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Design & Simulation of Micro strip Patch Antenna at Nano Scale

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ABSTRACT: *Micro strip is a type of electrical transmission line which can be fabricated using printed circuit board technology, and is used to convey microwave-frequency signals. It consists of a conducting strip separated from a ground plane by a dielectric layer known as the substrate. Micro strip patch antennas are becoming increasingly useful because they can be printed directly onto a circuit board. Micro strip antennas are becoming very widespread within the mobile phone market. Patch antennas are low cost, have a low profile and are easily fabricated. Our objective is to design a micro strip patch antenna at Nano scale. Dielectric FR4 substrate was used in this design. The antenna has a band of operation from 1.5881 GHz to 1.7759 GHZ (187 MHz bandwidth) as a receive antenna, from 2.039GHz to 2.349 GHz (310 MHz bandwidth) as a transmit antenna, and a VSWR of 2:1 or lower.*

Keywords *–Micro strip, dielectric, lithographic, Bends, Feeding.*

I. INTRODUCTION

A microstrip patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. Common microstrip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is possible. Some patch antennas do not use a dielectric substrate and instead are made of a metal patch mounted above a ground plane using dielectric spacers; the resulting structure is less rugged but has a wider bandwidth. Because such antennas have a very low profile, are mechanically rugged and can be shaped to conform to the curving skin of a vehicle, they are often mounted on the exterior of aircraft and spacecraft, or are incorporated into mobile radio communications devices [1]. A patchantenna (also known as a rectangular microstrip antenna) is a type of radio antenna with a low profile, which can be mounted on a flat surface. It consists of a flat rectangular sheet or "patch" of metal, mounted over a larger sheet of metal called a ground plane. The assembly is usually contained inside a plastic redone, which protects the antenna structure from damage. Patch antennas are simple to fabricate and easy to modify and customize. They are the original type of microstrip antenna described by Howell in 1972;the two metal sheets together form a resonant piece of microstrip transmission line with a length of approximately one-half wavelength of the radio waves. The radiation mechanism arises from discontinuities at each truncated edge of the microstrip transmission line. The radiation at the edges causes the antenna to act slightly larger electrically than its physical dimensions, so in order for the antenna to be resonant, a length of microstrip transmission line slightly shorter than one-half a wavelength at the frequency is used. A patch antenna is usually constructed on a dielectric substrate, using the same materials and lithography processes used to make printed circuit boards. Microstrip antennas are relatively inexpensive to manufacture and design because of the simple 2-dimensional physical geometry. They are usually employed at UHF and higher frequencies because the size of the antenna is directly tied to the wavelength at the resonant frequency. A single patch antenna provides a maximum directive gain of around 6-9 db. It is relatively easy to print an array of patches on a single (large) substrate using lithographic techniques. Patch arrays can provide much higher gains than a single patch at little additional cost; matching and phase adjustment can be performed with printed microstrip feed structures [2], again in the same operations that form the radiating patches. The ability to create high gain arrays in a low-profile antenna is one reason that patch arrays are common on airplanes and in other military applications. An advantage inherent to patch antennas is the ability to have polarization diversity.

Patch antennas can easily be designed to have vertical, horizontal, right hand circular or left hand circular polarizations, using multiple feed points, or a single feed point with asymmetric patch structures. This unique property allows patch antennas to be used in many types of communications links that may have varied requirements.

II. BENDS

In order to build a complete circuit in micro strip, it is often necessary for the path of a strip to turn through a large angle. An abrupt 90° bend in a micro strip will cause a significant portion of the signal on the strip to be reflected back towards its source, with only part of the signal transmitted on around the bend. One means of effecting a low-reflection bend, is to curve the path of the strip in an arc of radius at least 3 times the strip-width. However, a far more common technique, and one which consumes a smaller area of substrate, is to use a metered bend.

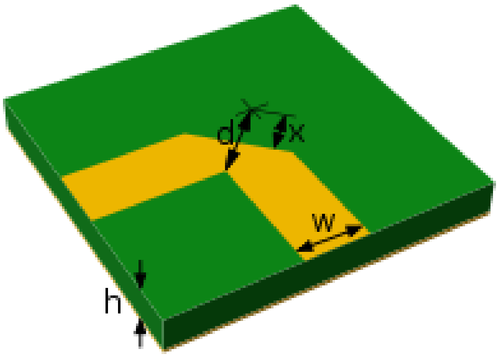


Figure 1: Micro strip 90° mitered bend.

