ISSN 2320 2599

Volume 3, No.6, November -December 2014

International Journal of Microwaves Applications

Available Online at http://warse.org/pdfs/2014/ijma01362014.pdf

The Effect of the Radius of the Circular Patch Antenna in the Ku-Band

Youssef Rhazi[1], Seddik Bri [2], Raja Touahni[1]

[1]Sciences Faculty of Kenitra, B.P. 133, Morocco, rhazi.lastid@yahoo.fr

[2] MIN, Electrical Engineering Department, High School of Technology: ESTM

Moulay Isamil University, B. P 3103, Meknès, Morocco, briseddik@gmail.com

ABSTRACT

This paper presents a more general approach to the evolution of the resonant frequency according to the radius of the circular patch antenna. Transmission line theory and the resonator model are adopted to analyze the operating frequencies of the proposed antenna.

A uniplanar corner-fed patch antenna is presented with single-point microstrip feed and single layer substrate.

We used HFSS (high frequency structured simulator) software for simulation of antenna and to find out the results. We keep changing the design of antenna as our motive was to achieve miniature antenna with better results than conventional antenna's.

Patch radius decreases as the resonant frequency increases (3.06 mm at 18.31 GHz and 2.51 mm at 19.35 GHz). The results obtained in this design compare favorably with results obtained from manual computation of the same parameters and these agree with other designs such as the rectangular patch.

Key words: Circular patch antenna, Transmission line, HFSS, Uniplanar corner fed.

1. INTRODUCTION

Circular microstrip patch antennas have profound applications especially in the field of medical, military and satellite communications. Their utilization has become diverse because of their small size and light weight.

Satellite communications require more and more bandwidth; the demand for wideband antennas operating at higher frequencies becomes inevitable. Inherently microstrip patch antennas have narrow bandwidth and low efficiency and their performance greatly depends on the feeding method. That's why the antennas must have a high gain, small physical size, bandwidth, integrated installation [1-3].

2. THEORY OF PATCH ANTENNA

Since microstrip antennas are often integrated with other microwave circuitry, a compromise has to be reached between good antenna performance and circuit design. The radiating element and the feed lines are usually photo etched on the dielectric substrate. The radiating patch may be square, rectangle, thin strip (dipole), circular, elliptical, triangle or any other configuration. A microstrip antenna is very versatile and made for a wide range of resonant frequencies, polarization patterns and impedances. It is suitable for mobile and government security systems where narrow bandwidth is priority. It is also used on laptops, microcomputers, mobile phones etc.

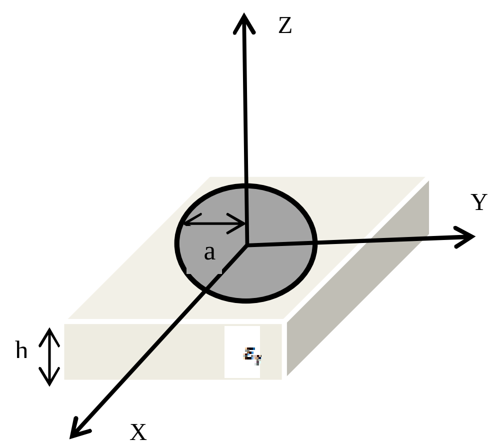

Figure 1: Circular patch antenna

In recent years microstrip antennas have been widely used in microwave frequencies and have been integrated in many electronic devices [4], [5]. This popularity is because of their compact and adaptable size, inexpensive printed circuit board technology, and ease of integration with related electronics. A typical circular microstrip patch antenna is shown in fig 1.

According to [5] the resonant frequency of a circular patch antenna with the radius of a, and substrate thickness of h and relative permittivity of , in its dominant mode (TM_{110}) is:

$$a = \frac{F}{\frac{2h}{1+\sqrt{\pi\varepsilon_{eff}F}\,.\ln\left(\frac{F\pi}{2h}\right)+1.7}} \quad (1)$$

Where:

$$F = \frac{8.791\times}{f_r\sqrt{\varepsilon_r}};$$

F=Resonant frequency in Hz;

ε=Dielectric effective constant;

R= Patch radius in mm;

h=Substrate thickness in mm;

On the other hand, the microstrip line dimensions are obtained as [3]:

$$\frac{W}{d} = \begin{cases} \frac{8e^{A}}{e^{2A}-2} & \frac{W}{d} < 2 \\ \frac{2}{\pi}\left[B - 1 - \ln(2B-1) + \frac{\varepsilon_r - 1}{2\varepsilon_r}\left\{\ln(B-1) + 0.39 - \frac{0.61}{\varepsilon_r}\right\}\right], & \frac{W}{d} > \end{cases} \quad (2)$$

Where l is the line length and:

$$A = \frac{Z_0}{60}\sqrt{\frac{\varepsilon_r}{}} + \frac{\varepsilon_r - 1}{\varepsilon_r + 1}\left(0.23 + \frac{0.}{\varepsilon}\right. \quad (3)$$

$$B = \frac{377\pi}{2Z_0\sqrt{\varepsilon_r}}$$

The resonant frequency calculation includes patch edge-field fringing effects and its effect on the effective dielectric constant. Ku-band antennas fed by an inset microstrip line have been designed, and simulated results are compared to the calculated results.

