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# DESIGN, SIMULATION AND PERFORMANCE ANALYSIS OF A LINE FEED RECTANGULAR MICRO-STRIP PATCH ANTENNA

Liton Chandra Paul, Nahid Sultan
Electronics & Telecommunication Engineering, Rajshahi University of Engineering & Technology, Kazla, Rajshahi-6204, Bangladesh
litonpaulete@gmail.com

***ABSTRACT***

*Microstrip patch antenna becomes very popular day by day because of its ease of analysis and fabrication, low cost, light weight, easy to feed and their attractive radiation characteristics. Although patch antenna has numerous advantages, it has also some drawbacks such as restricted bandwidth, low gain and a potential decrease in radiation pattern. The aim of the thesis is to design and fabricate a line feed rectangular Microstrip Patch Antenna and study the effect of antenna dimensions Length (L) , Width (W) and substrate parameters relative Dielectric constant, substrate thickness (t) on the Radiation parameters of Bandwidth and Beam-width.*

***KEYWORDS:*** *Rectangular microstrip antennas, dielectric substrate, resonant microstrip, radiation patterns, GEMS Software.*

## I. INTRODUCTION

The Microstrip Patch Antenna is a single-layer design which consists generally of four parts: patch, ground plane, substrate, and the feeding part [1]. The physical size of a microstrip antenna is small, but the electrical size measured in wavelength is not so small [2].The most commonly employed microstrip antenna is a rectangular patch. The rectangular patch antenna is approximately a one-half wavelength long section of rectangular microstrip transmission line. When air is the antenna substrate, the length of the rectangular microstrip antenna is approximately one-half of a free-space wavelength. As the antenna is loaded with a dielectric as its substrate, the length of the antenna decreases as the relative dielectric constant of the substrate increases. The resonant length of the antenna is slightly shorter because of the extended electric "fringing fields" which increase the electrical length of the antenna slightly. An early model of the microstrip antenna is a section of microstrip transmission line with equivalent loads on either end to represent the radiation loss [3].

## II. DESIGN PROCESS

This method of feeding is very widely used because it is very simple to design and analyze and very easy to manufacture. Figure-1 shows a patch with microstrip line feed from the side of the patch. The position of the feed point ($y_o$) of the patch in has been discussed in details in the section of Impedance Matching. It is widely used in both one patch antenna and multi-patches (array) antennas.

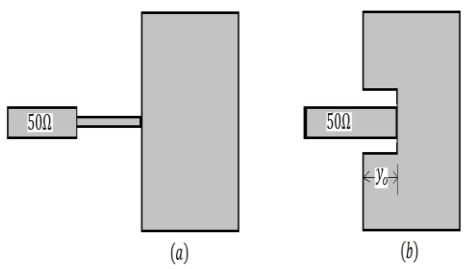


**Figure-1:** Microstrip patch antenna with feed from side

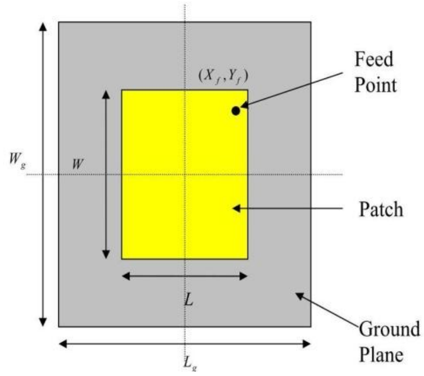


**Figure-2:** Top view of Microstrip Patch Antenna

**Step-1:** Calculation of width (W)
Width of the patch,

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

$f_0$=3 GHz ,$\varepsilon_r$=4.4, c=3.00 x $10^8$ m/s
We get,
W=0.0304mm=30.4mm

**Step 2:** Calculation of Effective dielectric constant (ε*reff*)

The effective dielectric constant is:

$$\varepsilon_{eff}=\frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}[1+12\frac{h}{w}]^{1/2}$$