To a first approximation, an abrupt un-miter bend behaves as a shunt capacitance placed between the ground plane and the bend in the strip. Mitering the bend reduces the area of metallization, and so removes the excess capacitance. The percentage miter is the cut-away fraction of the diagonal between the inner and outer corners of the un-miter bend. The optimum meter for a wide range of microstrip geometries has been determined experimentally by Douville and James. They find that a good fit for the optimum percentage miter is given by

$$M = 100\frac{x}{d}\% = (52 + 65e^{-\frac{27}{20}\frac{w}{h}})\%$$

Subject to $w/h \geq 0.25$ and with the substrate dielectric constant $\varepsilon_r \leq 25$. This formula is entirely independent of ε_r. The actual range of parameters for which Douville and James present evidence is $0.25 \leq w/h \leq 2.75$ and $2.5 \leq \varepsilon_r \leq 25$. Given by the formula at the minimum w/h of 0.25, the percentage miter is 98.4%, so that the strip is verynearly cut through.

III. FEEDING TECHNIQUE

Inset Feed

Previously, the patch antenna was fed at the end as shown here. Since this typically yields a high input impedance, we would like to modify the feed. Since the current is low at the ends of a half-wave patch and increases in magnitude toward the center, the input impedance (Z=V/I) could be reduced if the patch was fed closer to the center. Since the current has a sinusoidal distribution, moving in a distance R from the end will increase the current by cos(pi*R/L) - this is just noting that the wavelength is 2*L, and so the phase difference is 2*pi*R/(2*L) = pi*R/L. The voltage also decreases in magnitude by the same amount that the current increases. Hence, using Z=V/I, the input impedance scales as:

$$Z_{in}(R) = \cos^2\left(\frac{\pi R}{L}\right) Z_{in}(0)$$

In the above equation, Zin(0) is the input impedance if the patch was fed at the end. Hence, by feeding the patch antenna as shown, the input impedance can be decreased. As an example, if R=L/4, then cos(pi*R/L) = cos(pi/4), so that [cos(pi/4)]^2 = 1/2. Hence, a (1/8)-wavelength inset would decrease the input impedance by 50%. This method can be used to tune the input impedance to the desired value.

Fed with a Quarter-Wavelength Transmission Line

The microstrip antenna can also be matched to a transmission line of characteristic impedance Z0 by using a quarter-wavelength transmission line of characteristic impedance Z1.The goal is to match the input impedance (Zin) to the transmission line (Z0)[3]. If the impedance of the antenna is ZA, then the input impedance viewed from the beginning of the quarter-wavelength line becomes

$$Z_{in} = Z_0 = \frac{Z_1^2}{Z_A}$$

This input impedance Zin can be altered by selection of the Z1, so that Zin=Z0 and the antenna is impedance matched. The parameter Z1 can be altered by changing the width of the quarter-wavelength strip. The wider the strip is, the lower the characteristic impedance (Z0) is for that section of line.

Coaxial Cable or Probe Feed

Micro strip antennas can also be fed from underneath via a probe. The outer conductor of the coaxial cable is connected to the ground plane, and the center conductor is extended up to the patch antenna. The position of the feed can be altered as before control the input impedance. The coaxial feed introduces an inductance into the feed that may need to be taken into account if the height *h* gets large. In addition, the probe will also radiate, which can lead to radiation in undesirable directions [4].

Coupled (Indirect) Feeds

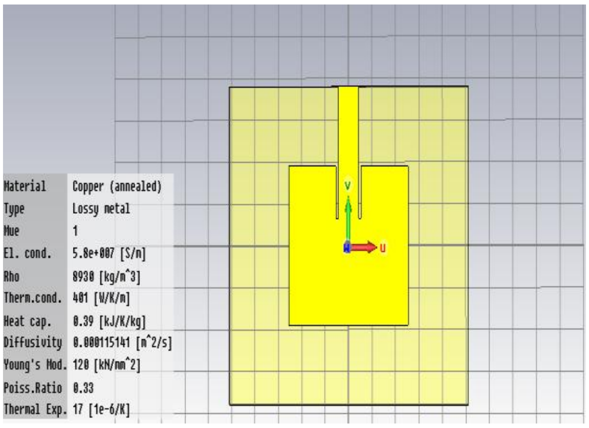
The feeds above can be altered such that they do not directly touch the antenna. For instance, the probe feed can be trimmed such that it does not extend all the way up to the antenna. The advantage of the coupled feed is that it adds an extra degree of freedom to the design [5]. The gap introduces a capacitance into the feed that can cancel out the inductance added by the probe feed.

Aperture Feeds

Another method of feeding micro strip antennas is the aperture feed. In this technique, the feed circuitry is shielded from the antenna by a conducting plane with a hole to transmit energy to the antenna**.** The upper substrate can be made with a lower permittivity to produce loosely bound fringing fields, yielding better radiation [6]. The lower substrate can be independently made with a high value of permittivity for tightly coupled fields that don't produce spurious radiation. The disadvantage of this method is increased difficulty in fabrication.

