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Design and Development of 4G MIMO Antenna

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ABSTRACT: This 4G MIMO antenna is designed to operate at a resonant frequency of 1920 MHz. Patchwork technique is used for the antenna fabrication for its simplicity and cost efficiency. The Transmit and Receive band are 60 MHz wide (1850-1910 MHz and 1930-1990 MHz respectively) which is the frequency requirement for LTE band. This antenna will be used as a trans-receiver in the BTS of a telecom service provider.

KEYWORDS: Antennas; 4G; MIMO; HFSS; Microstrip, FR4, Patch Antenna

I. INTRODUCTION

To meet the intended applications in Tele-Communication, for 4G, the following specifications, listed in Table I are chosen:

Table I : Specifications

Parameter	Specifications
Frequency Range	1.85 GHz – 1.99 GHz
Gain (Total)	20 dB
Beamwidth	Min 70^o in Horizontal planes
Return loss	Better than 10dB
Polarization	Linear
Connector type	SMA Tab type
Physical Dimensions	50x70 (mm)
Weight	< 100g

The different design parameters of the antenna are calculated by using the design equations. A simple rectangular microstrip patch antenna is used to meet the desired gain, polarization and return loss requirements. The simulation studies are carried out using Ansoft HFSS Simulation tool. The simulation results are obtained and optimization of different parameters are carried out for achieving aimed specifications.

II. PATCH ANTENNA

In the recent years, printed circuit antennas have been receiving much attention owing to their light weight, low cost, small size, easy fabrication, conformity to the surface and ease of installation. The antennas are ideally suited in many modern aerospace, vehicles, man portable systems and commercial applications. Depending upon the geometry and feed network, printed antennas can produce different polarization and radiation. Some antennas are very simple while others exhibit complex shapes.

A 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

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rugged but has a wider bandwidth. Because such antennas have a very low profile, they 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.

A. Patch Antenna Basics

All of the parameters in a rectangular patch antenna design (L, W, h, permittivity) control the properties of the antenna. Given below is a general idea of how the parameters affect performance, in order to understand the design process. First, the length of the patch L controls the resonant frequency. This is true in general, even for more complicated microstrip antennas that weave around - the length of the longest path on the microstrip controls the lowest frequency of operation. Equation (1) below gives the relationship between the resonant frequency and the patch length:

$$f_c \approx \frac{c}{2L\sqrt{\varepsilon_r}} = \frac{1}{2L\sqrt{\varepsilon_0 \varepsilon_r \mu_0}} \quad \ldots(1)$$

Second, the width W controls the input impedance and the radiation pattern. The wider the patch becomes the lower the input impedance is.

The permittivity of the substrate controls the ε_r fringing fields - lower permittivities have wider fringes and therefore better radiation. Decreasing the permittivity also increases the antenna's bandwidth. The efficiency is also increased with a lower value for the permittivity. The impedance of the antenna increases with higher permittivities.
Higher values of permittivity allow a "shrinking" of the patch antenna. Particularly in cell phones, the designers are given very little space and want the antenna to be a half-wavelength long. One technique is to use a substrate with a very high permittivity. Equation (1) above can be solved for L to illustrate this:

$$L \approx \frac{1}{2 f_c \sqrt{\varepsilon_0 \varepsilon_r \mu_0}}$$

Hence, if the permittivity is increased by a factor of 4, the length required decreases by a factor of 2. Using higher values for permittivity is frequently exploited in antenna miniaturization.
The height of the substrate h also controls the bandwidth - increasing the height increases the bandwidth. The fact that increasing the height of a patch antenna increases its bandwidth can be understood by recalling the general rule that "an antenna occupying more space in a spherical volume will have a wider bandwidth". This is the same principle that applies when noting that increasing the thickness of a dipole antenna increases its bandwidth. Increasing the height also increases the efficiency of the antenna. Increasing the height does induce surface waves that travel within the substrate (which is undesired radiation and may couple to other components).

