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A CPW-fed Microstrip Patch Antenna with Multiple Slots on Patch for 5.8 GHz RFID Application

P.Prasanna Kumar[1], N.Venkata Rajasekhar[2], Ansal K A[3]
[1, 2, 3] Department of Electronics Engineering, Pondicherry University, Puducherry, India-605014,
[1]pallepogu.prasanna96@gmail.com, [2]nvrs1991@gmail.com, [3]ansal.555@gmail.com

ABSTRACT

In this paper, a coplanar waveguide (CPW) fed microstrip patch antenna with multiple slots on patch is designed with method of movement (MOM) based IE3D tool. The designed antenna is having the substrate dimensions of 16 mm height and 12 mm width, which can operate at 5.8 GHz band with good impedance matching. The proposed antenna shows stable radiation pattern with 3.8 dBi gain, -54 dB return loss, 98% antenna efficiency. The proposed antenna properties make the antenna suitable for radio frequency identification (RFID) applications.

Key words: Coplanar Waveguide, Microstrip Patch Antenna, Multiple Slots, RFID.

1. INTRODUCTION

Radio frequency identification (RFID) is a rapidly developing technology that holds the potential to cause great economic impacts on many industries. The simplest RFID systems have two major components one is tag, other one is reader [1]. Tags respond with some identifying information when wirelessly interrogated by RFID readers. A number of frequency bands have been assigned to the RFID applications, such as 125 kHz, 902–928 MHz, 2.45 and 5.8 GHz [2]-[5]. The RFID systems operating frequency increases to the microwave region, the antenna design becomes more important. The tag is composed of a microprocessor and an antenna. It must have a low profile, low cost and small size when it is attached to an object to be identified. So, the usage of proper antenna in the tag becomes more essential.

In this communication, a Coplanar Wave Guide (CPW) fed microstrip patch antenna with multiple slots on patch is presented. The desired band is obtained by tuning the dimensions of slots, length and width of patch. The proposed antenna shows less than -10 dB return loss at 5.8 GHz band.

The rest of paper is organized as follows. Antenna design is presented in Section 2. The results and discussion are described in section 3. Conclusion is given at section 4.

2. ANTENNA DESIGN

The geometry of the proposed antenna is shown in Figure 1. The design of the proposed antenna follows the described guidelines followed by the optimization with the commercially available software IE3D. In the design, the antenna is printed on a 1.6 mm thick FR4 substrate of dielectric constant 4.4 and loss tangent 0.0245.

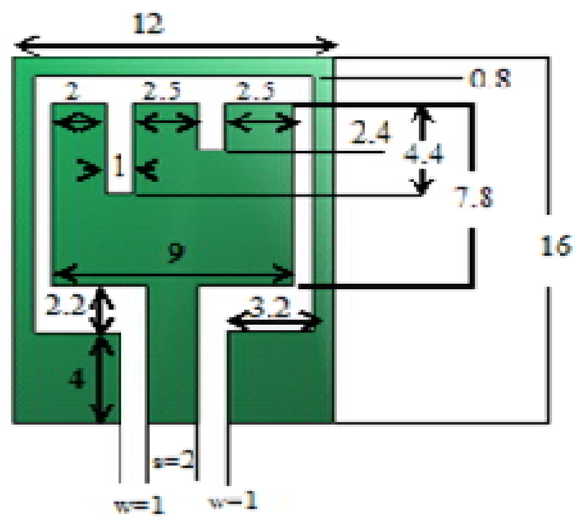


Figure 1: The geometry of the proposed antenna with detailed dimensions (Unit: mm).

The following design procedure is used to design this antenna with good radiation characteristics.
Specify: ε_r, f_r (in GHz) and h (in mm).

Here,

f_r is the resonance frequency.

ε_r is the dielectric constant.

h is the thickness of substrate.

Determine: width and length of ground plane, patch and the strip width, gap width, length and width of slot.

