

DESIGN AND ANALYSIS OF RECTANGULAR MICROSTRIP PATCH ANTENNA WITH DIFFERENT SUBSTRATES

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Abstract — The current advancements in the period of minimal effort and minimized communication systems have to a great extent been because of the appearance of little weight and capable of giving good output characteristics over a large frequency range. Micro strip patch antenna has turned out to be exceptionally well known and has pulled in much consideration towards the research on account of having the capacity to incorporate with microwave circuits and thusly they are extremely appropriate for applications, for example, cell gadgets, WLAN applications, route frameworks and numerous others.

In this work, the design of rectangular Micro strip patch antenna with three different substrates have been examined and considered. Here the comparative analyses of patch antenna is provided and comparison is done on the basis of return loss, gain, and radiation patterns(3D).The rectangular patch antenna is designed by utilizing HFSS software. The performance of designed antenna with different substrates was analyzed in terms of Gain, Return loss, VSWR and radiation pattern (3D).Dielectric Substrates that are considered in the design was Rogers RT/Duroid 5880,FR-4 Epoxy and Alumina having dielectric constant of 2.2,4.4 and 9.8 are utilized.

Keywords-Micro strip line, HFSS Software, Patch antenna, VSWR, Return Loss, Gain.

I. INTRODUCTION

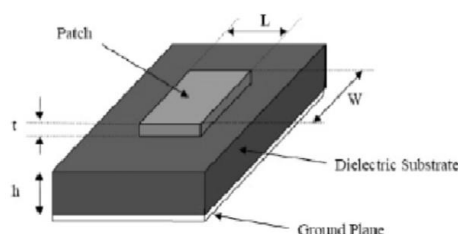
The word antenna is a module of any remote and Radio communication system is a device that has a capacity of transmission and gathering of electromagnetic energy. Per IEEE standard meanings of terms for radio waves(IEEE StdI45-1983) characterizes antenna as a method for emanating or accepting radio waves. More extensively, antenna at the transmitting end changes the information signal into an electromagnetic energy and transmits it by means of free space as a source of medium and at the receiving side the electromagnetic wave is received in this manner information signal by transformation process is received, this treatment know how to as transducer.

Micro strip patch Antennas (additionally just called rectangular patch antenna) are among the most basic antenna type being used today, especially in the frequency range of 1 to 6 GHz. This kind of antennas had its first extraordinary improvement in the 1970s, as communication system became noticeably normal at frequencies where its size and performance were extremely helpful. At a similar time, its level profile and decreased weight, contrasted with parabolic reflectors and other antenna alternatives, made it appealing for airborne and rocket applications. All the more as of late, those same properties, with extra size lessening utilizing high dielectric constant materials, have made patch antennas common in handsets, GPS receivers and different beneficiaries and other mass created wireless products. Presently a day, miniaturized scale strip antennas (patch antennas) are the most common antenna types being used.

In this work different dielectrics are utilized because of the fact that Dielectrics are considered for enhanced electrical and mechanical stability. They are utilized to decrease the size of the antenna (higher permittivity, bring down size) and can deliver relocation current which produces time changing Magnetic Field (by Ampere's Law). This can thus deliver time differing Electric Field (by Faraday's law) and an propagating EM field is made. Thus, a substrate can improve antennas radiation capacity.

II. STRUCTURE OF A PATCH ANTENNA

Micro strip patch antenna consists of radiation patch, dielectric substrate and ground plane shown in figure



Structure of a Micro Strip Patch Antenna

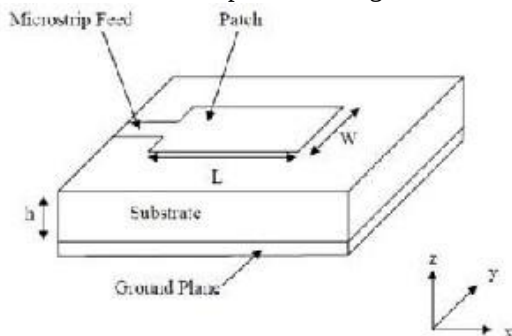
The patch and the ground plane are separated by a dielectric material. A flat plate over a ground plane and then the dielectric substrate at the center and the patch is at the top. The patch and the ground plane are generally conducting materials such as gold, copper and the patch can be any shape as the design specification. The feed line is used to feed the patch. There are many different types of feeding techniques. Usually, the patch and the feed line are photo etched to the substrate. The radiating patch can be square, rectangular, circular, triangular, elliptical, circular ring and dipole and so on.

