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Bandwidth Enhancement Of A Transmission Line Feed Single Layer Dielectric Substrate Microstrip Patch Antenna

Sheikh Dobir Hossain*
Dept. of Physics
Jessore University of Science and Technology
Jessore-7408, Bangladesh
s.dobir@just.edu.bd

Md. Khalid Hossain
Institute of Electronics
Atomic Energy Research Establishment
Savar, Dhaka, Bangladesh
khalid.baec@yahoo.com

Md. Al Amin
Dept. of CSE
Jessore University of Science and Technology
Jessore-7408, Bangladesh
malamin.ali@just.edu.bd

K. M. Abdus Sobahan
Dept. of AECE
IslamicUniversity
Kushtia-7003, Bangladesh
asobahan@yahoo.com

***Abstract*—In this paper we describe the simulation of a rectangular microstrip patch antenna with transmission line feed. Also it is our target to improve the bandwidth of our designed antenna. The use of lower value of dielectric constant with moderate thickness it has possible to obtain a larger bandwidth. We have use the copper material both in ground and patch hence it reduces the cost of our designed antenna. The designed antenna is simulated using ANSYS High frequency structural simulator 13.0 (HFSS) software. The resonance frequency of our designed antenna is 3 GHz and the bandwidth of the antenna is 415 MHz which is 20 percent higher than usual antenna bandwidth and is applicable for practical application such as RADAR and Satellite stations. Here we have also represents the design procedure, feed mechanism and simulation results of different antenna parameters.**

Keywords—Transmission line feed; return loss; bandwidth; single layer substrate; Single band antenna; HFSS.

I. INTRODUCTION

Antenna is a vital element in communication system. The demand of shrink sized wireless antenna with good efficiency and larger bandwidth in communication system increasing day by day. Thus, for the case of commercial and government communication systems, the low cost, small weight and low profile antennas is needed that are capable of maintaining high performance over a large spectrum of frequencies. A small size, lower weight, low-profile antenna is very much important to obtain better performance in aircraft, spacecraft, satellite, and missile applications. Instead of these recently many government and commercial applications have been using mobile radio and wireless communications that have similar specifications. The microstrip patch antennas [1]-[2] is important to fulfill these requirements. Because, these antennas are low profile, simple and less expensive to manufacture using modern printed-circuit technology, versatile in terms of resonant frequency, suitable for different polarization such as circular, linear and elliptical and also portable. [3]-[9]. This technological trend has focused on the design of microstrip antennas with a simple geometry. However there are some disadvantageous features of these microstrip antennas, which have reduced their diversification. Major operational limitations of microstrip antennas are their low efficiency, low power, high Q (sometimes in excess of 100), poor polarization purity, poor scan performance, spurious feed radiation and very narrow frequency bandwidth, which is typically only a fraction of a percent or at most a few percent. In some fields, such as in government security systems, narrow bandwidths are usable. However, there are some techniques, such as increasing the height of the substrate that can be used to extend the efficiency (to as large as 90 percent if surface waves are not included) and bandwidth (up to about 20 percent). Stacking, as well as other methods, of microstrip elements can also be used to increase the bandwidth [10]–[14].

II. EXPERIMENTAL MODEL

To design an antenna firstly it is necessary to specify some values such as operating frequency, value of dielectric constant and height of the dielectric substrate, which are 3 GHz, 2.40 and 1 mm respectively. After assuring these values we have to calculate the different parameter of the antenna. The designed single band antenna with a single layer dielectric substrate is shown in fig.1.

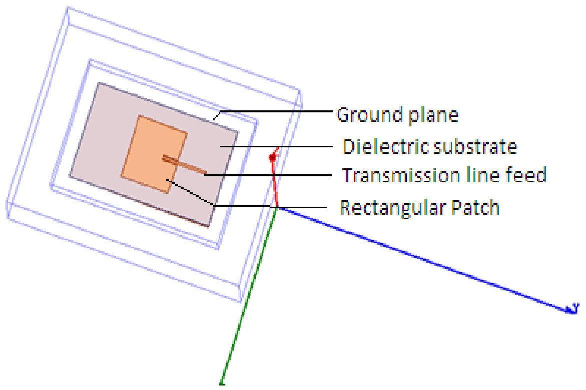


Fig.1. *Geometry of desired single band microstrip patch antenna*

The various parameter of our designed antenna can be obtained by using the following equations [14]-[15]. The width that's leads to good radiation efficiencies is

$$w = \frac{v_0}{2f_r} \times \sqrt{\frac{2}{\varepsilon_r + 1}} \quad (1)$$

Here, v_0=Velocity of light=$300 \times 10^9 mm/sec$

f_r =Resonant frequency

ε_r=Dielectric constant of the substrate

The value of effective dielectric constant is

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2\sqrt{1 + \frac{12h}{W}}} \quad (2)$$

Where, h is the thickness of the substrate and must be in mm unit

The normalized extension of the length is

$$a = \frac{a_{eff}}{\sqrt{\{1 + \frac{2h}{\pi\varepsilon_r a_{eff}}[\ln(\frac{\pi a_{eff}}{2h}) + 1.7726]\}}}$$

$$\frac{\Delta L_{eff}}{h} = 0.412 \frac{(\varepsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)} \quad (3)$$

