# Microstrip Patch Antenna Design for Ku Band Application

Vijaykumar V. Chodavadiya
Department of Electronics and Communication Engineering
School of Engineering, RK.University,
Rajkot, Gujarat, India.

Shivani S. Aggarwal
Department of Electronics and Communication Engineering
School of Engineering, RK.University,
Rajkot, Gujarat, India.

***Abstract*—Microstrip Patch Antenna is designed for Ku band 12GHz to 18GHz. The proposed antenna on a Teflon substrate with dielectric constant 2.1. At resonant frequency 12.54GHz the verify and tested result on CST Microwave Studio by CST STUDIO SUIT are Return loss = -26.5578 dB, Voltage Standing Wave Ratio = 1.0986392, Gain = 6.906dB, Directivity = 6.976dBi, Bandwidth = 4.1553GHz (33.14%) and Efficiency = 98.99%, all results are shown in simulation results.**

**Keywords—CST Microwave Studio, Microstrip Patch Antenna, Ku band.**

## I. INTRODUCTION

This Microstrip antenna have been one of the most innovative topics in antenna theory and design in recent years, and are increasingly finding application in a wide range of modern microwave systems [6]. Deschamps first proposed the concept of the MSA in 1953 [2]. However, practical antennas were developed by Munson [3]-[4] and Howell [5] in the 1970s. Microstrip antennas (MSA) offer many attractive features such as low weight, small size, ease of fabrication, ease of integration with Microwave Integrated Circuits (MIC) and can be made conformal to host surface. However, they suffer from low gain, narrow bandwidth, low efficiency, and low power handling capability [7]-[9]. In some applications, such as in government security systems, narrow bandwidths are desirable [7]. This proposed antenna has rectangular patch used. The rectangular patch is by far the most widely used configuration. It is very easy to analyze using both the transmission-line and cavity models, which are most accurate for thin substrates [7].

## II. ANTENNA DESIGN

### A. *Mathematical Analysis*

The design of the proposed antenna is shown in Fig.1 and Fig 2. The design of the proposed microstrip patch antenna was modeled using the classical equations [7].

Step 1: Calculation of the Width (*W*):

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

Where, $c = 3 \times 10^8$ m/s, $\varepsilon r = 2.1$, $fr$ = Designed Frequency

Step 2: Calculation of Effective dielectric constant ($\varepsilon reff$):

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

Where, $h$ = 0.8 mm

Step 3: Calculation of the Effective length ($Leff$):

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}} \quad (3)$$

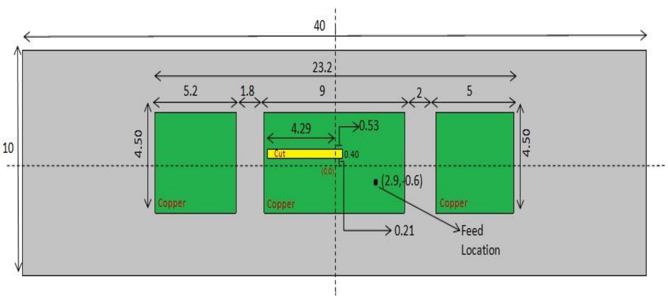
Step 4: Calculation of the length extension ($\Delta L$):

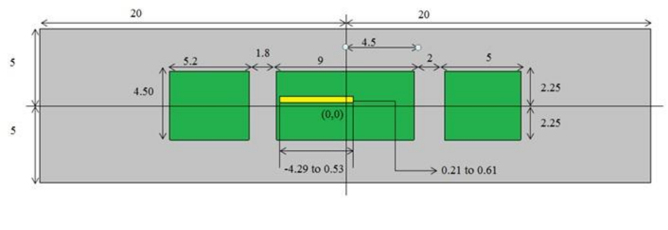
$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)} \quad (4)$$