III. METHODOLOGY

There are numerous systems that can be utilized to feed micro strip patch antennas. These systems are arranged into two classifications – contacting and non-contacting. In conducting system, the RF power is fed specifically to the transmitting patch with miniaturized scale strip line. In non-conducting technique, the electromagnetic field coupling is done to transfer power between the micro strip line and the radiating patch. The four most popular are the micro strip line feed, coaxial feed, aperture coupled feed, proximity coupled feed.

3.1 Micro strip Line Feed

Micro strip feed line is also a conducting strip, usually of much smaller width compared to the patch. The micro strip line feed is easy to fabricate, simple to match by controlling the inset position and rather simple to model. The conducting strip is directly connected, to the edge of the micro strip patch. The feed line also can be etched on the same substrate to provide a planar structure. The micro strip line and the patch are impedance matched so there is no need for any additional matching elements. This is done by properly controlling the inset position. However, as the substrate thickness increases, which for practical designs limit the bandwidth of the antenna.



The characteristic impedance of the transition section should be

$$Z_T = \sqrt{50 + Z_a} \quad (1)$$

The width of the transition line is calculated

$$Z_T = \frac{60}{\sqrt{\epsilon_r}} \ln \left(\frac{8d}{W_T} + \frac{W_T}{4d} \right) \quad (2)$$

The width of the 50Ω micro strip feed can be found

$$Z_0 = \frac{120\pi}{\sqrt{\epsilon_{\text{reff}} \left[1.393 + \frac{W}{h} + \frac{2}{3} \ln \left(\frac{W}{h} + 1.444 \right) \right]}} \quad (3)$$

Where $Z_0 = 50\Omega$

IV. IMPLEMENTATION

There are numerous techniques for examination for fix receiving wire, they are transmission line demonstrate, depression model and full wave display. The transmission line model is the most straightforward of all, it gives great physical knowledge, however it is less exact and it is harder to model coupling. Contrast with transmission line show, the hole model is more exact yet it is more mind boggling. The full wave models are to a great degree precise, adaptable and can treat single components, limited and exhibits, stacked components, subjective formed components and coupling. In any case, they are most perplexing models and more often than not give less physical.

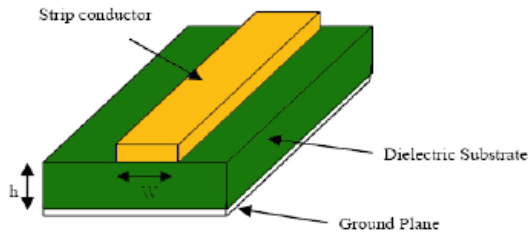
4.1 Transmission Line Model

We realize that the transmission line model is the most straightforward of everything except if yields the slightest exact outcomes. This model speaks to the smaller scale strip receiving wire by two openings of width, W and tallness h, isolated by transmission line of length, L. This is a non-homogenous line of two dielectrics, ordinarily the air and substrate. The expression for ϵ_{reff} is given by Balanis as:

$$\text{Where, } \epsilon_{\text{reff}} = \epsilon_{\text{reff}} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{W} \right]^{-\frac{1}{2}}$$

Effective dielectric constant
 ϵ_r = Dielectric constant of substrate

h = Height of dielectric substrate
 W = Width of the patch



4.2 Cavity Model

Despite the fact that the transmission line demonstrate talked about in the past area is anything but difficult to utilize, it has some innate hindrances. In particular, it is valuable for patches of rectangular plan and it overlooks field varieties along the emanating edges. These disservices can be overcome by utilizing the cavity show. A short review of this model is given underneath. In this model, the inside district of the dielectric substrate is demonstrated as a cavity limited by electric dividers on the top and base. The reason for this suspicion is the accompanying perceptions for thin substrates ($h \ll \lambda$) since the substrate is thin, the fields in the inside district don't fluctuate much in the z course, i.e. typical to the fix.

