International Journal of Electronics Signals and Systems

Volume 1 | Issue 4 Article 3

April 2012

The Design and Development of Microstrip Patch Antenna using simulation studies by ADS

Suman Nath
Department of Electrical Engineering Bengal Engineering & Science University, Shibpur, India, suman.therebel@gmail.com

Somnath Rana
Department of Electrical Engineering Bengal Engineering & Science University, Shibpur, India, somnath.besu.ee@gmail.com

Recommended Citation

Nath, Suman and Rana, Somnath (2012) "The Design and Development of Microstrip Patch Antenna using simulation studies by ADS," *International Journal of Electronics Signals and Systems*: Vol. 1 : Iss. 4 , Article 3.
DOI: 10.47893/IJESS.2012.1044
Available at: https://www.interscience.in/ijess/vol1/iss4/3

The Design and Development of Microstrip Patch Antenna using simulation studies by ADS

Suman Nath[1], Somnath Rana[2]
Department of Electrical Engineering
Bengal Engineering & Science University, Shibpur, India
Email : 1 suman.theRebel@gmail.com ,2 somnath.besu.ee@gmail.com

Abstract-* The matching network of a Microstrip Patch Antenna at 10.65 GHz was designed and developed using the software Advanced Design System (ADS). ADS is a powerful software for designing microwave electronic circuits. The Microstrip Patch antenna thus developed was tested at 10m Far Field Antenna Anechoic Chamber and Momentum Simulation studies of the same was carried out using a Network Analyzer that can analyze signals in GHz range.

Keywords–* Advanced Design System (ADS), Anechoic chamber, Microstrip patch antenna, momentum simulation, Radiation Absorbent Material (RAM).

1.0. INTRODUCTION

2.0. PROPERTIES OF A BASIC MICROSTRIP PATCH ANTENNA

The Microstrip patch antenna is a low- profile antenna that has a number of advantages over other antennas- it is lightweight, inexpensive, and easy to integrate with accompanying electronics. While the antenna can be 3-D in structure (wrapped around an object, for example), the elements are usually flat; hence their other name, planar antennas. Note that a planar antenna is not always a patch antenna **[5].**

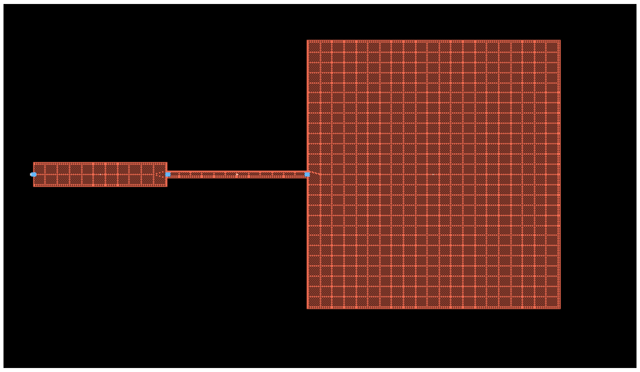

Figure1. Patch Antenna Layout

Figure1 & 2 shows a patch antenna in its basic form: a flat plate over a ground plane (usually a PC board). The center conductor of a coax serves as the feed probe to couple electromagnetic energy in and/or out of the patch. The electric field distribution of a rectangular patch excited in its fundamental mode is also indicated.

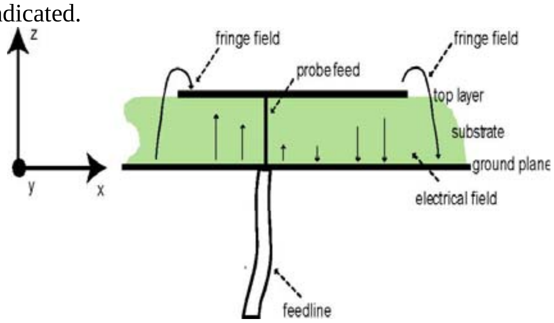

Figure2.