IV. DESIGN & EQUATIONS

The Micro strip patch antenna is often used in planar microwave radio active applications that require an Omni-directional pattern. The model of the dipole is shown in Fig.2. The dipole arm's width (W) and length (L)will be optimized for3. 0GHz operation, while the feed gap (g) and the substrate height (h)will be fixed. The model and simulation setup are outlined. The methods used to setup the simulation are outlined. In particular, the following topics are covered:



Material	Copper (annealed)
Type	Lossy metal
Mue	1
El. cond.	5.8e+007 [S/m]
Rho	8930 [kg/m^3]
Therm.cond.	401 [W/K/m]
Heat cap.	0.39 [kJ/K/kg]
Diffusivity	0.000115141 [m^2/s]
Young's Mod.	120 [kN/mm^2]
Poiss.Ratio	0.33
Thermal Exp.	17 [1e-6/K]

Figure 2: Micro strip Patch antenna

Infigure2, it shows the basic model of patch antenna. FR-4substrateusedinpatch antenna. FR-4isa grade designations signed to glass reinforce depoxy laminate sheets and printed board. Dielectric depend son height of patch antenna. Both Dipole arms are same length and same width. Gap between norms depends nits length. Ground plane of Antenna is 38.4 mm and Width is 46.8 mm, L & W of the patch is 28.8 mm & 37.2 mm.The patch width, effective dielectric constant, the length extension and also patch length are given by

$$w = \frac{C}{2f\sqrt{\mathcal{E}r}}$$

where *c* is the velocity of light, e is the dielectric content of substrate, *f* is the antenna working frequency, W isthe patch non resonant width, and the effective dielectric constant is egiven as,

$$\varepsilon_{eff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}\left[1 + 10\frac{H}{W}\right]^{-\frac{1}{2}}$$

The extension length Δ is calculates as,

$$\frac{\Delta L}{H} = 0.412\frac{(\varepsilon_{eff} + 0.300)\left(\frac{W}{H} + 0.262\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{H} + 0.813\right)}$$

By using above equation we can find the value of actual length of the patch as,

$$L = \frac{c}{2f\sqrt{\varepsilon_{eff}}} - 2\Delta L$$

V. SIMULATION & RESULTS

The antenna radiation pattern is a measure of its power or radiation distribution with respect to a particular type of coordinates. We generally consider spherical coordinates as the ideal antenna is suppose dtoradiate in a spherically symmetrical pattern. However antennae in practice are not Omni directional but have a radiation maximum along one particular direction. For e.g. Dipole antenna is a broad side antenna where in the maximum radiation occurs along the axis of the antenna. The radiation pattern of a typical dipole antenna is shown in figure2.

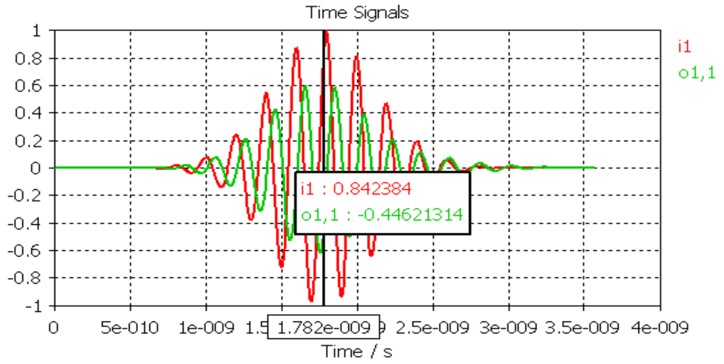


Figure 3: Time Signal.

In Figure 3 presents the graph of the time. It is clearly shown that lowest return loss is found at 1.60 GHz.And highest return loss found at 1 GHz frequency. Overall average return loss is not very effective per time.