This perception accommodates the electric dividers at the top and the base. At the point when the small scale strip fix is given power, charge dispersion is seen on the upper and lower surfaces of the fix and at the base of the ground plane. This charge appropriation is controlled by two systems an alluring instrument and an awful component as examined by Richards. The appealing instrument is between the inverse charges on the base side of the fix and the ground plane, which helps in keeping the charge fixation in place at the base of the fix.

The transmission line model is used and following steps are followed to design the antenna

1: Width calculation (W): The width W of the Micro strip patch antenna is calculated as:

$$W = \frac{c}{2f_0 \sqrt{\frac{(\epsilon_r + 1)}{2}}}$$

c = free space velocity of light. Substituting $c = 3 \times 10^8$ m/s

2: Effective dielectric constant calculation (ϵ_{reff})

The effective dielectric constant is:

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{W} \right]^{-\frac{1}{2}}$$

ϵ_{reff} = Effective dielectric constant

ϵ_r = Dielectric constant of substrate

h = Height of dielectric substrate

W = Width of the patch

3: Effective length calculation (L_{eff})

The effective length is:

$$L_{eff} = \frac{c}{2f_0 \sqrt{\epsilon_{reff}}}$$

4: Length extension calculation (ΔL):

The length extension is given by:

$$\Delta L = 0.412 h \frac{(\epsilon_{reff} + 0.3) \left(\frac{W}{h} + 0.264 \right)}{(\epsilon_{reff} - 0.258) \left(\frac{W}{h} + 0.8 \right)}$$

5: Actual length of patch calculation (L):

The actual length is obtained by:

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

Types of substrate	Height(h) in mm	Frequency (f_0)	Dielectric constant (ϵ_r)	Width (w) in mm	Length (L) in mm	Effective dielectric constant (ϵ_{reff})
RT-Duroid	1.6	2.45	2.2	48.4	43.37	1.99
FR4 Epoxy	1.6	2.45	4.4	37.26	33.77	3.28
Alumina	1.6	2.45	9.4	26.8	53.4	1.31

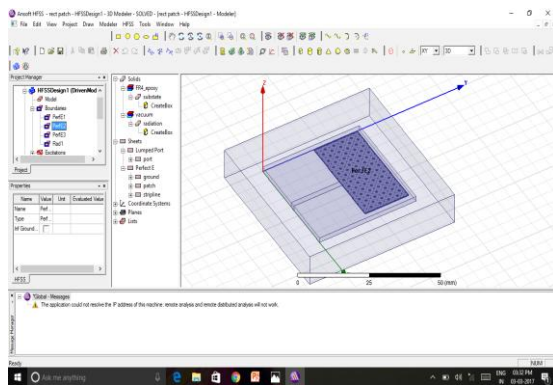
IV. RESULTS

• Design Parameters

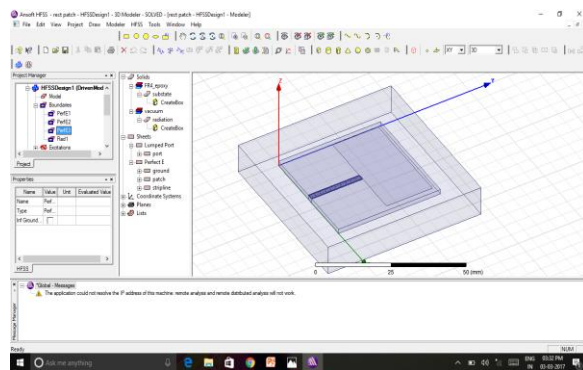
The antenna has been designed on the substrates like Roger RT 5880, Fr-4 Epoxy and Alumina for a good dielectric constant of 2.2, 4.4, and 9.4.