$\varepsilon_r$=4.4, h=1.3, W=30.4mm
We get,
$\varepsilon_{eff}$ = 4.0822

**Step 3:** Calculation of the Effective length ( *Leff*)
The effective length is:

$$L_{eff}=\frac{c}{2f_0\sqrt{\varepsilon_{eff}}}$$

$f_0$= 3GHz ,$\varepsilon_r$=4.4, c=3.00e+008 m/s

We get,
$L_{eff}$= 0.0247=24.7mm

**Step 4:** Calculation of the length extension ($\Delta L$)
The length extension is:

$$\Delta L = 0.412h\frac{(\varepsilon_{\mathrm{eff}}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{\mathrm{eff}}-0.264)(\frac{W}{h}+0.8)}$$

$\varepsilon_{eff}$=4.0822, h=1.3, W=30.4mm
We get,
$\Delta L$= 6.0016e-004=.60016mm

**Step 5:** Calculation of actual length of patch ($L$)
The actual length is obtained by:
L=$L_{eff}-2\Delta L$
$\Delta L$=.60016mm,$L_{eff}$=24.7mm
We get,
L= 0.0235=23.5mm

**Step 6:** Calculation of Total characteristic impedance of the Microstrip transmission line
Total characteristic impedance of the Microstrip transmission line

ZL=$\sqrt{Z1 * Z2}$
Z1=probe impedance=50Ω
Z2= Total input impedance of the rectangular patch antenna=317.9778
We get,
ZL= 126.0908

**Step 7:** Calculation of Length of the Microstrip transmission line
Length of the Microstrip transmission line
TL=$\frac{\lambda}{4}$=$\frac{\lambda_0}{4\sqrt{\varepsilon_r}}$
$\lambda_0$=$\frac{c}{f_0}$=.1,$f_0$= 3GHz ,$\varepsilon_r$=4.4, c=3.00e+008 m/s
We get,
TL= 0.0119=11.9mm
**Step 8:** Calculation of Directive Gain of the antenna
Directive Gain of the antenna
G=$e_r D$
= 3.5066
Where D=2.2 x $10^{17}$ and $e_r$=1.6 x $10^{-17}$

## III. Simulation and Result

The GEMS software used to model and simulate the Microstrip patch antenna and it also used for calculating and plotting Return loss, VSWR, current distributions, radiation patterns etc. GEMS (general electromagnetic solver) are a Full 3-D Parallel EM Simulation Software and System.

### *3.1 Return loss and Antenna Bandwidth:*

To design a rectangular microstrip patch antenna we decide the substrate material and the thickness of it. Design an antenna for the IEEE 802.11b/g, in the band of 3GHz.

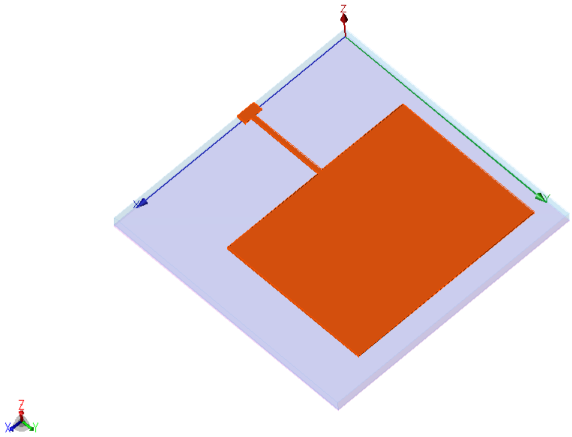

**Figure-3:** Microstrip patch antenna designed using GEMS for 3 GHz.

### Return Loss:

As show in figure-4 the simulation indicates a response at 2.937GHz with return loss = -8.314dB. A negative value of return loss shows that this antenna had not many losses while transmitting the signals.

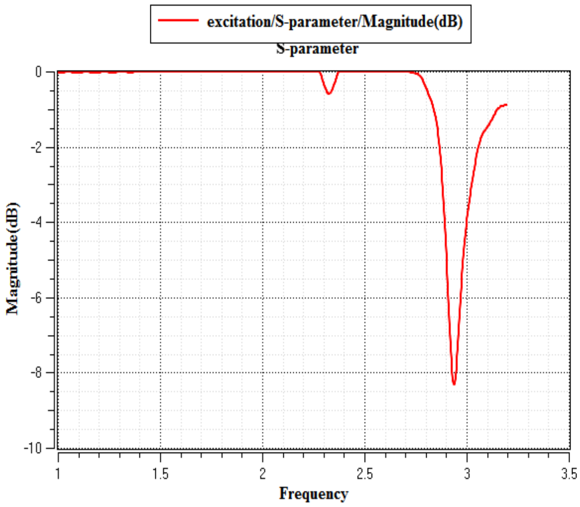


**Figure 4:** S-parameter plot for Return loss v/s frequency

## Antenna Bandwidth:

From the same figure the antenna bandwidth was calculated by using this formula:

