Design of Microstrip Patch Antenna for High Gain & Directivity at 3.5 GHz by Simulation studies using ADS

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Abstract: *The study of microstrip patch antennas has made great progress in recent years. A simple microstrip patch antenna consists of metallic patch and ground between which is a dielectric medium called the substrate.In this paper a simple microstrip patch antenna is designed in ADS at a resonant frequency of 3.55 GHz for WiMax applications. The gain of antenna is 5dB and directivity is 7dB.*

Keywords: *Radiation Pattern, Directivity, Gain, Bandwidth.*

I. INTRODUCTION

Microstrip antennas became very popular in the 1970s primarily for space borne applications. Today they are used for government and commercial applications. These antennas consist of a metallic patch on a grounded substrate [1]-[2].The metallic patch can take many different configurations. However, the rectangular and circular patches are the most popular because of ease of analysis and fabrication, and their attractive radiation characteristics, especially low cross-polarization radiation [1].

The microstrip antennas are low profile, conformable to planar and nonplanar surfaces, simple and inexpensive to fabricate using modern printed-circuit technology, mechanically robust when mounted on rigid surfaces, compatible with MMIC (Monolithic Microwave Integrated Circuit) designs, and very versatile in terms of resonant frequency, polarization, pattern, and impedance. These antennas can be mounted on the surface of high-performance aircraft, spacecraft, satellites, missiles, cars, and even handheld mobile telephones [1]-[2]-[3].

In this paper a microstrip patch antenna designed on ADS software. The antenna has been designed on a resonant frequency of 3.55 GHz. This frequency has been selected because it is suitable for WiMax applications. The dimensions of antenna like its height, length, width, etc. have been calculated using the design equations given in this paper.

This paper presents the introduction and applications of microstrip patch antennas. It includes the various design equations and methodologies required to calculate the dimensions of a microstrip patch antenna. The simulation layout and results of the antenna showing the gain and directivity of the antenna have been given. The sources and references used in the research have also been given to authenticate the design equations and results.

II. DESIGN EQUATIONS

Width of patch is given by

$$W = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r+1}{2}}}$$

Effective Dielectric Constant

Due to Fringing Effect, it makes the Microstrip look wider as compared to its physical dimensions. Since, some of the waves travel in substrate, and some of the waves travel in air, an effective dielectric constant is introduced to define fringing and wave propagation in antenna. The effective dielectric constant is defined such that the area where electric fields travel has approximately equivalent characteristics making calculations simpler.

For W/h>1, the effective dielectric constant is defined by the equation,

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

Effective Length

The electrical length of a patch antenna is greater than the physical length. This normalized extension in the length is calculated using equation,

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

Using this equation Δ is calculated. The actual length of the patch can now be determined by solving the equation for L

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

Frequency of operation is given by

$$f_r = \frac{c_0}{2(L + 2\Delta L)\sqrt{\varepsilon_{reff}}}$$

Center frequency will be defined as

$$f_0 = \frac{c}{2\sqrt{\varepsilon_{reff}}}\left[\left(\frac{m}{L}\right)^2 + \left(\frac{n}{W}\right)^2\right]$$

Variation of Input Impedance throughout Patch Antenna

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

Input –Output Impedance Relation

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

Calculation of the ground plane dimensions (Lg and Wg)

Lg = 6h+ L

Wg = 6h+ W

III. DESIGN AND SIMULATED RESULTS

Here we are taking Fr-4 dielectric material which has a dielectric constant of 4.6 and height of substrate is taken as 1.6 mm. The Operating Frequency of antenna is 3.5 GHz which is selected for WiMax applications. By these parameter we can calculate the length (L), Width (W) of patch easily.

Layout

The layout of the antenna has been drawn using the ADS software. The parameters are calculated using the above formulas.

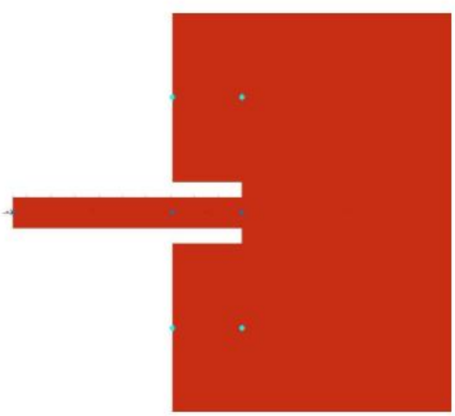

Figure 3 Layout with Inset feed

S-parameter

The S11 defines the power transmitted from port 1 to port 1 itself, hence defining the reflection in the antenna. For maximum radiation, the reflection should be as less as possible to make the antenna more efficient.