1. The parameters of the ground plane are calculated as below [6]

$$L = \frac{0.088c}{f_r\sqrt{\varepsilon_{ref}}} \qquad (1)$$

$$W = \frac{0.066c}{f_r\sqrt{\varepsilon_{ref}}} \qquad (2)$$

Where,

$$\varepsilon_{ref} = \frac{\varepsilon_r + 1}{2} \qquad (3)$$

The coefficients 0.088 and 0.066 are derived empirically after studying the effect of ground plane on the impedance matching for the antenna.

2. For an efficient radiator, a practical length of patch considered as 0.28 λ_g where λ_g is guided wavelength which is equal to $\lambda_0/\sqrt{\varepsilon_{reff}}$ and the width of the patch that leads to good radiation efficiency is $W_P = 1.5L_P$.
3. The length of slots considered as $\leq L_p/2$, width of slot is calculated as $1/0.11L_P$.
4. To excite the antenna, a 50Ω CPW transmission line, having a strip of width S and a gap of distance W between the signal strip and the ground plane, is used. The expression for the strip width *s* and gap width *w* are given below [7]

$$\frac{s}{h} \leq \frac{80}{3(1+\ln \varepsilon_r)} \qquad (4)$$

$$\frac{w}{h} \leq \frac{10}{3(1+\ln \varepsilon_r)} \qquad (5)$$

The values of the design parameters calculated using the presented method and optimized using IE3D software. The detailed dimensions of a CPW fed microstrip patch antenna with multiple slots on patch shown in Figure 1.

3. RESULTS AND DISCUSSION

In the proposed antenna, the center frequency 5.8 GHz is obtained by considering the patch dimensions as $(L_P x W_P)$ 7.8 mm x 9 mm, the ground plane dimensions as (LxW) 16 mm x 12 mm and the good impedance matching is achieved by considering the length of slots as 4.4 mm, 2.4 mm and the width of slots as 1 mm. By doing this, the better return loss (-54 dB) obtained at 5.8 GHz band, as shown in Figure 2.The return loss will be changes by varying the dimensions of open slots on the patch. Here by adjusting proper dimensions good return loss is obtained at resonance frequency 5.8GHz, which is desirable for RFID application.

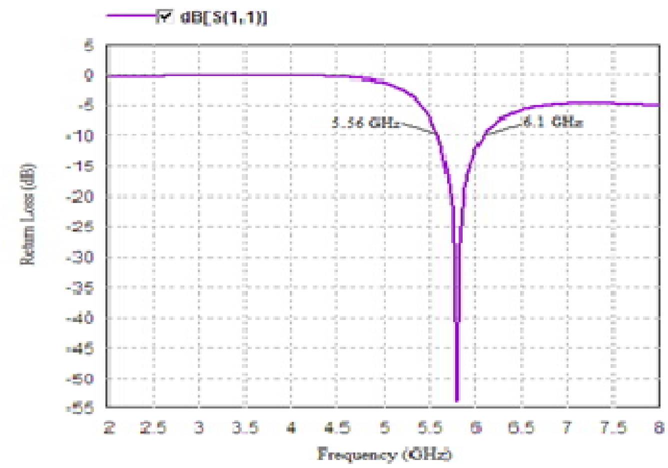


Figure 2: The simulated return loss of the proposed antenna

The simulated gain of the proposed antenna versus frequency is presented in Figure 3. It can be seen that the gain of the proposed antenna remain relatively constant over the entire bandwidth. The peak antenna gain of the proposed antenna is about 3.8 dBi. Also, the gain variation within the bandwidth is greater than about 2 dBi.

