Line Feed Microstrip Patch Antenna for Lowest Frequency Microwave Band

Amruta Murkute
M. E. student, deptt.ECE,
Chandigarh University, Gharuan, Mohali
Chandigarh, India

Harbinder Singh
Asst. Prof. Deptt.ECE,
Chandigarh University, Gharuan, Mohali
Chandigarh, India

ABSTRACT
In this paper, a rectangular microstrip patch antenna is proposed. The proposed antenna is exited through a 50 ohm microstrip feeding line. A prototype of the antenna is fabricated and tested. Return loss of -25.22 is achieved for 3.4GHz frequency.

Keywords
Single feed, rectangular patch, microstrip patch antenna and lowest frequency microwave bands.

1. INTRODUCTION
Microstrip patch antenna (MPA) is a new comer in the field of antenna engineering and it is seems to be reminded of characteristics generally to be desired when grouping an antenna specification [1]. There are requirement of low profile antennas, where the cost, size, performance and ease of installation are constraint [2]. These requirements are fulfilled by MPA. The Ofcom recently allot spectrum of 3.4GHz and 2.3GHz [3]. The lowest frequency microwave bands are 1.2GHz (1240-1325MHz, 23 cm), 2.3GHz (2300-2450MHz, 13 cm) and 3.4GHz (3400-3475MHz, 9 cm). Hence there is a need of an antenna for suitable transmission at this frequency. MPA is one of the best suggested antennas at this frequency.

In this paper, a simple single feed rectangular MPA is proposed for 3.4GHz frequency. The 50 ohm feeding line is used to excite an antenna. The further discussion is done in section 2, 3 and 4.

2. ANTENNA DESIGN

2.1 Design Specifications
Fig. 1 illustrates the antenna designed for 3.4GHz frequency. There are three essential parameters for the design of MPA.

2.2.1 *Frequency of operation (f_0)*
The resonant frequency of the antenna must be selected appropriately. The satellite communication system uses s-band of frequency range from 2-4GHz. Hence the antenna designed must be able to operate in this frequency range. The resonant frequency selected for projected antenna design is 3.4GHz.

2.2.2 *Dielectric constant of substrate (ε_r)*
The dielectric substrate selected for projected antenna design is FR4_epoxy which has a dielectric constant of 4.4. A substrate with cheap cost has been selected since it reduces the overall cost of antenna.

2.2.3 *Height of dielectric substrate (h)*
For the MPA used in satellite communication it is essential that the antenna is not bulky. Hence the height of dielectric substrate is selected as 1.58mm.

Hence the essential parameters for design are:

- $f_0 = 3.4GHz$
- $\varepsilon_r = 4.4$
- $h = 1.58mm$

2.2 Design Procedure
Step 1 : Calculation of width (W)

The width of proposed MPA is given as,

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

Substituting $c = 3 \times 10^8\, m/s, \varepsilon_r = 4.4$ and $f_0 = 3.4GHz$ it get,

$$W = 26.84mm$$

Step 2 : Calculation of effective dielectric constant (ε_{reff})

The effective dielectric constant of proposed MPA is given as,

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

Substituting $\varepsilon_r = 4.4$, $h = 1.58mm$ and $W = 26.84mm$ it get,

$$\varepsilon_{reff} = 4.92$$

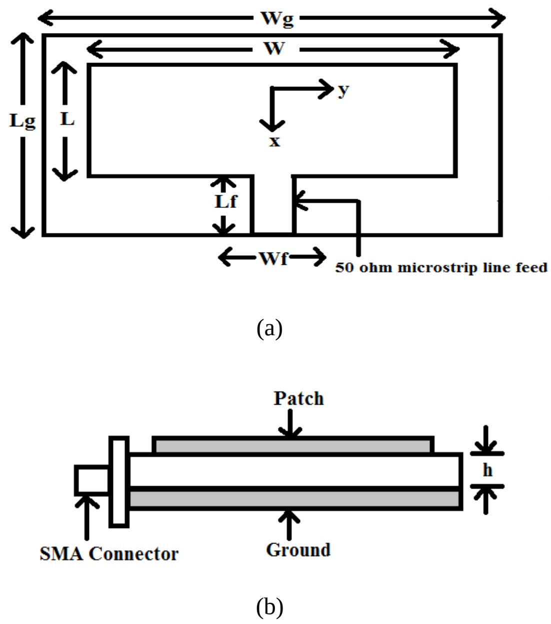

Fig. 1. (a) Top view (b) Side view of proposed antenna

Step 3 : Calculation of effective length (L_{eff})

The effective length of proposed MPA is given as,

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

Substituting $c = 3 \times 10^8\, m/s$, $\varepsilon_{reff} = 4.92$ and $f_0 = 3.4GHz$ it get,

$$L_{eff} = 19.88mm$$

Step 4 : Calculation of length extension (ΔL)