The electric field is zero at the center of the patch, maximum (positive) at one side, and minimum (negative) on the opposite side. It should be mentioned that the minimum and maximum continuously change side according to the instantaneous phase of the applied signal. The electric field does not stop abruptly at the patch's periphery as in a cavity; rather, the fields extend the outer periphery to some degree. These field extensions are known as fringing fields and cause the patch to radiate. Some popular analytic modeling techniques for patch antennas are based on this leaky-cavity concept. Therefore, the fundamental mode of a rectangular patch is often denoted using cavity theory as the TM10 mode **[4].**

Since this notation frequently causes confusion, we will briefly explain it. TM stands for Transversal Magnetic field distribution. This means that only three field components are considered instead of six. The field components of interest are: the electric field in the z direction and the magnetic field components in x and y direction using a Cartesian coordinate system, where the x and y axes is parallel with the ground- plane and the z- axis is perpendicular. In general, the modes are designated as TMnmz. The z value is mostly omitted since the electric field variation is considered negligible in the z-axis. Hence TMnm remains with n and m the field variations in x and y direction. The field variation in the y direction (impedance width direction) is negligible; thus m is 0. And the field has one minimum-to-maximum variation in the x direction (resonance length direction); thus n is 1 in the case of the fundamental. Hence the notation TM10.

3.0. EQUIVALENT CIRCUIT OF MICROSTRIP PATCH ANTENNA

The Equivalent circuit of the patch of 10.65 GHz Microstrip patch antenna in ADS platform is shown in screen snapshot, Figure3:

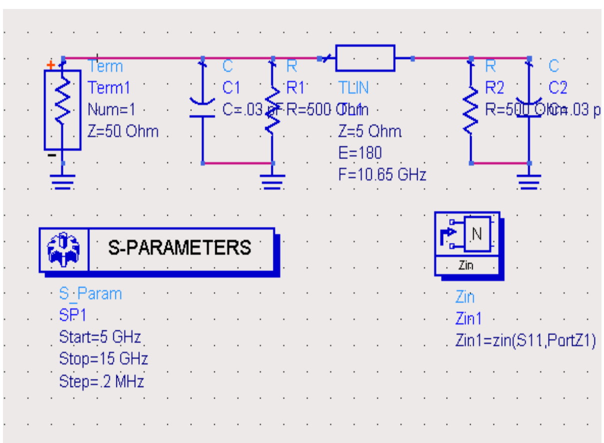

Figure3.

The equivalent circuit of the feedline (refer Figure2) that is a real Transmission Line in ADS platform is shown in screen snapshot, Figure4:

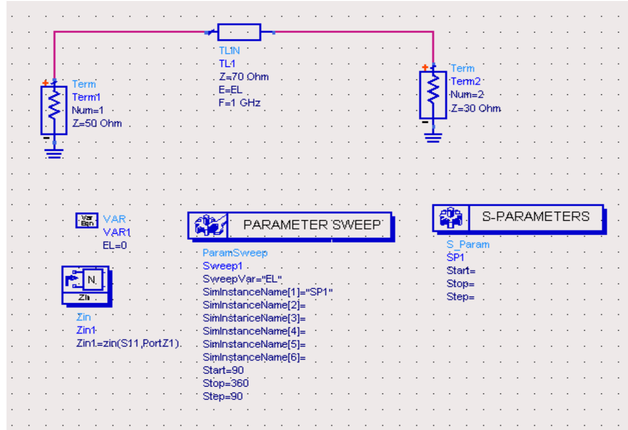

Figure4.

The various parameters like Resistance (R), Capacitance (C), Impedance (Z), Frequency (F) etc, are the inputs required for the equivalent circuit of the patch (Figure3) and the feedline (Figure4) of the Microstrip patch antenna. The individual equivalent circuits of the patch and the feedline are then connected together to develop the overall Patch antenna schematics as shown in Figure5.

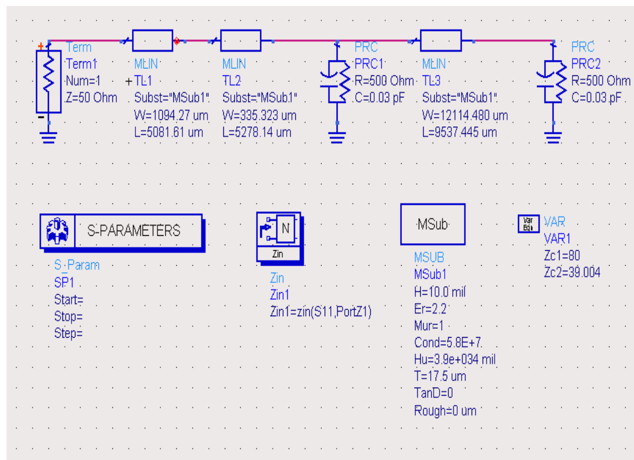

Figure5. Overall Patch antenna schematics

4.0. FINAL REPRESENTATION OF THE DESIGNED CIRCUIT

The Overall patch antenna circuit as designed in the ADS platform is finally represented as shown in Figure6 and it is used for momentum simulation.