3. ANTENNA STRUCTURE AND DESIGN

The substrate used for these patches is 10 mil Rogers R04350 (ε_r = 3.48, tan δ =0.004). HFSS was used in an iterative approach to locate the 50 Ω location on the patch [6]. Figure 2 shows the final dimensions and layout of the microstrip feeding the circular patch.

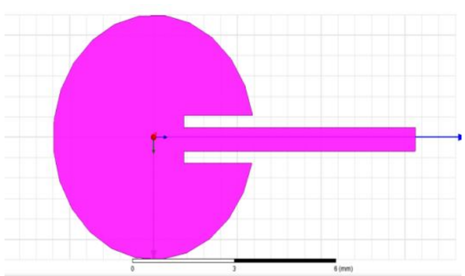

Figure 2: Circular patch antenna

This section describes design methodology for a circular microstrip antenna. The generic antenna layout highlighting the main design parameters and dimensions, where a is the radius of the circular patch, FR is the radius where the desired input impedance is calculated, L is the length and W is the width of the feed line. The feed line is a quarter-wave transformer to match the input impedance of the patch to 50 ohm. The distance G between the radiating element edge and the ground edge is λ/4 according to [7].

The commercially available Rogers R04350substrate was used in the antenna fabrication [8-10]. These parameters are used in the design procedure for determining the radius and input impedance of the circular patch antenna.

Where F_r is the resonance frequency in Hz, ε_r is the substrate dielectric constant and h is the substrate thickness in mm.

As shown in the figure 3, a microstrip transmission line is used to feed the circular microstrip antenna. The feed is inserted deep into the circular radiating element for the proper impedance matching. This arrangement for the feeding a microstrip antenna is known as the “inset-feeding”. HFSS is employed to perform the design and optimization process. The design parameters are from 2.9 mm to 3.2 mm, g=0.3 mm, w_f=0.54 mm.

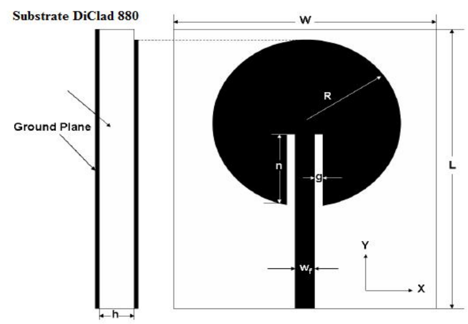

Figure 3: Design of circular patch antenna

4. SIMULATION RESULTS

Figure 4 shows the simulated return losses for circular patches ranging in diameter from 2.9 mm to 3.2 mm. All patches used the same feed dimensions given in figure 3. As seen, the return loss degrades as the resonant frequency increases. Table 1 shows the calculated resonant frequency and measured operating frequency. The error between theoretical resonant frequencies and measured operating frequencies is less than 1.3%.

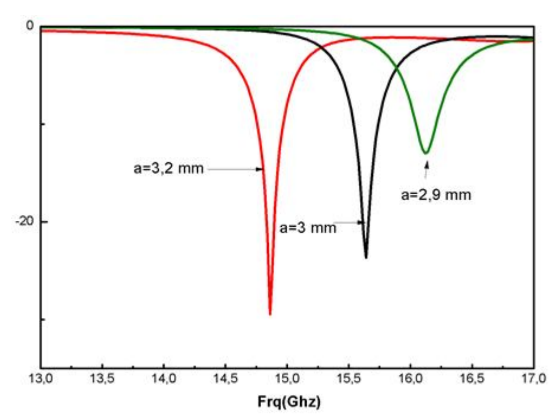

Figure 4: Return loss of circular antenna on the frequency Ku-band

To prove that the secondary (lower) resonant frequency is due to the shape of circular antenna, the effect of the radius of CPW on return loss is shown in Figure 4.
Table 1 compares the simulated and measured results. We note that there is a similarity between our results and measured results [11]. The return loss decreased to above 15 GHz (which are in the frequency range of the Ku band).