The length extension of proposed MPA is given as,

$$\Delta L = 0.412h \frac{(\varepsilon_{reff} + o.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)}$$

Substituting all values it get,

$$\Delta L = 0.73mm$$

Step 5 : Calculation of actual length of patch (L)

The actual length of patch of proposed MPA is given as,

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

Substituting values of L_{eff} *and* ΔL it get,

$$L = 18.42mm$$

Step 6 : Calculation of ground plane dimension

$$L_g = 6h + L = 27.9mm$$

$$W_g = 6h + W = 36.32mm$$

3. PARAMETRIC STUDY

In this section, the effect of the physical parameters like patch length and patch Width are studied, by changing one variable at a time and maintaining all other variables Constant so that one can obtain an estimated antenna for the required applications.

3.1 Effect of Patch Width

The Figure below shows the effect of patch width on the S11 parameter. By changing the width dimensions the resonant frequency of antenna is decreased.

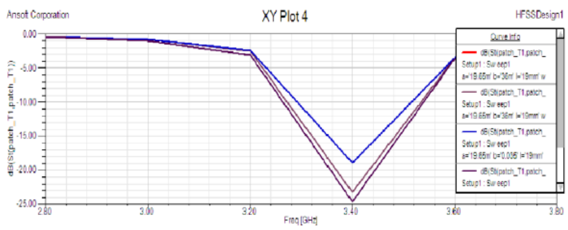

Fig. 2. Variation of S11 parameter w.r.t patch width

3.2 Effect of Patch Length

The Figure below shows the effect of patch length on the S11 parameter, by varying the patch length there is a change in the desired frequency.

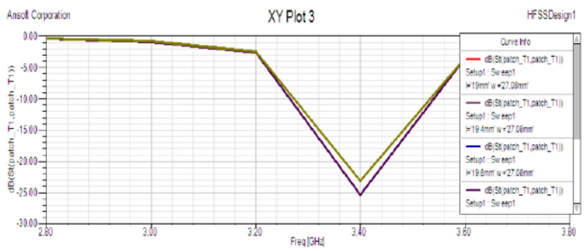

Fig. 3. Variation of S11 parameter w.r.t patch length

The simulated results of various parameters of the above proposed antenna are revisited in the succeeding table. The values of variables show that antenna results are good for 3.4GHz applications.

Table 1. Simulated Result of Various Parameters

Parameters	Value
Operating frequency	3.4GHz
Return loss	-25dB
Impedance	50 ohms
VSWR	1.06
Bandwidth	92 MHz

4. RESULT AND DISCUSSION

The proposed antenna is simulated using High frequency structure Simulator (HFSS). The rectangular patch of dimensions $L \times W$ is printed on the top of dielectric substrate FR_4 epoxy which has dielectric constant $\varepsilon_r = 4.4$ and height h = 1.58mm. The ground plane is placed below the substrate has dimensions$L_g \times W_g$. The single feed is used to excite the antenna has a dimension $L_f \times W_f$.

Table 2. Antenna Parameters

Variable	Value
w_p	45mm
L_p	19.65mm
h_p	0.02mm
W_g	36mm
L_g	30.42mm
W_f	2mm

The simulated antenna design using HFSS is given in the Figure below:

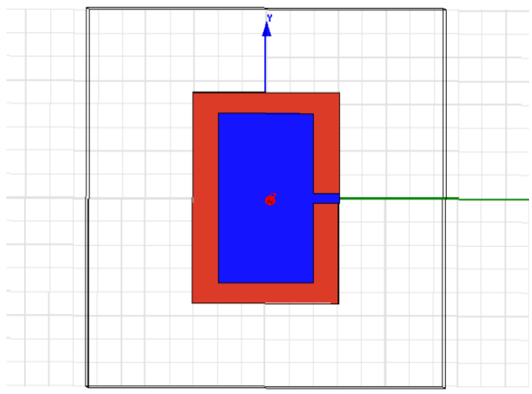

Fig. 4. Proposed antenna using HFSS11

The simulation result of proposed antenna such as return loss and VSWR are given below,