The following equation roughly describes how the bandwidth scales with these parameters:

$$B \propto \frac{\varepsilon_r - 1}{\varepsilon_r^2} \frac{W}{L} h$$

B. Design Procedure

Resonance is determined by length along the feed axis
– Length is approximately
– Width is loosely equal to length, however maximum efficiency is given for width by (1)

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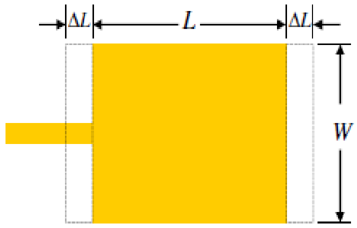
$$W = \frac{v_0}{2 * f_r} \sqrt{\frac{2}{\varepsilon_r + 1}} \qquad \varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} * \left[1 + 12 * \frac{h}{W}\right]$$

$$\frac{\Delta L}{h} = 0.412 * \frac{(\varepsilon_{eff} + 0.3) \cdot \left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258) \cdot \left(\frac{W}{h} + 0.8\right)} \qquad L = \frac{v_0}{2 \cdot f_r \cdot \sqrt{\varepsilon_{eff}}} - 2 \cdot \Delta L$$

Fringe Effect



Frequency requirements for LTE band II:
• Approximately 7.5% bandwidth
• Transmit band is 60 MHz wide, 1850-1910 MHz
• Receive band is 60 MHz wide, 1930-1990 MHz

The design will then center at 1920 MHz:
• Start a patch Length =1440 mils, with a Width =1860 mils
• Substrate is FR4 Er=4.5, height = .059 inches

III.SIMULATION AND OPTIMIZATION

A. Creating the Model

We choose a simple rectangular microstrip design with the radiating dipole on the top and the ground plane on the bottom side of the substrate box. Ensure that the direction of radiation should be along the Z Axis (Fig 1).

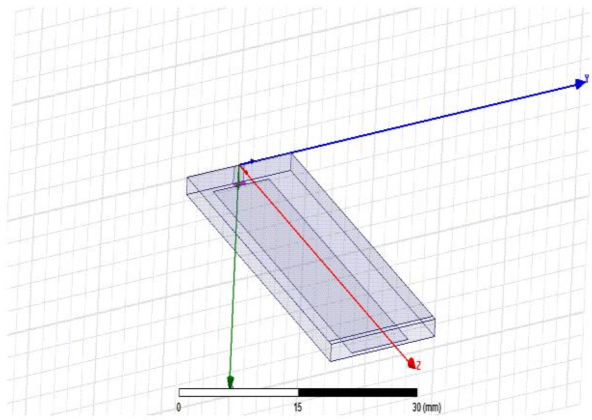


Fig. 1: Creating the Model

B. Creating Perfect Electric Conductor

The feed line, top (radiating element) and bottom (ground plane) need to be assigned a perfect electric conductor because the positive terminal of the input is given to the feed and the ground is negative. (Fig 2)

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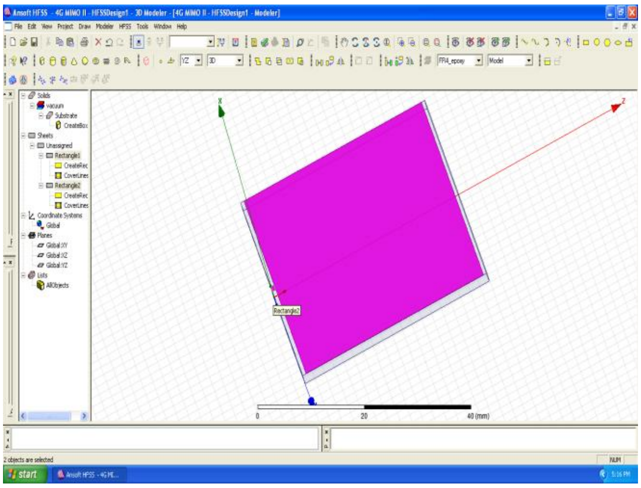

Fig. 2: Creating Perfect Electric Conductor

C. Creating radiation box

An air box has to be defined in to model open space so that the radiation from the structure is absorbed and not reflected back. The air box should be a quarter-wavelength long of the frequency of interest in the direction of the radiated field. In the directions where the radiation is minimal, this quarter-wavelength condition does not have to be met and an air "space" may not even have to be defined.