The effective length of the patch is

$$L_{eff} = (L + 2\Delta L_{eff}) \quad (4)$$

Where actual length is

$$L = \frac{v_0}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L \quad (5)$$

And the length of the location of feed point inside the patch is

$$Z_0 = \frac{120\pi}{\sqrt{\varepsilon_{reff}}\,(1.393 + \frac{W}{h} + \frac{2}{3}\ln(\frac{W}{h} + 1.444))} \quad (6)$$

III. ANTENNA PARAMETER

The values of different calculated parameters of our desired single band transmission line feed antenna are represents in table 1

Table 1. *The values of different parameters of single-band rectangular microstrip antenna*

Parameters	Values
Length of the Patch (Lp)	39.53 mm
Width of the Patch (Wp)	33.49 mm
Dielectric constant of the Patch (ε_r)	2.40
Thickness the dielectric substrate (h)	1.00 mm
Inset depth of the Patch (Y_0)	10.23mm
Width of the Microstrip line (W_f)	1.565mm
Thickness of the Microstrip Patch (Mt)	0.1mm
Gap between transmission line and patch (Gpf)	0.783mm

IV. BANDWIDTH ENHANCING

In the previous section we have mentioned that the microstrip patch in its pure form cannot satisfy the bandwidth requirements for most wireless communication systems. However a typical modification of the pure formed of the structure of the printed antenna must be undertaken to meet the impedance bandwidth specifications. From the very beginning of the patch antenna there has a lot of bandwidth enhancements investigated, all with varying degrees of success and complexity. The various techniques such as Parasitically Coupled (or Gap-Coupled) Patches, Stacked Microstrip Patches, Increasing thickness of dielectric substrate, Large Slot Aperture-Coupled Patches , Aperture-Stacked Patches and Alternative Printed Antenna Solutions have been invented and here we have used Increasing thickness of dielectric substrate technique to obtained the desired bandwidth of the designed single band antenna.

V. SIMULATION RESULTS

A. Return Loss

The return loss (RL) is the parameter that indicates the amount of power lost in the load and does not return as a reflection. Fig.2. shows the return loss of the designed single band rectangular microstrip antenna. The designed antenna shows good return loss of -28 dB which agrees well with the previous result [9]. The antenna resonates at 3 GHz frequency which is applicable for RADAR and Satellite stations and gives a bandwidth of approximately 415 MHz. The bandwidth is calculated by subtracting lower frequency from upper frequency at -10 dB [15].

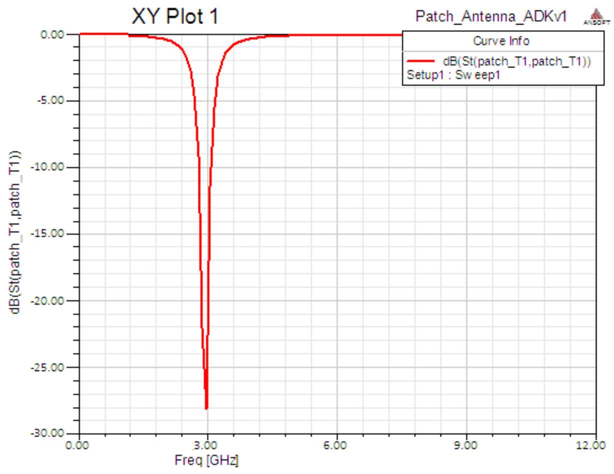


Fig.2. *Simulated returns loss of single band antenna at 3 GHz*

B. Smith Chart

The Smith Chart is a fantastic tool which is used to visualize the impedance of a transmission line and an antenna system as a function of frequency. The Smith Charts can also be used to obtain the proper impedance matching between antenna and transmission line. Fig.3 shows Smith Chart of the designed single band rectangular microstrip antenna. The designed antenna gives an impedance of approximately 49 ohms showing the antenna is perfectly matched and the power loss is minimum [15].

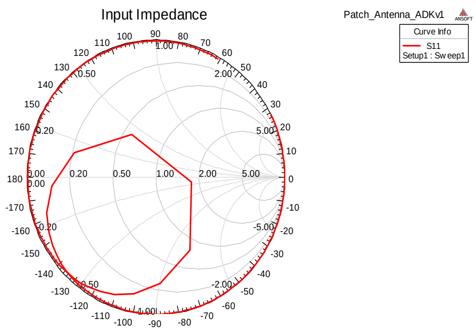
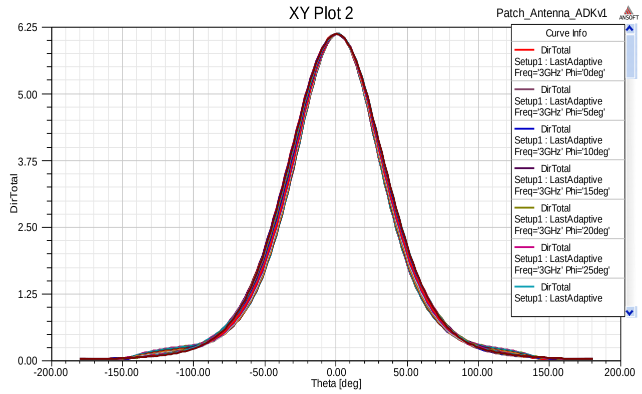