Bandwidth=$\frac{f_2-f_1}{\sqrt{f_1 f_2}}\times 100\%$

The value of f1 and f2 were taken at –6dB or 6% from the transmitted power.

$$\text{Bandwidth}=\frac{2.981G-2.903G}{\sqrt{2.981G\times 2.903G}}\times 100\%=2.6515\%$$

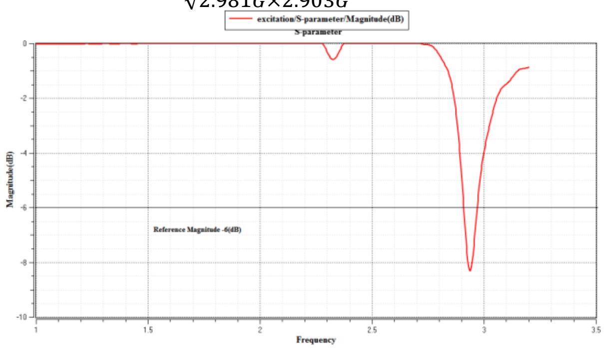


**Figure-5:** S-parameter plot for Return loss v/s frequency indicating reference magnitude

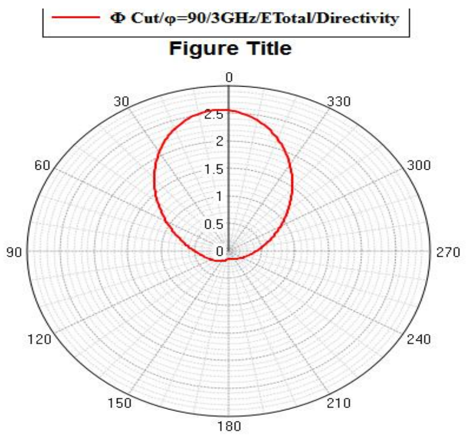


**Figure-6:** Directivity versus angle for f = 3 GHz at$\varphi$=90 in polar co-ordinate

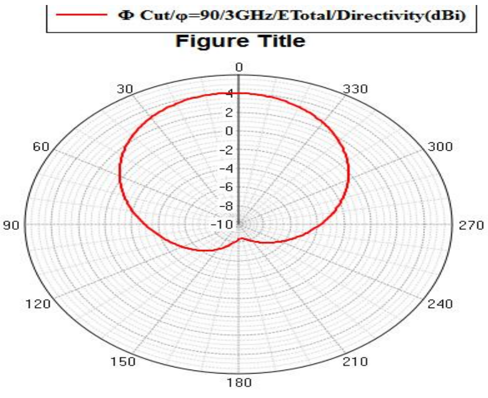


**Figure-7:** Directivity (dBi) versus angle for f = 3GHz at $\varphi$=90 in polar co-ordinate

From the fig-7, A maximum Directivity 4.154 dB was attained at the frequency of 3 GHz.

