DESIGN AND ANALYSIS OF CIRCULAR PATCH ANTENNA

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Abstract. The ANSI-based circular microstrip patch antenna is designed to work at 7.4GHz and 12GHz using HFSS simulator software for various WLAN (Wireless Local Area Network) applications, Bluetooth, and IoT communications. The circular patch antenna is made using FR4, which is 4.4 KE, 1.6 mm high, and has a gain of 3 dB. It tests countless antenna features such as return loss, radiation adjustment, bandwidth, directivity, antenna gain, and radiation productivity.
Keywords: circular patch microstrip antenna, HFSS, WLAN.

1. Introduction

In contemporary years, the contemporary trend in the providence of connection is emerging with little cost, little weight, and little profile aerials that can provide high accomplishment in the low distribution. This technical orientation drove to different functions for the design of microstrip antennas. For abounding efficient models, improvements to microstrip antennas meet their competencies. Though, research is still underway to overcome these deficiencies. The circular microstrip patch antenna has a deep utilization to microstrip antennas, especially in the pharmaceutical, militant, mobile, and planetoid transmissions fields.

Microstrip antennas fluctuate in impedance hanging on the plangency frequency, polarity, prototype, and explicit patch composition. Their progress is different due to their narrow capacity and inefficiency [1] Fast and slow design is important when prototyping antennas for consummation calculation. As cellular pertinence draws better and feels the necessity for more higher bandwidth, the demand for broadband antennas on high-frequency alternations is unavoidable. [2] Deep down, microstrip antennas have narrowed bandwidth and capacity, abundantly depending on limitations such as potential resoluteness, fascination, and damage.

Microstrip antennas do largely broadside radiators. [3]The patch can come in many formats, but the most familiar are square and circular, because of the analytical, gin-like, attractive radiation properties, especially the shallow cross-polarity. The patch was created so that its design would not be as complicated as potential. [4]
2. Antenna Design

Microstrip antennas are flexible and are used in series to connect large configurations that cannot be achieved from one component. We use the cluster to prolong the consummation of the antenna, to check the emission configuration axis of the antenna system, to extend the directivity, and to bring the best performance compared to a specific option. [5] In a network configuration, components are displayed at one end or at different edges.

Next, we calculated the area of the circular patch following the method:

2.1 Width (W) calculation:

The first step in this process is to adjust the antenna patch width by adjusting the specific height or compactness of the antenna patch. It calculates the subsequent mathematical statement:

\[ W = \frac{C}{2fr} \left( \frac{2}{r + 1} \right) \]

Here, light velocity = c, dielectric surface constant = \( \varepsilon_r \), fr = required resonance frequency.

2.2 Effective Dielectric Constant (reff) calculation:

It is predicted by the consecutive mathematical statement:

\[ \varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \left[ 1 + 12 \frac{h}{w} \right]^{-1/2} \]

Here, h = Crest of the dielectric surface, The dielectric persistent of the dielectric surface=\( \varepsilon_r \), W = Amplitude of the patch antenna.

2.3 Patch Effective Length (Leff) is calculated:

The patch effective length is estimated by the following equation:

\[ Leff = \frac{c}{2fr\sqrt{\varepsilon_{reff}}} \]

Here, Light velocity = C, fr = desired resonance frequency, reff = constant for effective dielectric.

2.4 Patch Length Extension (\( \Delta L \)) Computation:

As an outcome of the edge field effect around the boundary of the patch, the antenna appears to be electrically more enormous than its absolute real size. The diameter of the patch inflation is considered by the subsequent mathematical statement:

\[ \Delta L = 0.412h \left( \varepsilon_{reff} + 0.3 \right) \left( \frac{W}{h} + 0.264 \right) \]

Here, h = peak or compactness of the dielectric surface, W = diameter of the patch antenna, reff = perpetual for the effective dielectric.

2.5 Patch Real Length (L):

The definite patch diameter is considered by the mathematical statement:

\[ L = Leff - 2\Delta L \]

Here, leff = patch effective length, \( \Delta L \) = patch length extension

2.6 Ground Dimension (Wg, Lg) Calculation:

Ground, width length is considered by the subsequent mathematical statements, respectively:

\[ Wg = 6h + W, Lg = 6h + L. \]

Here, h = crest or compactness of the dielectric surface, W = diameter of the patch, L = patch diameter[6][8].
3. Method of Analysis

There remain special search processes for because of the antennas. The proposed antenna has a two-dimensional emission patch on the weak current, so it can be administered as a two-dimensional planer segment for analytical aspirations. The analytical processes of the proposed antennas can be subdivided into 2 groups. While in the base group, the processes depend on the division of an equal magnetic field around the patch edges (relative to the position antenna). There are triple familiar techniques of analysis [3]:

- Transmission line model
- Model of the Ava Chamber
- Multiport network model

In the crumbling faction, the processes depend on the ongoing dissemination of the patch conductor and the ground plane (compatible with bipolar antennas controlled in wave reflection / scrutiny techniques). The succeeding is some numerical progressions for fixing microstrip antennas:

- Finn limit-element method
- The seconds method
- Spectral-domain technique
- Limit-changing time-domain method
- Adopted cavitation technique.

4. Benefits of Microstrip Patch Antenna

Transmission situated operations. The microstrip patch antenna spots much pertinence in wireless transmission. For precedent, planetoid transmissions require oblique polarization transmission portraits. They had large in intensity and extravagant because of the province.