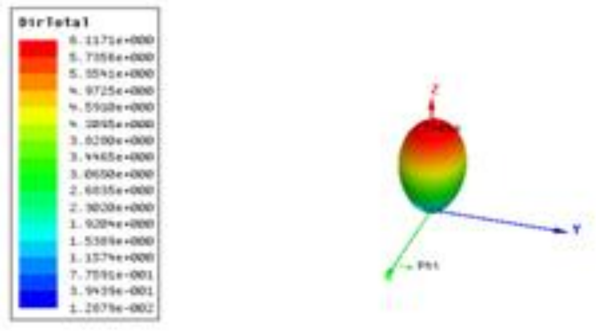
Fig.3. Smith chart of single band microstrip antenna at 3 GHz

C. Directivity

Directivity is a fundamental antenna parameter which measures how 'directional' an antenna's radiation pattern is. Basically a simple antenna radiates power equally in all direction and would have effectively zero directionality i.e. the directivity of this type of antenna would be 1 (or 0 dB) [15]-[17]. The Directivity of the designed single band rectangular Microstrip Antenna in 2D and 3D pattern is shown in Fig.4. The designed antenna gives a directivity of 6.11 dBi at the resonant frequency 3 GHz. From 2D pattern, it is also clear that the main lobe magnitude is 6.11 dBi and direction of the main lobe is 0.0 deg.



(a)

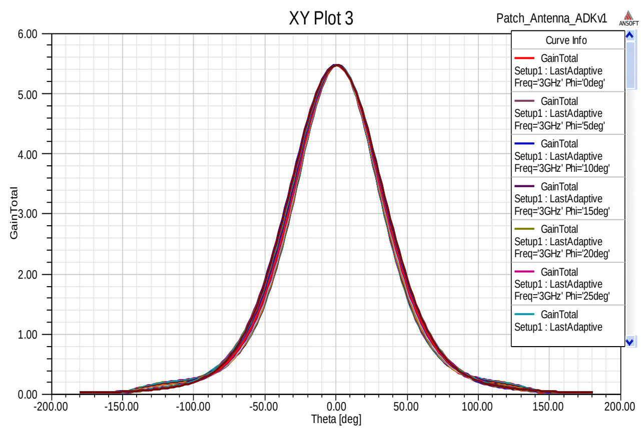


(b)

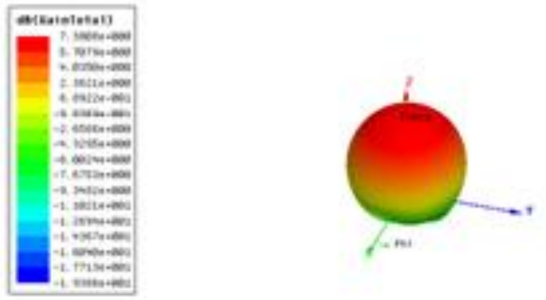
Fig.4. *Directivity of single band antenna at 3 GHz (a) 2D Pattern (b) 3D Pattern*

D. Gain

The term antenna gain defines how much power is transmitted in the direction of peak radiation to that of an isotropic source. Antenna gain is more commonly quoted in a real antenna's specification sheet because it takes into account the actual losses that occur. The gain of the designed rectangular microstrip antenna in 2D and 3D Pattern is shown in Fig.5. The gain of the designed single band rectangular microstrip antenna is found 5.9 dB at the resonant frequency of 3 GHz. From 2D pattern, it is also clear that the main lobe magnitude is 5.9 dBi.



(a)



(b)

Fig.5. *Gain of single band antenna at 3 GHz (a) 2D Pattern (b) 3D Pattern*

VI. SUMMARY OF THE RESULTS

The simulated results of various parameters of the designed single band antenna are summarized in the table 2.

Table 2. *Summary of the designed single band antenna parameters at 3 GHz frequency*

Parameters	Values
Operating frequency	3GHz
Return loss	-28dB
Impedance	49 ohms
Bandwidth	415 MHz
Directivity	6.11dB
Gain	5.9 dB

The simulated values of the different parameters show that the antenna results are good for practical applications.

VII. CONCLUSIONS

In this thesis, we report the configurations and simulation results of a transmission line feeding single layer dielectric substrate microstrip patch. The simulation results are obtained by using the ANSYS HFSS 13.0 software. The desired larger bandwidth is obtained by increasing the thickness of the dielectric substrate. From the simulation results it is clear that the bandwidth of the desired single band antenna has increased by the value of 20 percent than the previous designed antenna and this antenna is applicable for practical application such as RADAR and Satellite stations.

VIII. ACKNOWLEDGEMENT

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