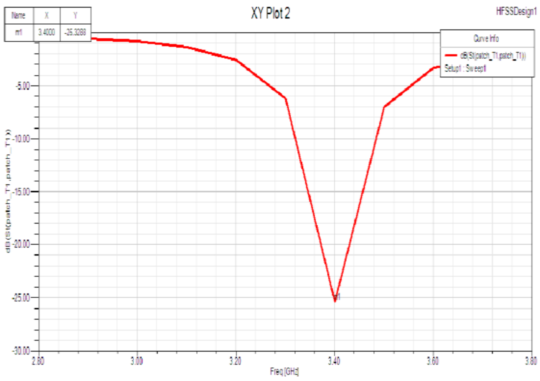

Fig. 5. S11 parameter of designed antenna

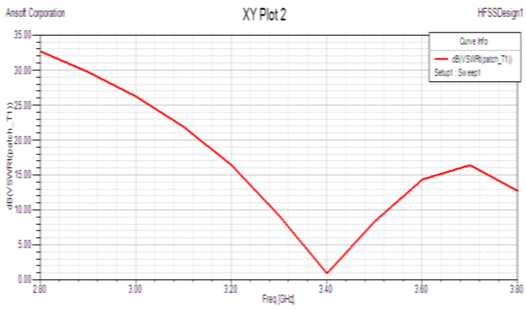

Fig. 6. VSWR of designed antenna

The fabricated low cost and light weight MPA is given below,

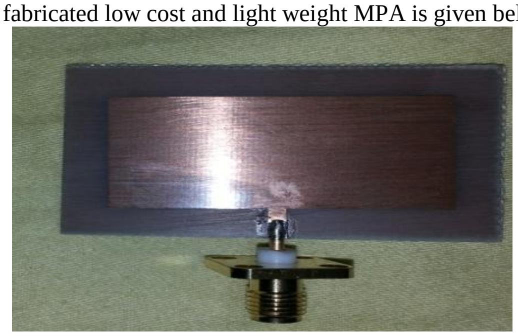

Fig. 7. Fabricated antenna

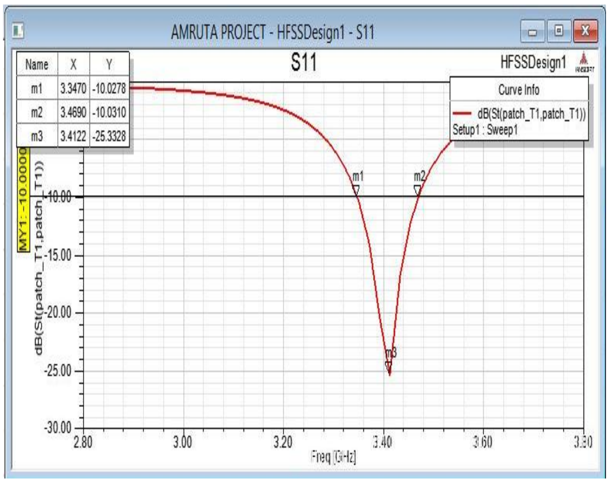

Fig. 8. Measured return loss

The table below shows the comparison of the simulated and the tested results of the designed antenna.

Table 3. Tested Result of Designed Antenna

Parameters	Tested results at 3.4 GHz frequency
Return loss	-22dB
Impedance	46.43 ohms
Resonating frequency	3.48 GHz

5. CONCLUSION

A rectangular MPA for 3.4GHz is presented in this paper. The return loss less than -10 dB is achieved by proposed antenna. Return loss of -25.22 dB is achieved. Bandwidth and VSWR yield in 3.4GHz are 92MHz and 1.06 respectively. Future work can be done on antenna parameter, which is return loss by changing substrate material and by using different patch shapes.

6. REFERENCES

[1] James R. James, Peter S. Hall, “Handbook of Microstrip Antennas”, vol. 1, London: Peter Peregrinus Ltd., 1989.

[2] Theodore S. Rappaport, “Wireless Communication and Practice”, Second edition, 2002.

[3] “2.4 and 3.4GHz spectrum award”, USA, 2013.

[4] Balanis, C. A., “Antenna Theory Analysis and Design”, 3rd Edition. New Jersey, John Wiley and Sons, 2005.

[5] David Sinchez-Hemindez and Ian D. Robertson, “Analysis and Design of a Dual-Band Circularly Polarized Microstrip Patch Antenna” *IEEE Transactions on Antennas and Propagation*, issue 43, No2, February, 1995.

[6] R.J. Lin, M. Ye, “A Novel Dual-Band Microstrip Antenna for WLAN Application” *Wireless Mobile and Computing (CCWMC) IET International Communication Conference*, Shanghai, China, pp.269-271, December 2009.

[7] M. Khodier" and C. G. Christodoulou, "A Technique to Further Increase the Bandwidth of Stacked Microstrip Antennas", *Antennas and Propagation Society International Symposium*, Salt Lake City, UT, vol. 3, pp 1394-1397, 2000.

[8] D de Haaij, JW Odendaal and J Joubert, "Increasing The Bandwidth of A Microstrip Patch Antenna with A Single Parallel Resonant Circuit" *IEEE Africon conference in Africa*, vol. 2, pp 527-529, 2002.

[9] A. A. Abdelaziz, "Bandwidth Enhancement of Microstrip Antenna" *Progress In Electromagnetic Research*, PIER, vol. 63, pp. 311–317, 2006.