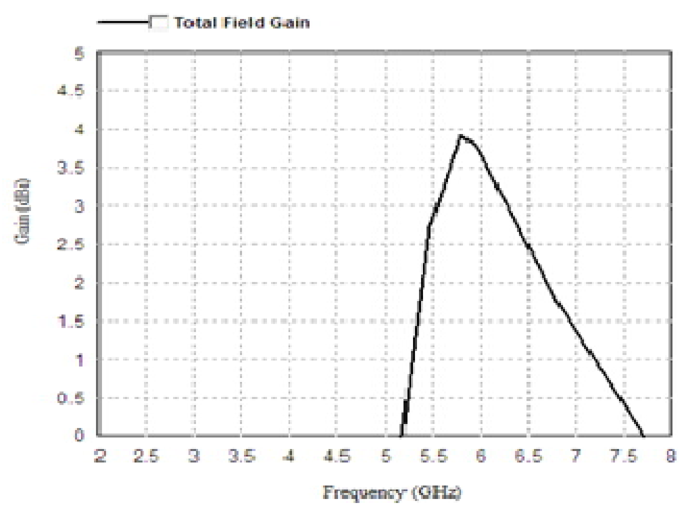


Figure 3: Simulated gain of the proposed antenna

The simulated antenna efficiency is shown in Figure 4. The proposed antenna shows above 90% efficiency over the entire bandwidth which is most desirable for RFID applications. Here the optimum efficiency should be 75% for radiating antenna, which means radiating power should be 75% of the input power feeding to antenna. The maximum antenna efficiency 98% is obtained at 5.8 GHz.

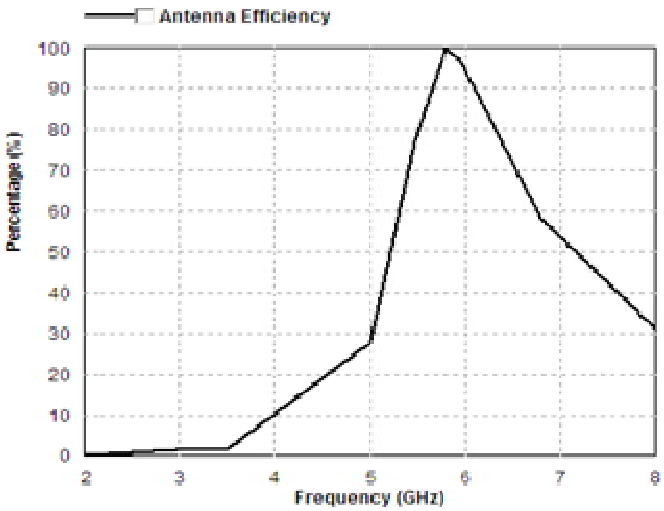


Figure 4: Simulated antenna efficiency of the proposed antenna

Figure 5 shows the current distribution of the proposed antenna at 5.8 GHz. Here, it's clear that the current is perturbed across the ground plane more comparing with remaining part, so it causes the resonance at the particular frequency. We can see that on the radiating patch with open slot has almost uniform current distribution.

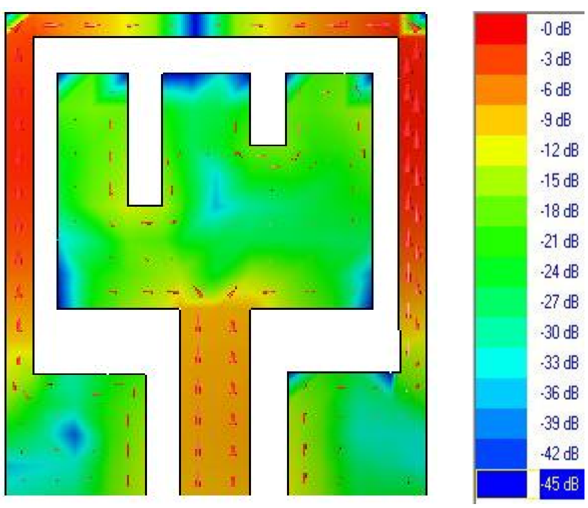
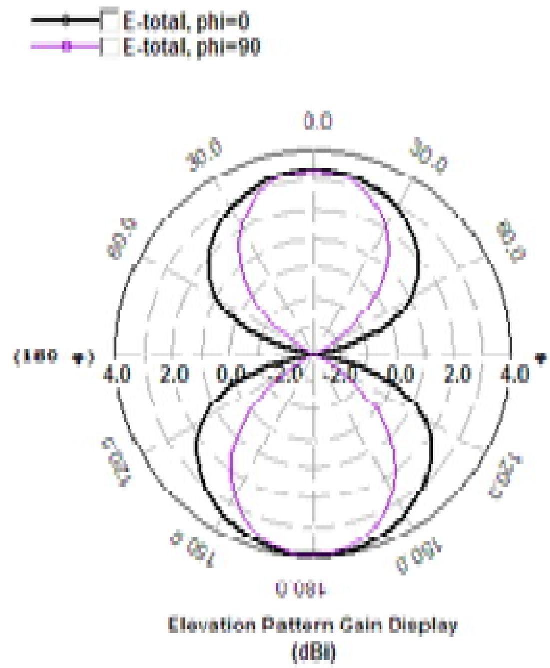
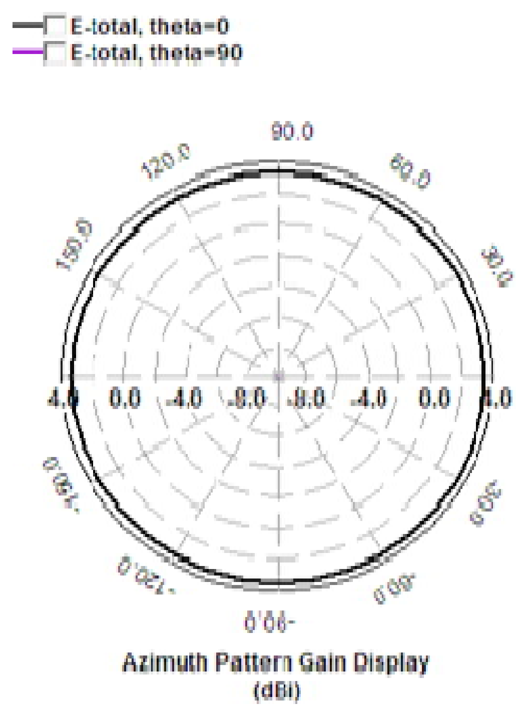