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

$$L = L_{eff} - 2\Delta L \quad (5)$$

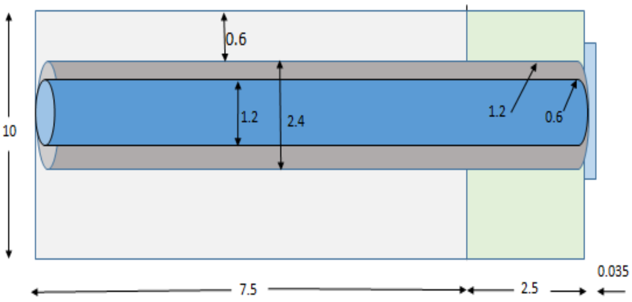
Antenna Description






All dimensions are in millimeter (mm)

Fig.1. Top view of the Microstrip Patch Antenna




All dimensions are in millimeter (mm)

Fig.2. Left side view of the Microstrip Patch Antenna

The proposed microstrip patch antenna at designed frequency 14 GHz on Teflon dielectric substrate simulated with CST MW STUDIO simulator. Proposed antenna has good gain and bandwidth achieved if $L$ = 9 mm and $W$ = 4.5 mm with feed position change to $Xf$ = 2.9 mm in X direction and $Yf$ = -0.6 mm in Y direction from origin (x=0, y= 0). Also parasitic patch 1 and parasitic patch 2 cause wide bandwidth is achieved. Fig.3 shows Microstrip patch antenna designed using CST Microwave Studio.

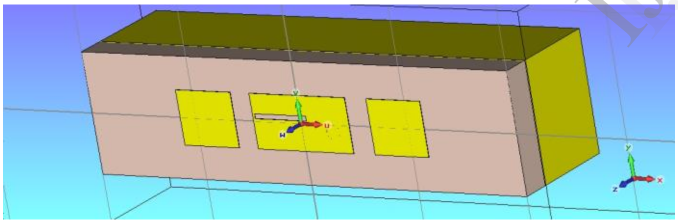


Fig.3. Microstrip patch antenna designed using CST Microwave Studio

The antenna is being excited with the coaxial feed point located at distance dx and dy from the centre of the patch. The following Table 1 gives the design parameter specifications of the Microstrip Antenna.

TABLE 1
DESIGN PARAMETER SPECIFICATIONS OF THE RECTANGULAR MICROSTRIP PATCH ANTENNA

| | |
|---|---|
| Dielectric Constant of the Substrate ($\varepsilon r$) | 2.1-Teflon (PTFE) |
| Height of the dielectric substrate ($h$) | 0.8 mm |
| Height($t$) of Patch and Ground | 0.035 mm |
| Patch (Length($L$) ,Width($W$)) | (23.2, 4.5) mm |
| Substrate and Ground (Length, Width) | (40, 10) mm |
| Design Frequency($fr$) | 14 GHz |
| Slit in main patch ($x$, $y$) | (4.82, 0.4) mm |
| Main Patch(x, y) | (9, 4.5) mm |
| Parasitic Patch 1 ($x$, $y$) | (5.2, 4.5) mm |
| Parasitic Patch 2 ($x$, $y$) | (5, 4.5) mm |
| Feed location ($Xf$, $Yf$) from(0, 0) | (2.9, -0.6) mm |
| Co-axial Cable Type | Inde P-Trim |
| Feed Diameter | 1.2mm |

## III. RESULT AND DISCUSSION

The simulated return loss (S1,1) of the proposed antenna is depicted in Fig.4 and Fig.5. The graph shows the maximum return loss of -26.5578dB at the resonant frequency 12.54GHz. The graph also depicts that below -10dB the antenna attained the bandwidth of 4.1553GHz (33.14%) which is 13% more bandwidth achieved than bandwidth achieved in [14].

The voltage standing wave ratio (VSWR) of the proposed antenna shown in Fig.6. It can be observed from the result that the VSWR value is less than 2 for whole operating band, which considered as suitable for the antenna.

Fig.7 and Fig.8 depict far field radiation directivity and far field radiation gain of proposed antenna respectively. Directivity and Gain is 6.976 dBi and 6.906 dB respectively. Fig.9 and Fig.10 shows structure with far-field transperent. Beanwidth is 104.7° at 3dB. Table 2 shows the summary of results of the microstrip patch antenna.