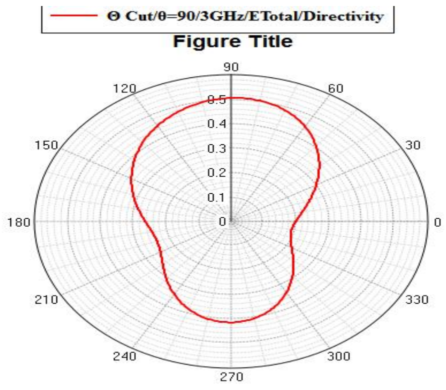


**Figure 8:** Directivity versus angle for f = 3 GHz at Θ=90

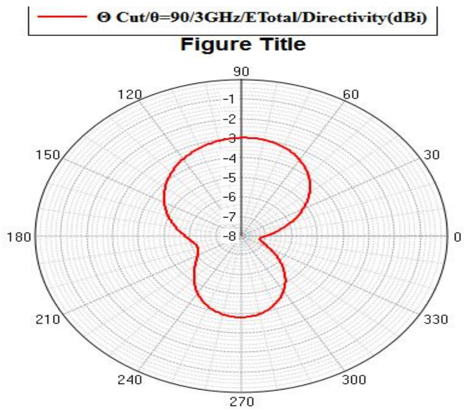


**Figure 9:** Directivity (dB) versus angle for f = 3 GHz at Θ =90 in polar co-ordinate

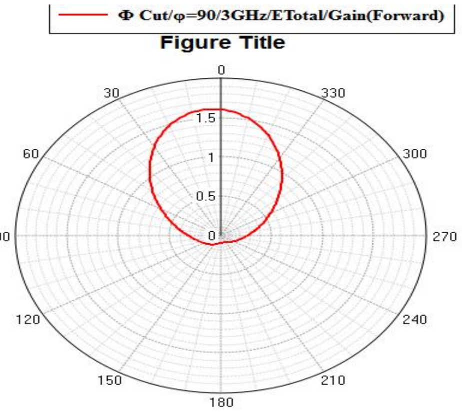


**Figure 10:** Gain versus angle for f =3 GHz at *φ*=90

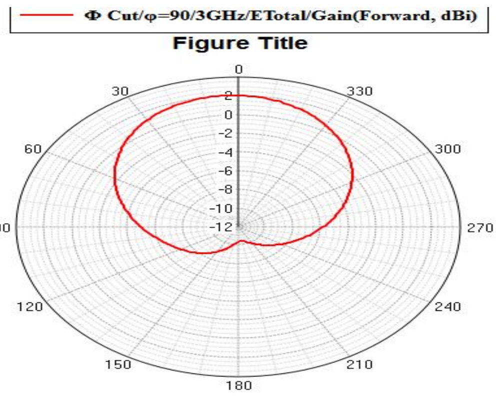


**Figure 11:** Gain (dB) versus angle for f = 3 GHz at *φ*=90 in polar co-ordinate

From the Fig-11, A maximum gain 2.059 dB was attained at the frequency of 3 GHz.