Since the radiation of a p antenna is concentrated along the z direction, a rectangular box enclosing the structure is only needed; the height of the air box is more than all the dimensions of the PCB.

D. Creating Wave Port

In order to excite the structure an excitation source has to be chosen. For this simulation a wave port will be used. The wave port will excite the first mode of the microstrip line and then HFSS will use this field to excite the entire structure. In order to get an accurate result, the wave port has to be defined properly; if it is too small the field will be truncated (characteristic impedance will be incorrectly calculated) and if it is too large a waveguide mode may appear. After the wave port rectangle is drawn, the WAVEPORT excitation was assigned to it.

E. Setting the Analysis

After the above steps, we must save the project and perform the "Validation Check" as shown in figure. Finally we go ahead and simulate the Project by clicking on "HFSS" and then "Analyze All".

F. Optimized Values

The results obtained after optimization met our required specifications. Hence we fixed all our parameters accordingly.

A FR4 substrate board having a dielectric constant of 4.4 was used in the project. This was chosen because the lower the dielectric constant, more will be the propagation of the EM Waves through the substrate. Hence a low dielectric constant substrate was chosen.

Its thickness is kept to be 0.8mm and the perfect electric conductors are Copper.

The feed line used is a microstrip line having a thickness of 4.8 mm, which matches the input impedance of the antenna and the feed.

IV. RESULTS & DISCUSSION

After the model is simulated, and optimized, the results are obtained using Ansoft HFSS software, and noted. The required radiation pattern is directional, having a minimum bandwidth of 70 degrees. The return loss requirement is lower than 10 dB so that the telecom VSWR requirements are met with. Thus the results of simulation are shown below.

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A. Radiation Pattern

The radiation pattern plots are shown in Figure 3. The pattern obtained clearly has a beamwidth of more than 70 degrees over the desired frequency band, as per the requirements listed in Table I. Moreover, the consistency of the pattern at various angles shows that the signal may be omnipresent in the surrounding area, suitable for 4G applications.