Radius (mm)	Simulated resonant frequency (Ghz)	Measured resonant frequency (Ghz)	Simulated Return loss (dB)	Measure d Return loss (dB)	ΔS (dB)
3.2	14.85	14.41	-29.45	-33	3.55
3	15.64	15.46	-23.67	-21.51	2.16
2.9	16.12	16.02	-12.97	-15	2.03

Table 1: Comparison results of the circular patch antenna

Figure 4 shows the return loss. Figures 5 and 6 show the response in radiation pattern and gain 3D.

Simulated results agree well with measured ones, which demonstrate the desirable performances and efficiency of the proposed structure.

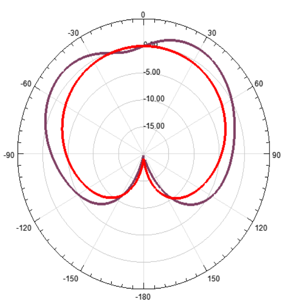

Figure 5: Radiation Pattern of circular patch

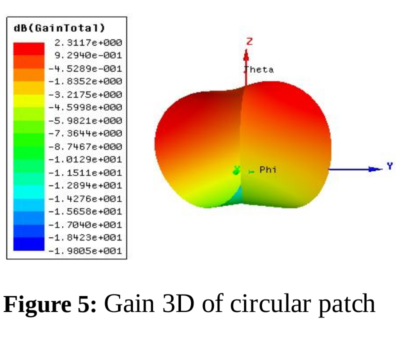

Figure 5: Gain 3D of circular patch

5. CONCLUSION

Design of circular microstrip antennas has been investigated via the transmission line. A circular microstrip antenna with a probe feed is obtained and the required parameters at the frequency of 14.85 GHz to 16.12 GHz have been investigated successfully.

The microstrip antenna performance can be upgraded concerning the feed type, the size of the patch and the substrate used.

REFERENCES

1. M.Iftissane, S.Bri, L.Zenkouar, A.Mamouni, "**Conception of Patch Antenna at Wide Band**", Int. J. Emerg. Sci., 1(3), pp. 400-417, September 2011.
2. S.Bri, A. Nakheli, A. EL fadl, "**Conception of Patch Antenna at Wide Band: Dual and Broadband Patch Antenna**", ISN: 978-3-8484-8921-3, Edition LAP - Lambert Academic publishing – Germany, 2012.
3. M.Iftissane, S.Bri, L.Zenkouar, A.Mamouni, "**Design and Modelling of Broad band Patch Antennas**", AMSE: A General Physics and Electrical Applications Vol. 84, Issue 2, pp.78-98, November 2011.
4. A. Boufrioua, and A. Benghalia, "**Effects of the resistive patch and the uniaxial anisotropic substrate on the resonant frequency and the scattering radar cross section of a rectangular microstrip antenna**," Aerospace Science and Technology, vol. 10(3), 2006, pp. 217–221.
5. P. Soontornpipit, C. M. Furse, Y. C. Chung, and B. M. Lin, "**Optimization of a buried microstrip antenna for simultaneous communication and sensing of soil moisture**," IEEE Transa
6. Gardu~no-Nolasco, E., J. R. Sosa-Pedroza, and H. Jardon-Aguilar, \An UWB **microstrip feeding quasi circular antenna**," 7th International Congress on Electrical Computer Science and Automatic Control, Tuxtla Gutièrrez, Chiapas, México, September 2010.
7. W. C. Liu, "**Design of a multiband CPW-fed monopole antenna using a particle swarm optimization approach**," IEEE Trans. Antennas Propag, vol. 53, pp. 3273–3279, 2005.
8. C. A. Balanis, "**Antenna Theory, Analysis and Design**", JOHN WILEY & SONS, INC, New York 1997.
9. R.Garg, P.Bharita, I.Bahl,A.Ittipibon ,"**Microstrip antenna design and handbook**'', Artech House, Boston, London, 2001.
10. Lo, Y.T., Solomon D. and Richards, W.F. "**Theory and Experiment on Microstrip Antennas**," IEEE Transactions on Antennas and Propagation, AP-27, pp. 137-149, 1979.
11. A. D. Yaghjian and S. R. Best, "**Impedance, bandwidth, and Q of antennas**," IEEETransactions on Antennas and Propagation, vol. 53, no. 4, pp. 1298– 1324, Apr. 2005.
12. N. Kawasaki. **Parametric study of thermal and chemical nonequilibrium nozzle flow**, M.S. thesis, Dept. Electron. Eng., Osaka Univ., Osaka, Japan, 1993.