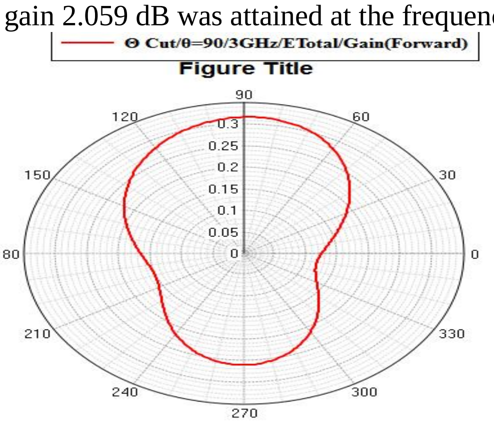


**Figure 12:** Gain versus angle for f = 3 GHz at Θ=90

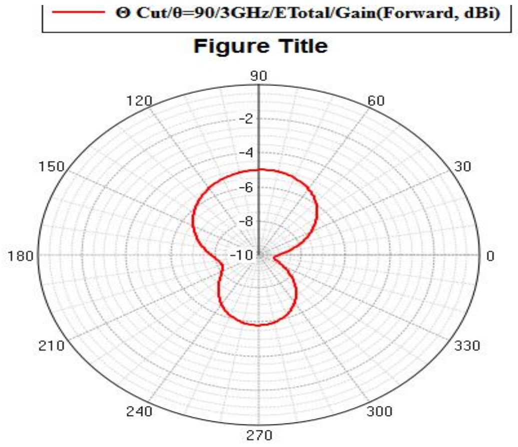


**Figure 13:** Gain (dB) versus angle for f = 3 GHz at Θ=90 in polar co-ordinate

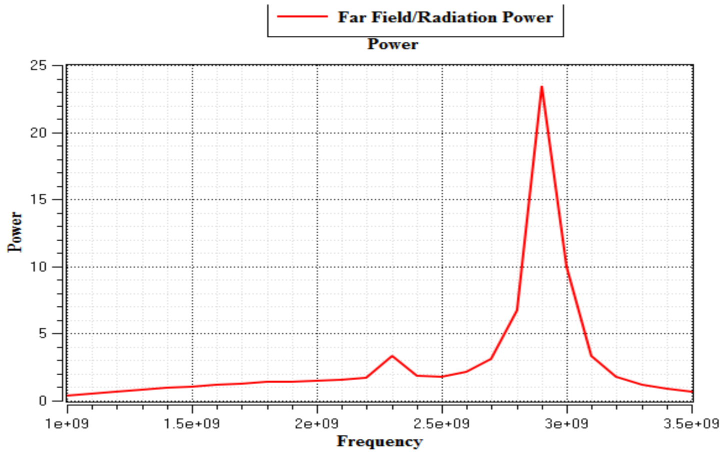


**Figure 14:** Radiated power Vs Frequency graph

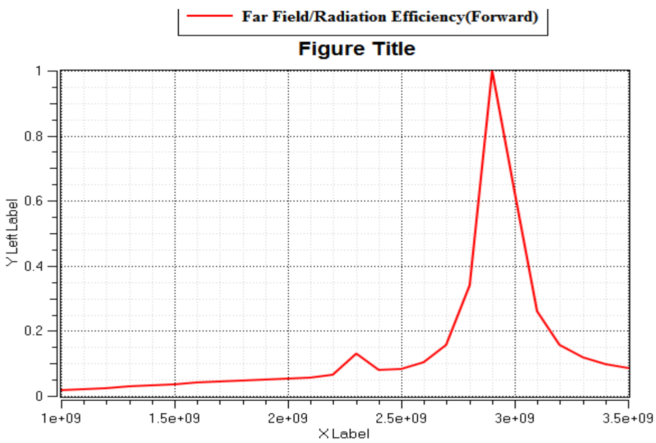


**Figure 15:** Radiation efficiency Vs Frequency graph

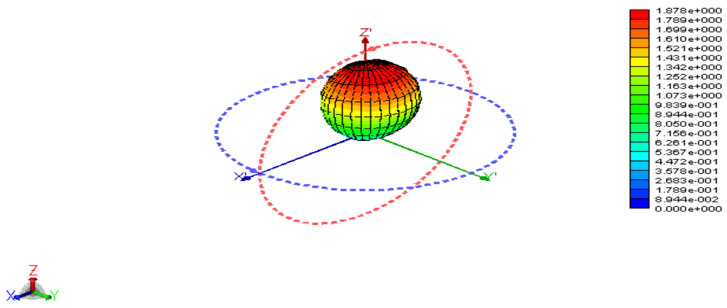

**Figure 16:** Directivity versus angle for f = 3 GHz in 3D pattern

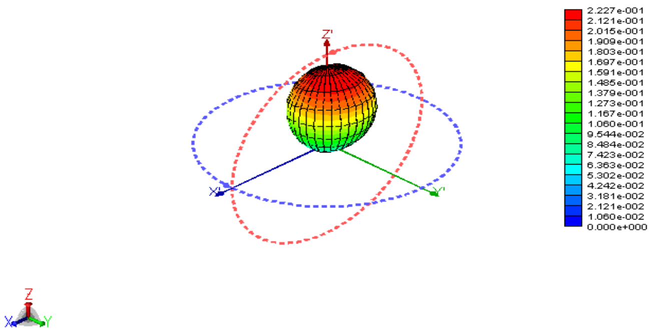

**Figure 17:** Gain versus angle for f = 3 GHz in 3D pattern

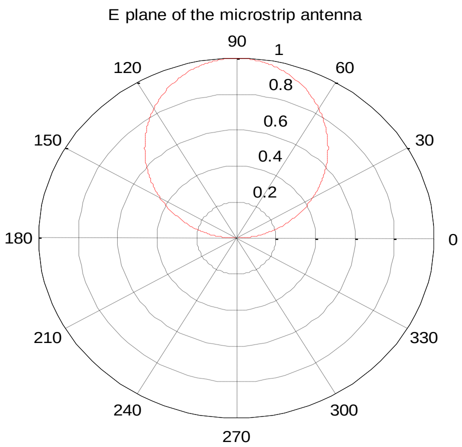


**Figure 18:** E plane of the microstrip antenna simulated in Matlab.

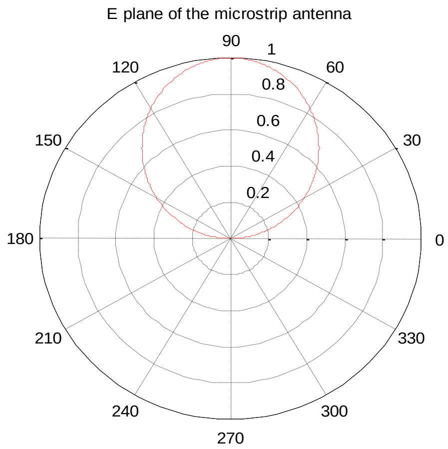


**Figure 19:** H plane of the Microstrip antenna simulated in Matlab

**Table No-1:** Different Parameters of Rectangular Microstrip Patch Antenna

| | |
|---|---|
| Shape | Rectangular |
| Frequency of operation | 3GHz |
| Dielectric constant of the substrate | 4.4 |
| Height of dielectric substrate | 1.3mm |
| Feeding Method | Microstrip Line Feed |
| Directivity | 4.154dB |
| Beamwidth | 2.6515% |
| gain | 2.059 dB |
| Poalarization | Linear |

## IV. CONCLUSION

As we observe the table-1 which displays all the parameters and the results for the design. There are different dimensions, dielectric constant, and frequencies. Having gone through the results it happened to be a bit difficult to decide the optimized design of the antenna, as there are different aspects that are involved in the design of the antenna. We can say that there are many aspects that affect the performance of the antenna. Dimensions, selection of the substrate, feed technique and also the Operating frequency can take their position in effecting the performance.

## V. FUTURE WORK

It is very important to take the feed technique the impedance and the substrate is main parameters into consideration. The proper position to terminate the Feed line also affects the performance of the antenna. In future other different type of feed techniques can be used to calculate the overall performance of the antenna without missing the optimized parameters in the action.

## REFERENCES

[1]. Balanis, Constantine, "Antenna theory - Analysis and Design", John Wiley & Sons Ltd, Reprinted 1997.