5. SIMULATION RESULTS AND DISCUSSION

The expected antenna design is shown in fig. I. The 10 x 6.5 mm2 FR-4 substrate is the recommended antenna layout, relative permittivity $\varepsilon_r = 4.4$ with the compactness of 1.6 mm, and the improved antenna values are represented in Table I of the recommended design.
Figure 1. Proposed Antenna

Table 1. Antenna Dimensions Table

| Parameters | Values (mm) |
|------------|-------------|
| A          | 15          |
| B          | 5           |
| C          | 15          |
| D          | 7           |
| E          | 15          |
| F          | 10          |
| G          | 5           |
| H          | 5           |
| I          | 5           |
| J          | 5           |
| K          | 5           |
| L          | 7           |
| M          | 10          |
| N          | 10          |
| O          | 10          |
| P          | 3           |
Figure 2. Return Loss vs Frequency

Figure 3. Antenna Gain at 7.4GHz

Figure 4. Antenna Gain at 12GHz

The radiation figure of a recommended antenna at resonant frequencies. As a MPA, the antenna has a great gain of 3dB at 7.4GHz and 3dB at 12GHz.
Figure 5. Antenna Radiation patterns at 14GHz

6. Conclusion
This journal refers to the layout and study of circular microstrip patch antennas executed using HFSS software. In this paper, the recommended antenna layout is repeated by assessing the return loss, antenna, and radiation abundance. The microstrip patch antenna of oblique radiant domains was auspiciously described with FR4 epoxy glass. A study of the HFSS simulation software explained that the antenna reverberated at 7.4GHz and 12GHz frequencies. Ku-band functions have a reflection coefficient of -35.84 dB (S11) and d17.71 dB with gains of 3dB and 3dB, respectively.

7. References
[1] Balanis, C.A., “Antenna Theory – Analysis and Design”, John Wiley & Sons, Inc 1997.
[2] C. A. Balanis, “Advanced Engineering Electromagnetics”, New York, John Wiley and Sons, 1989.
[3] Garg, R., Bhartia, P., Bahl, I., Ittipiboon, “A., Microstrip Antenna Design Handbook”, Artech House, Inc, 2001.
[4] Kin-Lu Wong, “Compact and Broadband Microstrip Antennas”, Copyright 2002 John Wiley & Sons, Inc.
[5] H.Iwasaki, “A circularly polarized small-size microstrip antenna with a cross slot,” IEEE Trans. Antennas Propagat. Vol.44, pp.1399–1401, Oct.1996.
[6] D. M. Pozar and D. H. Schaubert, Microstrip Antennas, “The Analysis and Design of Microstrip Antennas and Arrays”, IEEE Press, 1995.
[7] JR James & P S Hall, “Handbook of Microstrip Antennas”, Peter Peregrinus Ltd., 1989.
[8] Hemant Kumar Gupta, P.K Singhal, Pavan Kumar Sharma “Slotted Circular microstrip patch antenna designs in multiband application in Wireless Communication”,” IJET 1 (3)(2012) 158-167.
[9] N.P Yadav, J.A Ansari and Kamakshi, “Analysis of Circular Disk Patch Antenna Loaded with U and V shape slot for Broadband Operation,” IJMOT vol 6 no 5 SEP 2011.
[10] K.V.L Bhavani, B.T.P Madhav, P. Poorna Priya “Design of Compact U-Slot Circular Patch Antenna on RT DUROID 5880 Substrate” IJMER Vol 1 Issue 1, pp. 140-145.

[11] Barun Mazumdar, “Design of Circular Patch antenna using L-slit for WIMAX, WLAN & X-Band applications”, IJARCE, vol. 1, Issue 9, NOV 2012.

[12] P.A. Ambresh and P.M Hadalgi “Design and Analysis of a Compact Microstrip Patch Antenna for Dual Frequency Band using Slits”, IJMOT, vol. 7, No 4 JULY 2012.

[13] Yahya S. H. Khraisat, “Design of 4 Elements Rectangular Microstrip Patch Antenna with High Gain for 2.4 GHz Applications,” Modern Applied Sciences, Vol. 6, No. 1, January 2012.

[14] Ayyappan, Manoj B. Jagadish Chadran, “Design and Analysis of Circular Microstrip Antenna at 5.8 GHz with Fr-4 Substrate,” International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 5, Special Issue 4, March 2016.

[15] Ken Paramayudha, Arief Budi Santiko, Yuyu Wahyu, Folin Oktafiani, “Design and Realization of Circular Patch Antenna for S-Band Coastal Radar” (2016).

[16] Togcuoglu, N. B., Albayrak, Y., Saylik, M. N., Daye, M. A., Bal, M., Imeci, M., & Imeci, T., “Circular patch antenna with circular and rectangular slots”, 25th Signal Processing and Communications Applications Conference (SIU) 2017.

[17] A.V. Ponkia, V.V Dwivedi, J.P. Chaudhari, "Dual Band Circular Shaped Slotted Microstrip Patch Antenna", Invention Journals on Antenna and Propagation, 2012.

[18] N. Boskovic, B. Jokanovic, F. Oliveri, D. Tarchi, "High Gain Printed Antenna Array for FMCW Radar at 17 GHz", 2015.

[19] Shanthi P., Soundarya S., Meghana S., "Design of Dual Band Microstrip Antenna for 2.4 GHz and 3.6 GHz", International Journal of Recent Technology and Engineering (IJRTE), Volume 8(1), PP.No:2402-2406.

[20] Keshav Gupta, Kiran Jain, Pratibha Singh, “Analysis and Design of Circular Microstrip Patch Antenna at 5.8 GHz,” International Journal of Computer Science and Information Technologies, Vol. 5 (3), 2015, 3895-3898.

[21] S. Whitehead, “Adopting Wireless Machine-to-Machine Technology,” IEEE Journal of Computing and Control Engineering, vol. 15, no. 5, pp. 40-46, Oct-Nov. 2004.