Rectangular Microstrip Patch Antenna DESIGN(Non Contacting Feed Line)

This design is widely representing the view of our antenna from which we will be obtaining the Rectangular plot and VSWR plot. The Case 1 is depicting the dimension of feed line, rectangular patch, Ground Plane and substrate. Here it is very contextual to mention that patch and feed line are separated by some distance. In the similar manner in case 2 both the patch and feed line are connected with one another. In graphical form both the designs are widely shown:



CaseII Rectangular Microstrip Patch Antenna
DESIGN (Contacting Feed Line)



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Tabular Representation for all the feed lines :

Solution Frequency- 17.8GHz
Resonance Frequency-17.2GHz (obtained)

3. RESULTS AND DISCUSSION

Now we are going to demonstrate the combined return loss plot and combined VSWR plot of both the antennas in the following manner. As a matter of fact, antennas with different feed line lengths and the superstrate used in both the case. To get more acquainted with these results we are also representing the results in the tabular form as well.

S.No.	Feed Line Length	Return Loss	VSWR	Bandwidth
1.	Capacitive Coupled FeedLine	-12dB	1.5	6.4%
2.	Non Capacitive Coupled Feed Line	-44dB	1	8%

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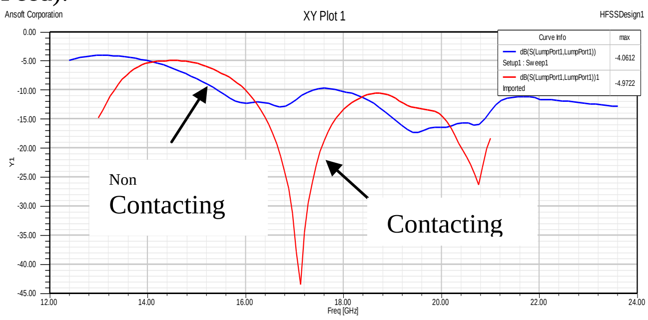
As a matter of fact, after observing the tabular representation it may be said that we are getting maximum bandwidth of 8% and VSWR of 1with contacting feed line. In fact, the return loss which is obtained in this case is of quite higher value compared to that which is obtained in capacitive coupled feed line case.

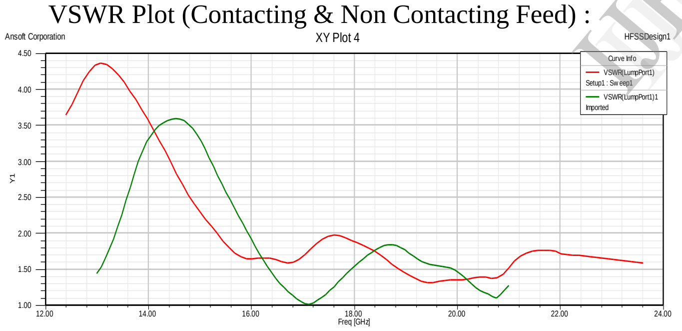
In order to obtain the well defined results we are herewith representing the Return Loss, VSWR and Smith Chart Plot The Smith Chart is surely representing the view of its traversion through the resistive part only.

Rectangular Plot (Contacting & Non contacting Coupled Feed):



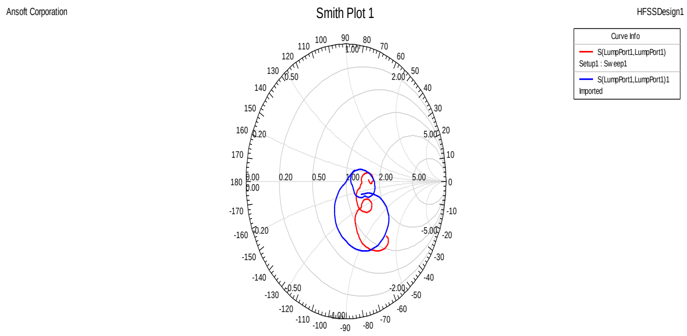
The above plot is extensively representing the combined Rectangular plots for both the antennas The red line plot is for contacting feed line and the blue is for Non Contacting feed line. The highest return loss that we are obtaining is of -44db.

VSWR Plot (Contacting & Non Contacting Feed) :



The above plot is representing the superimposed VSWR Plot for capacitive and Non Capacitive coupled feed. The Green Line curve variation is representing the plot for Contacting feed line and the Red curve is representing the plot for Non Capactive coupled feed.

Smith Chart (Contacting & Non Contacting Feed):



The blue circled line is representing the case of Contacting feed line which is also emphasizing the maximum resistive part and the Red Circled line is widely representing the case of Non Contacting feed line. The VSWR is around 1.1 for the contacting feed line case which is the best case between the two observed cases.

4. CONCLUSION

In this manner it may efficiently be concluded that we designed a rectangular microstrip patch antenna with feed line of non contacting lengths i.e. creating a capacitive coupling between patch and feed line and a feed line of contacting length. We obtained two results with different Return losses, VSWRs and percentage bandwidths but out of these two we received a maximum bandwidth of 8% and vswr of 1 at feed line length of contacting dimension. which is also very well evidenced by the return loss plot shown above. We received return losses at resonance frequency of 17.2Ghz which is a part of ku band (12-18 GHz) thus it can be used for satellite communication and broadcasting of television signals.

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