[2]. A. Boualleg, N. Merabtine, "Analysis of radiation patterns of rectangular microstrip antennas with uniform substrate", Semiconductor Physics, Quantum Electronics & Optoelectronics, 2005. V. 8, N 3. P. 88-91.
[3] H. Pues and A Van de Capelle, "Accurate transmission-line model for the rectangular microstrip antenna," Proc. IEE, vol. 131, pt. H, no. 6, pp. 334-340, Dec. 1984.
[4] S K Behera, "Novel Tuned Rectangular Patch Antenna As a Load for Phase Power Combining" Ph.D Thesis, Jadavpur University, Kolkata.

[5] R. Garg, P. Bhartia, I. Bahl, and A. Ittipiboon, Microstrip Antenna Design Handbook, ArtechHouse; 2000, K. F. Lee, Ed., Advances in Microstrip and Printed Antennas, John Wiley, 1997; D. M. Pozar and D. H. Schaubert, Microstrip Antennas: The Analysis and Design of Microstrip Antennas and Arrays, IEEE Press, 1995

[6] D. R. Jackson, S. A. Long, J. T. Williams, and V. B. Davis, "Computer- aided design ofrectangular microstrip antennas", ch. 5 of Advances in Microstrip and Printed Antennas, K. F. Lee, Editor, John Wiley, 1997.

[7] W. F. Richards, Y
. T. Lo, and D. D. Harrison, "An improved theory of microstrip antennas with applications," IEEE Trans. Antennas and Propagation, vol. AP-29, pp, 38-46, Jan. 1981.

[8] D. M. Pozar, "A reciprocity method of analysis for printed slot and slot- coupled microstrip antennas," IEEE Trans. Antennas and Propagation, vol. AP-34, pp. 1439-1446, Dec. 1986.

## Authors Profile.

**Liton Chandra Paul** completed his B.Sc. (First class first with honors) in Electronics & Telecommunication Engineering (ETE) from Rajshahi University of Engineering & Technology (RUET), Bangladesh, in 2012. Currently, he is a lecturer of Electronics and Communication Engineering department at the University of Information Technology & Sciences (UITS), Bangladesh. He has three international journal, two international conference paper and one national conference paper. His research interests include Antenna, Mobile communication, Wireless & Satellite Communication, Image Processing, Antenna, Digital Communication, Data Communication.

**Nahid Sultan** received his B.Sc. in Electronics and Telecommunication Engineering from Rajshahi University of Engineering & Technology, Bangladesh. His research interests include various micro strip patch antennas.