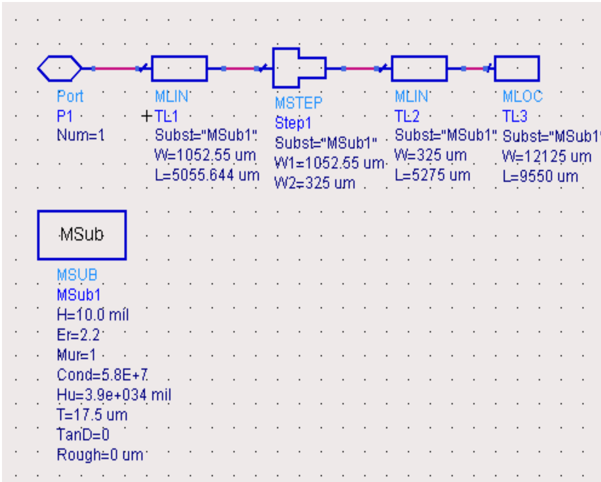

Figure6.

5.0. FUNDAMENTAL SPECIFICATIONS OF PATCH ANTENNAS

5.0.1. RADIATION PATTERN

The patch's radiation at the fringing fields results in a certain far-field radiation pattern. This radiation pattern shows that the antenna radiates more power in a certain direction than another direction. The antenna is said to have certain directivity. This is commonly expressed in dB.

An estimation of the expected directivity of a patch can be derived with ease. The fringing fields at the radiating edges can be viewed as two radiating slots placed above a ground-plane. Assuming all radiation occurs in one half of the hemisphere, this results in 3dB directivity **[1].** This case is often described as a perfect front-to-back ratio; all radiation towards the front and no radiation towards the back. This front-to-back ratio is highly dependent on ground-plane size and shape in practical cases. Another 3dB can be added since there are 2 slots. The slots are typically taken to have a length equal to the impedance width (length according to the y-axis) of the patch and a width equal to the substrate height. Such a plot typically has a gain of about 2 to 3 dB (cfr. simple dipole). This result in a total gain of 8 to 9 dB **[2].**

The rectangular patch excited in its fundamental mode has a maximum directivity in the direction perpendicular to the patch (broadside). The directivity decreases when moving away from broadside towards lower elevations. The 3dB beamwidth (or angular width) is twice the angle with respect to the angle of the maximum directivity, where this directivity has rolled off 3dB with respect to the maximum directivity. An example of a radiation pattern can be found below in Figure7.

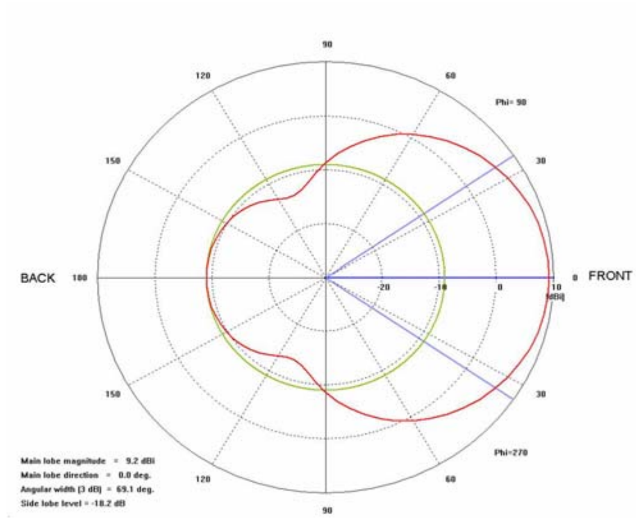

Figure7.

The electric field radiation pattern of the 10.65GHz Microstrip patch antenna designed by us is shown below in Figure8.

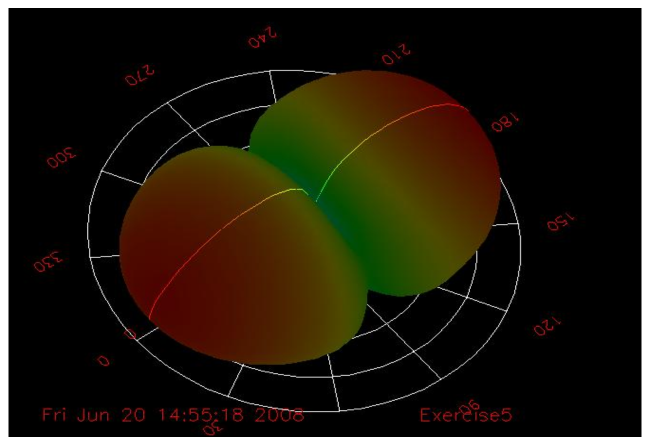

Figure8.