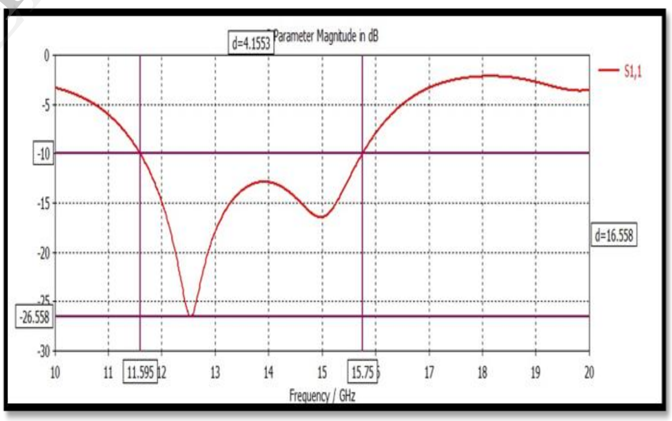



Fig.4. Return Loss vs. Frequency

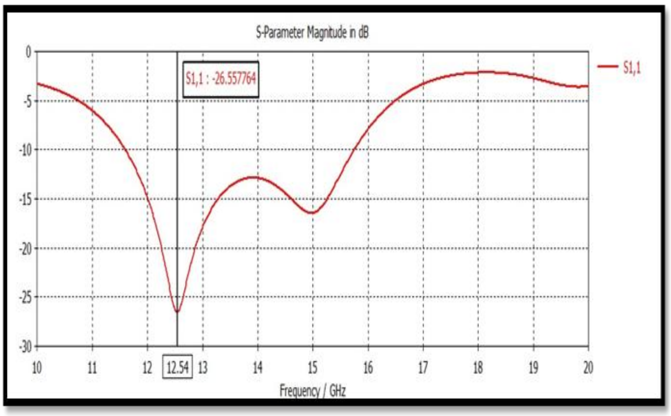



Fig.5. Return Loss vs. Frequency

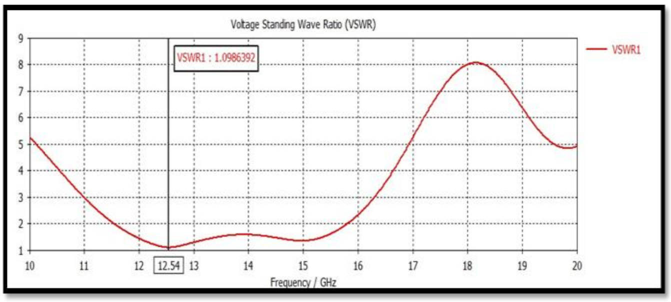



Fig.6. VSWR vs. Frequency

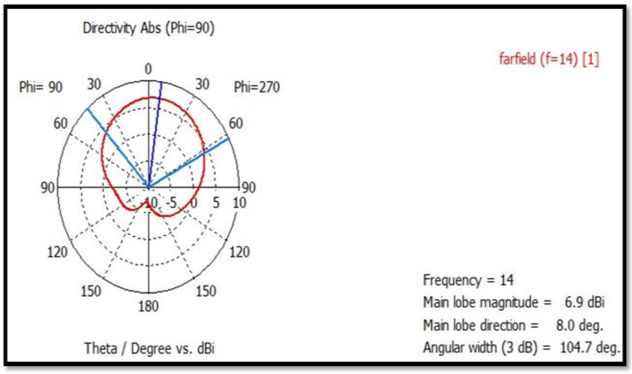



Fig.7. Directivity at 12.54 GHz

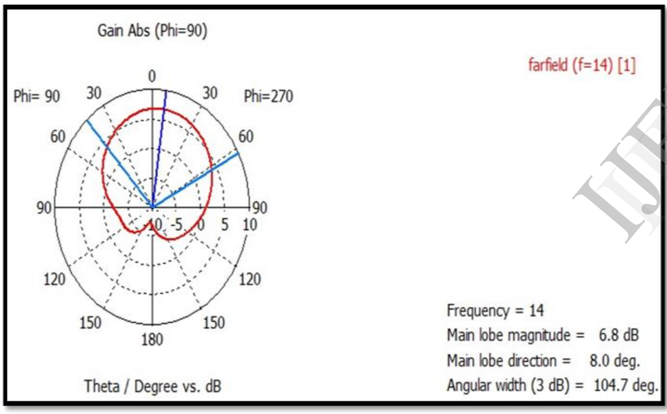



Fig.8. Gain at 12.54 GHz

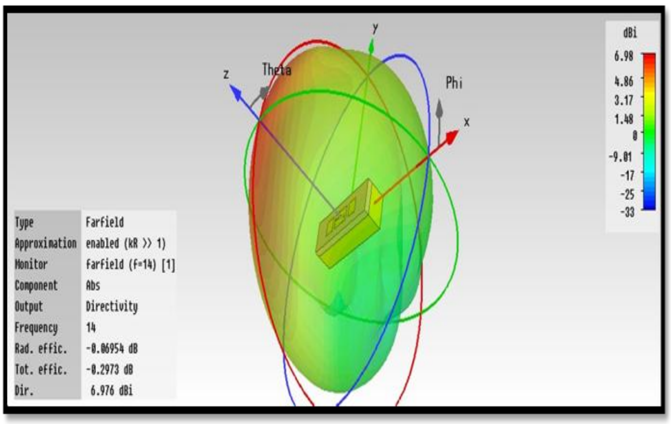



Fig.9. Structure with far-field transperent at 12.54 GHz

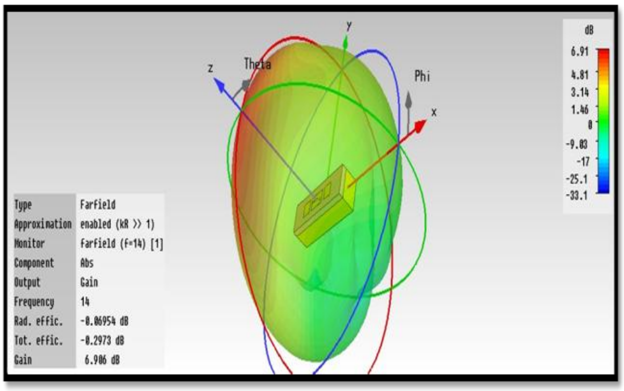



Fig.10. Structure with far-field transperent at 12.54 GHz

TABLE 2
MICROSTRIP PATCH ANTENNA PARAMETERS

| | |
|---|---|
| Return loss (S1,1) | -26.5578 dB |
| Directivity(D) | 6.976 dBi |
| Gain (G) | 6.906 dB |
| Radiation Efficiency(η) | 98.99 % |

## IV. CONCLUSIONS

The proposed frequency range at 14GHz and analysis Radiation Characteristics of microstrip patch antenna by CST STUDIO SUIT. The proposed antenna on a Teflon substrate with dielectric constant 2.1. At 12.54GHz resonant frequency the verify and tested result on CST Microwave Studio by CST STUDIO SUIT are Return loss = -26.5578 dB, VSWR = 1.0986392, Directivity = 6.976 dBi, Gain = 6.906 dB, Bandwidth = 4.1553 GHz (33.14 %) (at |S1,1| < -10dB and VSWR < 2), Efficiency= 98.99 % and Beamwidth at 3dB = 104.7°, all results shown in simulation results. Very thin slit or slot in the patch cause Bandwidth and Return loss (S1,1) is improved. Parasitic patch cause wide bandwidth is achieved. Also 13% more bandwidth achieved than bandwidth achieved in [14]. The future scope of work revolves around increasing the gain up to 28dB - 30 dB by modifications in design and making array of the same proposed patch antenna. Detailed theoretical explanations can be derived at a later stage to find out a best optimize design with proper dimensions of the notches and strip of proposed antenna.



## REFERENCES

[1] CST Microwave Studio by CST STUDIO SUIT Version 2010.00.

[2] G. A. Deschamps, "Microstrip Microwave Antennas," *Proc. 3rd USAF Symposium on Antennas*, 1953.

[3] R. E. Munson, "Single Slot Cavity Antennas Assembly," *U.S. Patent No. 3713162*, January 23, 1973.