4.1 Rectangular Patch

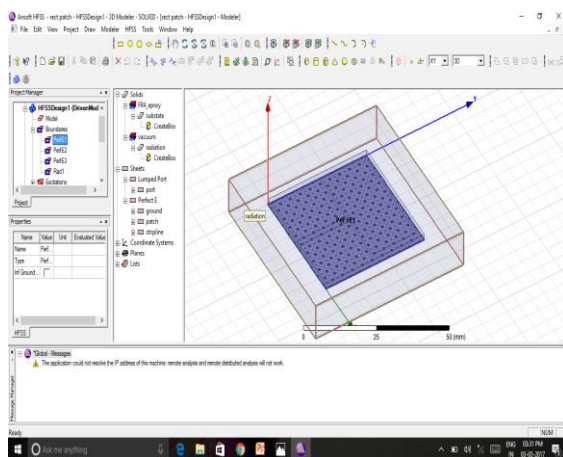
The objective of this is how to create, simulate and analyze a rectangular micro strip patch antenna resonating at a frequency of 7.5 GHz. With the help of above parameter calculations from the design equations, a simple micro strip patch antenna is designed using HFSS tool.



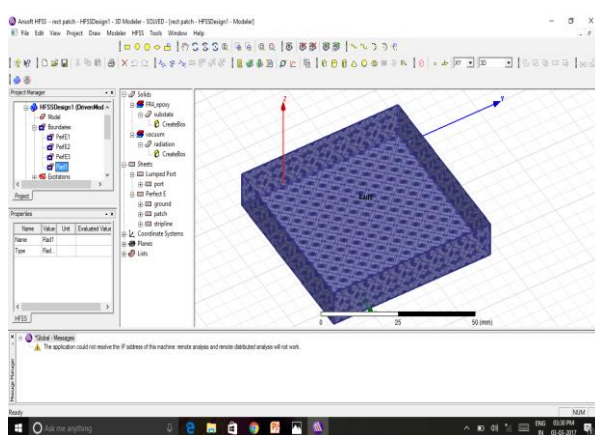
Assigning boundary condition to Patch



Assigning boundary condition to Feeding



Assigning boundary condition to Ground

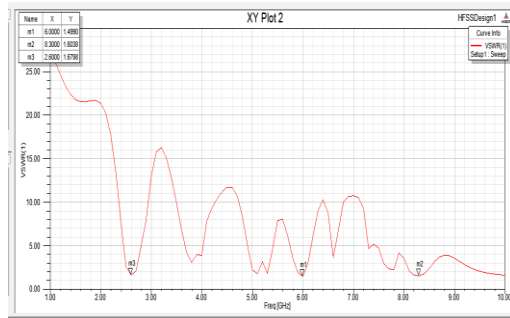


Assigning boundary condition to Radiation Box

4.2 Simulated Results of Rectangular Patch Antenna

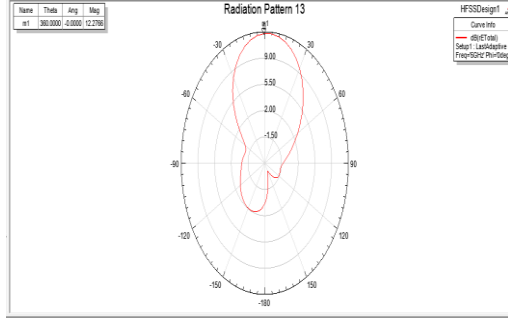
4.2.1. RT Duroid Substrate ($\epsilon_r=2.2$)

4.2.1.1. VSWR



The simulated VSWR of the optimized antenna from HFSS at 6GHz .VSWR is obtained at 1.49.

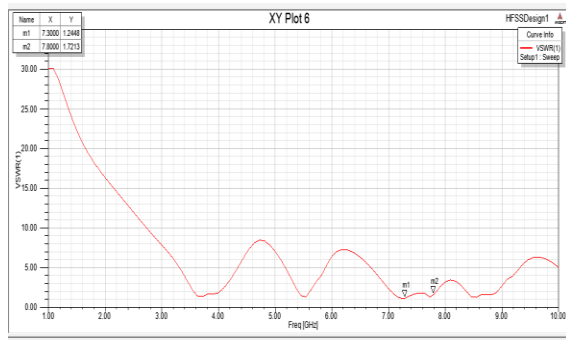
4.2.1.2 Gain



The simulated Gain of the optimized antenna from HFSS at 7.2GHz Gain is obtained at 12.27 db.