5.0.2. BANDWIDTH

Another important parameter of any antenna is the bandwidth it covers. Only impedance bandwidth is specified most of the time. However, it is important to realize that several definitions of bandwidth exist-impedance bandwidth, directivity bandwidth, polarization bandwidth, and efficiency bandwidth. Directivity and efficiency are often combined as gain bandwidth. The following definitions are important:

(1) Impedance bandwidth/return loss: This is the frequency range wherein the structure has a usable bandwidth compared to a certain impedance, usually 50 ohm. The impedance bandwidth depends on large number of

parameters related to the patch antenna element itself (e.g., quality factor) and the type of feed used. The plot below (Figure9) shows the return loss of a patch antenna and indicates the return loss bandwidth at the desired S11/VSWR (S11 wanted/VSWR wanted). The bandwidth is typically limited to a few percent. This is the major disadvantage of basic patch antennas. Several techniques to improve the bandwidth exist, but these are beyond the scope of this paper **[3].**

(2) Directivity/gain bandwidth: This is the frequency range wherein the antenna meets a certain directivity/gain requirement (e.g., 1dB gain flatness).

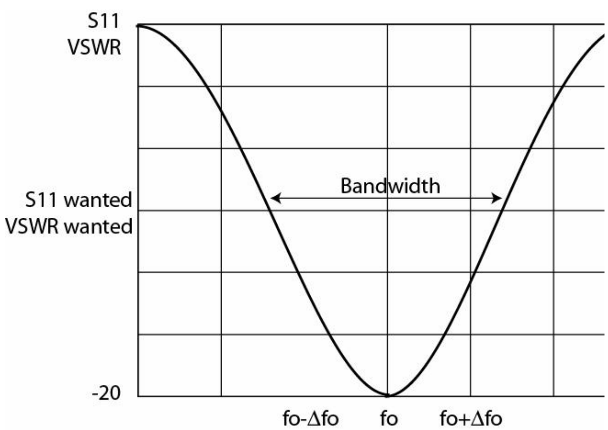

Figure9.

(3) Efficiency bandwidth: This is the frequency range wherein the antenna has reasonable (application dependent) radiation/total efficiency.

(4) Polarization bandwidth: This is the frequency range wherein the antenna maintains its polarization.

(5) Axial ratio bandwidth: This bandwidth is related to the polarization bandwidth and this number expresses the quality of the circular polarization of an antenna.

Shown below (Figure10a & b) are the results of momentum simulations of the patch antenna we designed - the return loss of the patch antenna and indicates the return loss bandwidth at the desired S11 (S11 wanted).

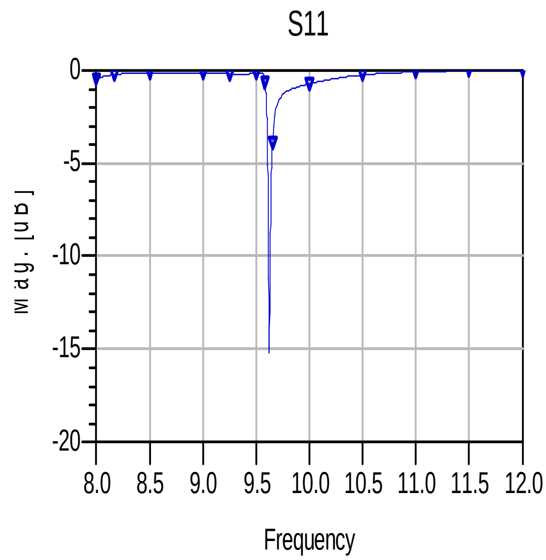

Figure10a.

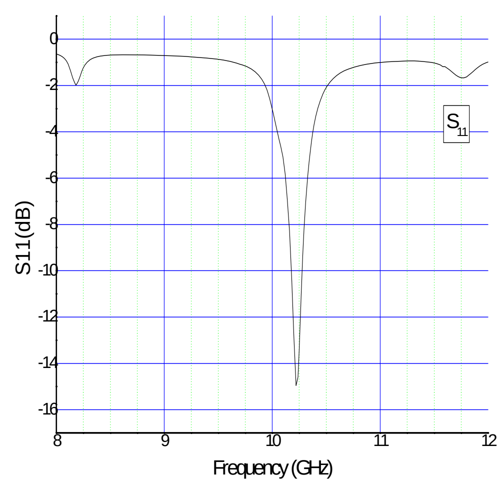

Figure10b.