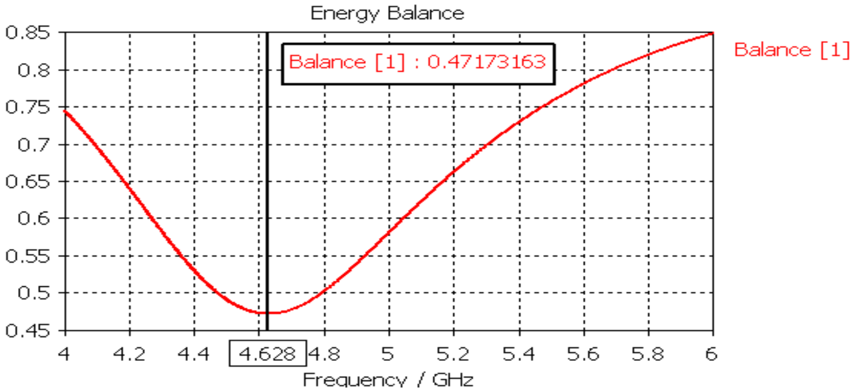
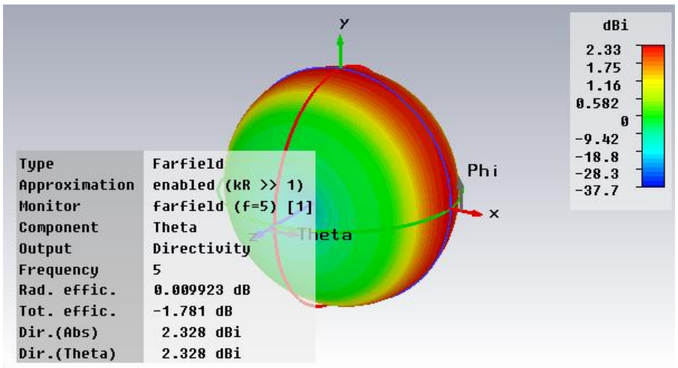


Figure 4: Frequency Vs Imaginary Impedance Graph.

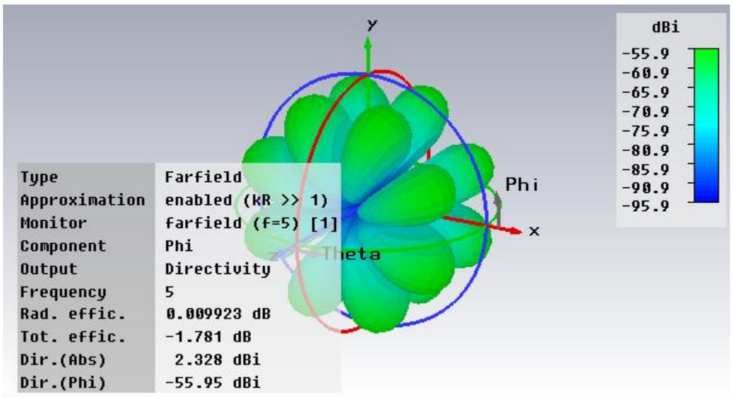
In figure 4 describe the Impedance graph. There are two lines. One of them the upper one represents Imaginary Impedance graph and other one presents Real Impedance graph. We got Imaginary values are the highest in every frequency rather than real impedance graph. When frequency is 1.70 GHz found the highest impedance values for both graph.



Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=5) [1]
Component	Theta
Output	Directivity
Frequency	5
Rad. effic.	0.009923 dB
Tot. effic.	-1.781 dB
Dir.(Abs)	2.328 dBi
Dir.(Theta)	2.328 dBi

Figure 5: Radiation pattern of patch antenna.

In figure 5 describe the radiation graph. There are two lines. One of them the upper one light color graph represents patch antenna and other one presents dark red graph represents with microstrip lines. We got without far field values are the highest in every angel rather than other graph.



Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=5) [1]
Component	Phi
Output	Directivity
Frequency	5
Rad. effic.	0.009923 dB
Tot. effic.	-1.781 dB
Dir.(Abs)	2.328 dBi
Dir.(Phi)	-55.95 dBi

Figure 6: 3D pattern of microstrip patch antenna.

	Theta [deg]	rETotal [V] Setup : LastAdaptive Freq='0.9GHz' Phi='0deg'
1	-180.000000	447.377879
2	-175.000000	440.121530
3	-170.000000	431.593863
4	-165.000000	421.963485
5	-160.000000	411.437042
6	-155.000000	400.249550
7	-150.000000	388.653887
8	-145.000000	376.910252
9	-140.000000	365.276345
10	-135.000000	353.998841
11	-130.000000	343.306583
12	-125.000000	333.405660
13	-120.000000	324.476369
14	-115.000000	316.671854

We found at least 73 values from our simulation here we submit 14 values as a sample.it is clearly shown that it follow per 90 degree cycle that means per 90 degree its values at the nadir point and after that complete 90 degree it is in crest point.

VI. CONCLUSION

This thesis detailed the various aspects associated with the modeling of micro strip patch antenna. One of thegoals was the introduction of HFSS as an effectivetoolforelectromagneticanalysis.Aneffortwasmadeto imparting understanding of the design process in HFSS, which would aid the reader in building any simulation in HFSS.A comprehensive and graphic description of each step taken in creating the simulation of the patch antenna was presented. Achieved Gain is 4 db. Obviously there are some drawbacks of dipole antenna like:

- Lowbandwidth
- HighImpedance
- Movingspaceproblem
- Size

VII. Acknowledgements

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