[4] R. E. Munson, "Conformal Microstrip Antennas and Microstrip Phased Arrays," *IEEE Trans. Antennas Propagation*, Vol. AP-22, pp. 74-78, 1974.

[5] J. Q. Howell, "Microstrip Antennas," *IEEE Trans. Antennas Propagation*, Vol. AP-23, pp. 90-93, January 1975.

[6] D. M. Pozar, "Microstrip Antennas," *Proceedings of IEEE*, Vol. 80, No. 1, January 1992

[7] C. A. Balanis, *Antenna Theory: Analysis and Design*, 3rd Ed. Wiley, 2005.

[8] G. Kumar and K. P. Ray, *Broadband Microstrip Antennas*, Artech House, Inc, 2003.

[9] R. Garg, P. Bhartia, I. Bahl, and A. Ittipiboon, *Microstrip Antenna Design Handbook*, Artech House, Inc, 2001.

[10] K. L. Wong, *Compact and Broadband Microstrip Antennas*, A John Wiley & Sons inc., Publication, 2000.

[11] S. K. Dubey, S. K. Pathak, and K. K. Modh, "High gain multiple resonance Ku-band microstrip patch antenna," *Applied Electromagnetics Conference (AEMC)*, Vol. 1, No. 3, pp. 18-22, Dec. 2011.

[12] O. M. Khan, Z. Ahmad, and D. Q. Islam, "Ku Band Microstrip Patch Antenna Array," *International Conference on Emerging Technologies (ICET)*, Vol. 35, No. 40, pp. 12-13, Nov. 2007.

[13] N. Misran, M. T. Islam, N. M. Yusob, and A. T. Mobashsher, "Design of a compact dual band microstrip antenna for Ku-band application," *International Conference on Electrical Engineering and Informatics(ICEEI)*, Vol.02, pp. 699-702, 5-7 Aug. 2009.

[14] H. Parikh, S. Pandey, and K. Modh, "Wideband and high gain stacked microstrip antenna for Ku band application," *Nirma University International Conference on Engineering (NUiCONE)*, Vol.1, No.5, pp.6-8, Dec. 2012.

[15] M. Iftissane, S. Bri, L. Zenkouar, and A. Mamouni "Conception of Patch Antenna at Wide Band," *Int. J. Emerg. Sci.*, *1(3)*, pp. 400-417, Sept. 2011.

[16] C. Vishnu, R. Rana, *Design of linearly polarized Rectangular Microstrip Patch antenna using IE3D/PCO*, M.Tech Thesis, National Institute of Technology, Rourkela, 2009.

[17] A. A. Eldek and C. E. Smith, "Rectangular Slot Antenna With Patch stub for Ultra Wideband Applications and Phased Array systems," *Progress In Electromagnetics Research, PIER 53*, pp. 227–237, 2005.

[18] P. G. Elliot and M. S. Mahmoud, "Microstrip patch radiating elements for circularly polarized phased array," *MITRE Corporation*, 2005.

[19] H. Xiang and X. Jiang, "Design of a High Gain Microstrip Antenna Array at Ku-band," *ISAPE Proc.*, Kunming, China, 2008

[20] A. A. Eldek, A. Z. Elsherbeni, C. E. Smith, and K. F. Lee, " Wideband Planar slot Antennas," *Center of Applied Electromagnetic Systems Research*, 2004.

[21] R. Che, B. Dong, and C. Yu, "Study and design of Ku band direct broadcast satellite microstrip antenna array," *Proceedings of ICCTA*, 2009.

[22] M. Ghiyasvand, H. R. Dalili Oskouei, and K. Forooraghi, "Broadband Proximity Coupled Microstrip Antenna for Direct Broadcast Satellite Reception Using PBG Structures," *Microwave Conference Proceedings, Asia-Pacific Conference Proceedings(APMC)*, Vol. 3, No. 4, pp. 4-7, December 2005.

[23] M. H. Awida, "Substrate-Integrated Waveguide Ku-Band Cavity-Backed 2 X 2 Microstrip Patch Array Antenna," *IEEE Antennas and Wireless Propagation Letters*, Vol. 8, 2009.

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