A Network Analyzer shows the results obtained for our patch antenna (Figure11):

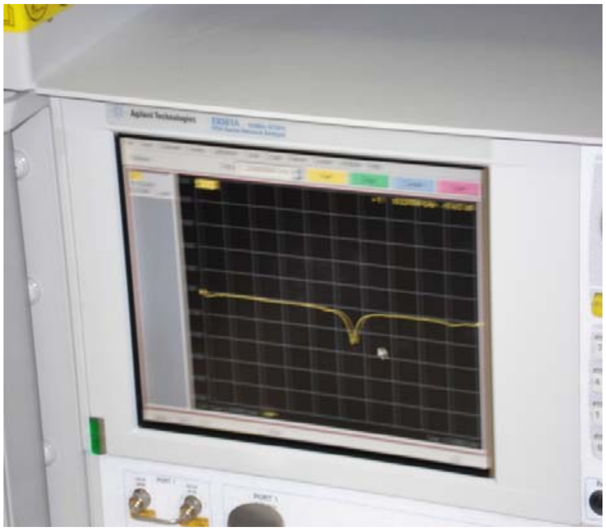

Figure11.

6.0. ANECHOIC CHAMBER

Measurements of radiation patterns of the 10.65GHz Microstrip patch antenna we designed were done at a 10m Far Field Antenna Anechoic Chamber. As shown in Figure12 below, the Anechoic chamber has its internal surfaces covered with Radiation Absorbent Material (RAM). The chamber attenuates waves and provides a shielded environment for radio frequency and microwaves.

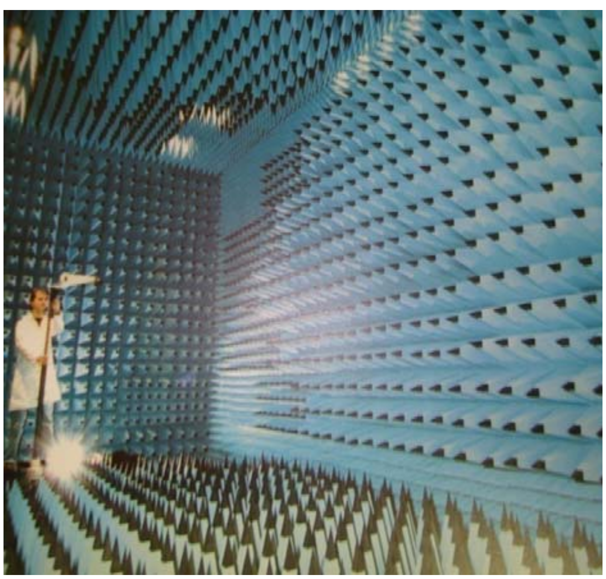

Figure12.

7.0. ACKNOWLEDGMENTS

[1] Dr. Robert Cahill, Senior Professor, High Frequency Electronics (HFE) group at Queen's University Belfast (QUB).

[2] Dr. Eugene Brennan, Post doctoral scholar, High Frequency Electronics (HFE) group at Queen's University Belfast (QUB).

[3] Mr. Constantine Talalaev, PhD student, High Frequency Electronics (HFE) group at Queen's University Belfast (QUB).

[4] Mr. Sean O'Kane, PhD student, High Frequency Electronics (HFE) group at Queen's University Belfast (QUB).

[5] Mr. Serenus Jeyakumar, PhD student, High Frequency Electronics (HFE) group at Queen's University Belfast (QUB).

8.0. REFERENCES

[1] He W., Jin R., Geng J. (2008) E-Shape patch with wideband and circular polarization for millimeter-wave communication. *IEEE Transactions on Antennas and Propagation*. 56(3), 893-895.

[2] Lau K.L., Luk K.M., Lee K.L. (2006) Design of a circularly-polarized vertical patch antenna *IEEE Transactions on Antennas and Propagation*. 54(4), 1332- 1335.

[3] Zhang Y.P., Wang J.J. (2006) Theory and analysis of differentially-driven microstrip antennas.

[4] IEEE *Transactions on Antennas and Propagation*. 54(4), 1092-1099.

[5] Matin M.M., Sharif B.S., Tsimenidis C.C. (2007) Probe fed stacked patch antenna for wideband applications.