Gain

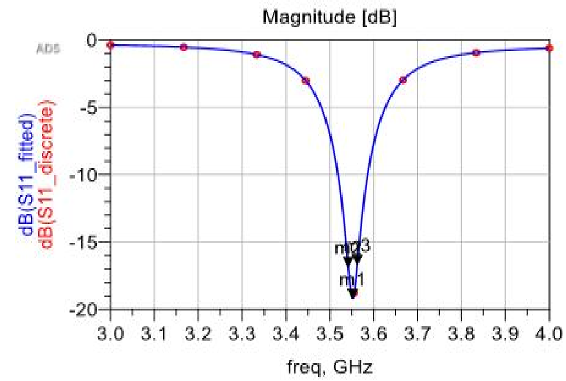

Figure 1 S11 Parameter Plot

Antenna Gain is also referred as Power gain or simply Gain. This combines of antenna efficiency and directivity. For a transmitting antenna it shows how efficiently antenna is able to radiate the given power into space in a particular direction. While in case of receiving antenna it shows how well the antenna is to convert the received electromagnetic waves into electrical power.

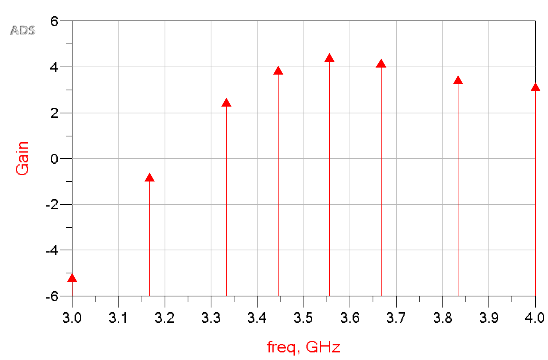

Figure 2 Gain Vs Frequency

Directivity

Directivity of an antenna shows that how much the antenna is able to radiate in a particular given direction. It is a major requirement when antenna is working as a receiver. If an antenna radiates equally in all direction then then the directivity of antenna is 1 or when measured with respect to isotropic antenna is 0dB.

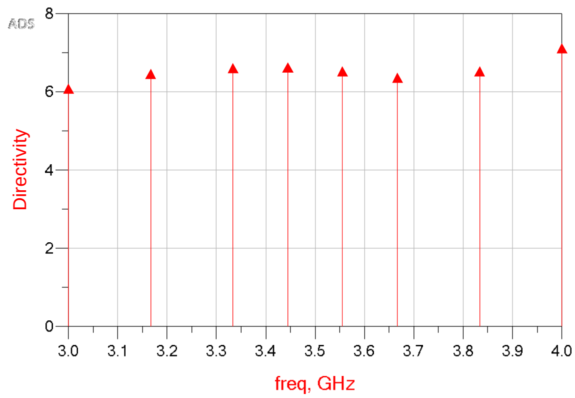

Figure 4 Directivity Vs Frequency

Efficiency

Efficiency of an antenna is the ratio of the output power radiated to the input power received.

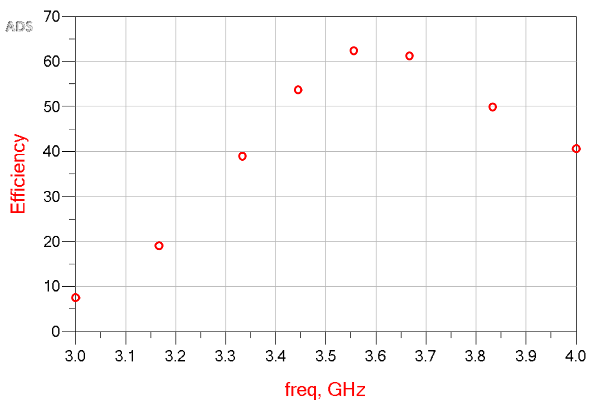

Figure 5 Efficiency Vs Frequency

Power radiated

It is the amount of power radiated by antenna.

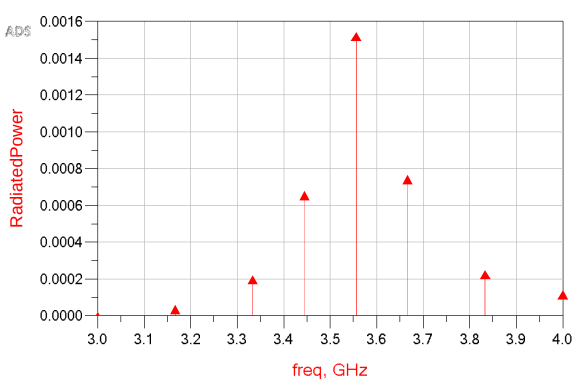

Figure 6 Power radiated

we can see from the graphs, the return loss has decreased to a large level i.e. -19 dB which is good outcome and simultaneously, it have a bandwidth of up to 20 MHz, which is still usable as Wi-max working at 3.5 GHz as it have a BW of 1.5-20 MHz .

IV. CONCLUSION

The present state of work includes the design procedure of microstrip patch antenna at a resonant frequency of 3.55 GHz which is suitable for WLAN application, Satellite communications and WiMax applications. The results shows the improved bandwidth, gain is high and the s parameters graphical resultsshows the increase in the efficiency and wide radiation patterns detailed experimental studies can be taken up at a later stage to find out a design procedure for balanced amplifying antennas.

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