Figure 5: Current Distribution pattern of the proposed antenna

The radiation characteristics at frequency of 5.8 GHz for the proposed antenna are shown in Figure 6. The results, in general, show this antenna has a stable dipole-like radiation pattern in the elevation plane and a nearly omnidirectional pattern in the azimuth plane.



(a)



(b)

Figure 6: (a) Elevation pattern at 5.8 GHz, (b) Azimuthal pattern at 5.8 GHz

4. CONCLUSION

In this paper, a CPW fed microstrip patch antenna with multiple slots on patch is designed using IE3D software. The proposed antenna having return loss -54 dB at 5.80 GHz, and provides good impedance bandwidth 540 MHz, the radiation patterns of the antenna are symmetric and Omni directional in elevation plane and azimuthal plane, respectively. It can be preferred for RFID application.

REFERENCES

[1] Keskilammi, M., and Kivikoski, M.: **"Using text as a meander line for RFID transponder antennas"**, IEEE Antennas Wirel. Propag. Lett, 3, (1), pp. 372–374, 2004.

[2] Chen, S.Y., and Hsu, P.: **"CPW-fed folded-slot antenna for 5.8 GHz RFID tags"**, Electron. Lett, 40, (24), pp. 1516–1517, 2004.

[3] W.-C. Liu and Z.-K. Hu, P.: **"Broadband CPW-fed folded-slot monopole antenna for 5.8 GHz RFID application"**, Electron. Lett, Vol. 41 No. 17, 18th August 2005.

[4] K.Manikandan, S.Raghavan and T.Shanmuganantham, **"CPW Fed Tapered Slot Antenna for 5 GHz Band Applications"**, International Journal of Microwave and Optical Technology , U.S.A., Vol. no. 3, No.1, pp.22 –26,Jan'2008.

[5] T.Shanmuganantham, K. Balamanikandan, and S.Raghavan, **"CPW-Fed Slot Antenna for Wideband Applications,"** International Journal of Antennas and Propagation, Vol. 2008, pp.1 - 4, Hindawi Publication, U.S.A., 2008.

[6] Qing-Xin Chu and Liang-Hua Ye **"Design of Compact Dual-Wideband Antenna With Assembled Monopoles,"** IEEE Trans.Antennas Propag, vol. 58, No. 12, December 2010.

[7] Rainee N. Simons, **"Coplanar Waveguide Circuits, Components, and Systems"**, John Wiley & sons, inc., New York, March 2001 Edition.

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