4.2.2. FR4 Epoxy substrate($\epsilon_r=4.4$)

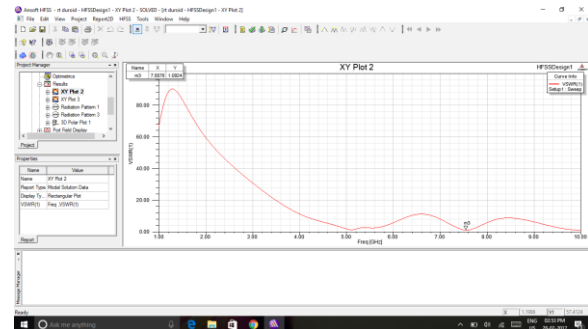
4.2.2.1. VSWR



The VSWR of Rectangular Patch Antenna with FR4 Epoxy substrate is observed to be 1.24 at 7.2GHz

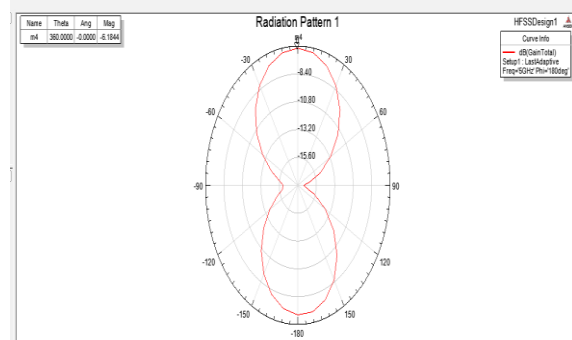
4.2.3 Alumina Substrate ($\epsilon_r=9.4$)

4.2.3.1. VSWR



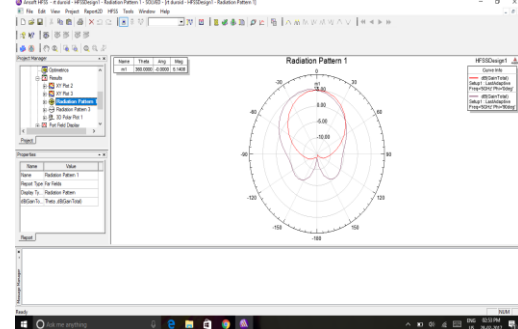
The VSWR of rectangular patch antenna with Alumina Substrate is observed to be 1.09at 7.5 GHz.

4.2.2.2 Gain



The Gain of Rectangular Patch Antenna with FR-4 Epoxy substrate is observed to be 6.1dB.

4.2.3.1 Gain



The Gain of rectangular patch antenna with Alumina Substrate is observed to be 5.1dB.

PARAMETERS	RECTANGULAR PATCH		
Dielectric Substrate	RT Duroid	FR4 Epoxy	Alumina
Dielectric constant (ϵ_r)	2.2	4.4	9.4
Return loss(dB)	-13	-22.9	-27.1
VSWR	1.49	1.24	1.09
Gain(dB)	12.27	6.1	5.1
Feeding	Micro strip line feeding		
Impedance	50 Ω		

V. CONCLUSION

This work presents the design and performance of rectangular patches on three different substrates. The improved parameters is achieved without much increase in thickness of the structure. All the simulation was done with HFSS tool. The maximum gain of rectangular patch antenna is observed to be 12.27dB for RT Duroid substrate. However the gain of patch antenna is observed to be 6.1dB for Fr-4 Epoxy substrate and 5.1dB for Alumina substrate. For calculating those parameters three types of substrates are utilized. From these results, we presume that as dielectric constant of a dielectric substrate increases the gain and directivity decreases. In this way, for better results the estimation of dielectric constants ought to be low. Hence, even though the gain obtained with RT Duroid substrate is high, the commonly used substrate is Fr-4 Epoxy because it is of low cost and readily available material.

VI. FUTURE SCOPE

In this work, different dielectric constants are utilized for a single frequency operation. By keeping the frequency constant estimation of gain, directivity is done. A further review can consider the plan of a patch antenna array working at UHF frequency. This will additionally have enhanced the directive characteristics with exceptionally or very high gains to meet the demands for long distance communication and in addition giving a fixed beam of specified shape or a beam that scans in response to system stimulus. Design simulation is very challenging as it will take exceptionally complex programming to accomplish the craving results and it is extremely tedious.

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