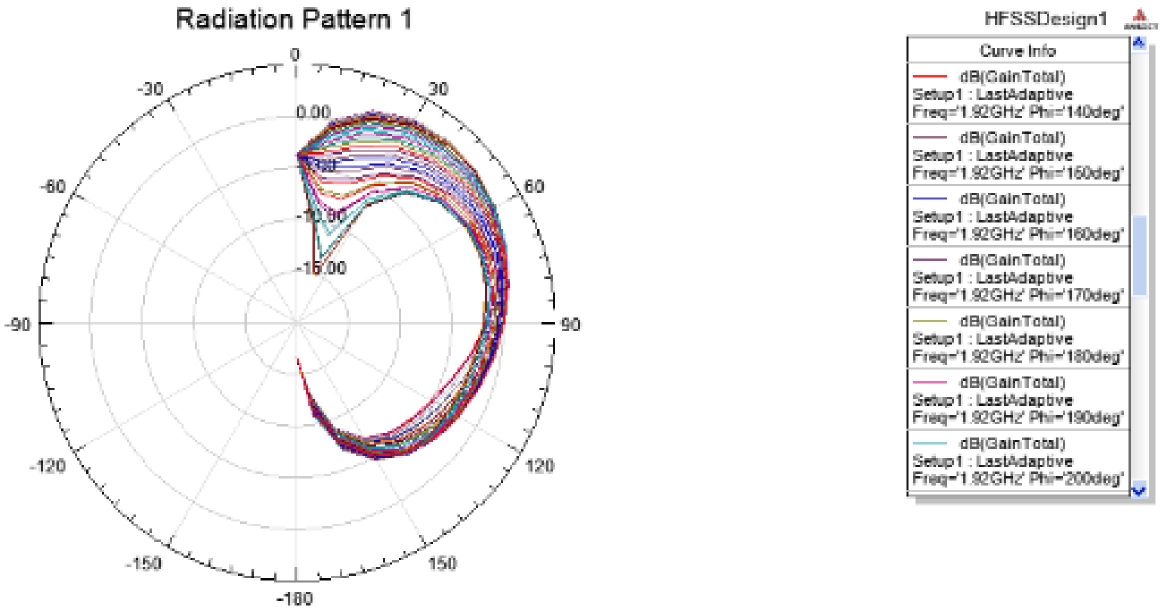

Fig 3. Radiation Pattern

B. Return Loss

The return loss required for the antenna is less than 10dB value. As is depicted in Fig 4, the return loss is resonant at a lower frequency than 1.78 GHz. However, even at our operational bandwidth, the value is appreciably low and conforms to our requirements.

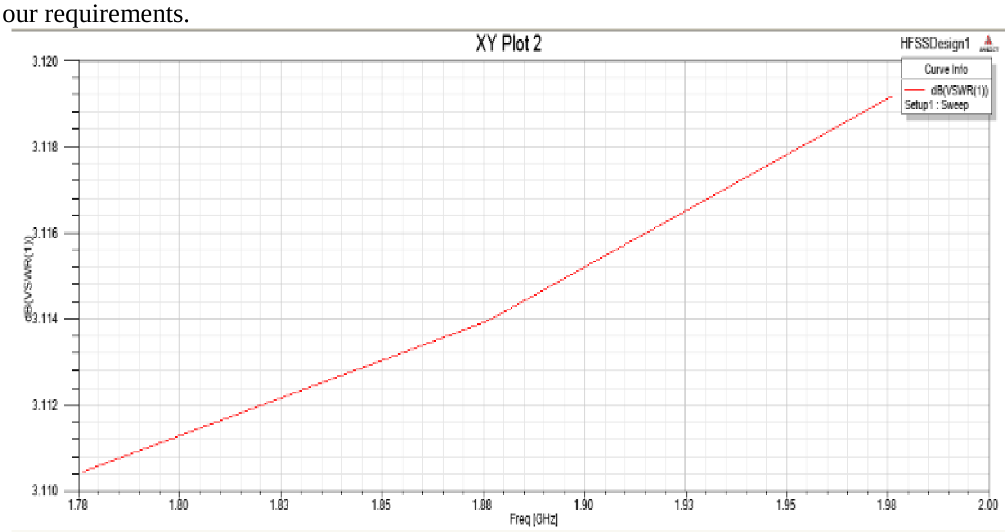

Fig 4. Return Loss

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V.CONCLUSION

After the Simulation and Optimization processes, the antenna is ready for fabrication. The novelty of this design is its simplicity, small size and the fact that the radiation is observed only on the forward lobe. Thus all of the energy must be propagated in the forward direction, to the entire 4G frequency band resonant at 1920 MHz.

REFERENCES

1. Copy of Published Paper in International journal for Computer Science and Emerging Technologies.
2. Balanis, Constantine. "Antenna theory: a review", proceedings of the IEEE, vol. 80, January 1992.
3. Jasik, "Antenna Engineering Handbook", McGraw-Hill, pp 18-1 to 18-23, 1961
4. http://en.wikipedia.org/wiki/Microstrip_antenna
5. www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=6&cad=rja&uact=8&ved=0CD8QFjAF&url=http%3A%2F%2Flinux.students.engr.scu.edu%2F~bhorwath%2Fpresentations%2FMicrostrip%2520Patch%2520Antenna%2520Design.pdf&ei=zIBhVPGnLoOmuQS5qoLAAg&usg=AFQjCNHeLpB7R48343wIBa7pDLQGlZ39RQ&bvm=bv.79189006,d.c2E
6. http://www.antennatheory.com/antennas/patches/patch4.php
7. http://en.wikipedia.org/wiki/Microstrip_antenna
8. http://searchmobilecomputing.techtarget.com/definition/4G