International Journal of Advance Research and Innovation
Vol. 2(4), Oct-Dec 2014, pp. 33-36
Doi: 10.51976/ijari.241407

Article Info
Received: 25 Oct 2014 | Revised Submission: 30 Oct 2014 | Accepted: 20 Nov 2014 | Available Online: 15 Dec 2014

Dual-Frequency Band Circular Microstrip Antenna for Radar Application

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ABSTRACT

This paper presents a circular shaped microstrip antenna through an inset feed. Simulation results show that the designed antenna can be used as a dual frequency antenna with effective return loss of -33.43 dB and -35.90 dB at 1.609GHz and 2.239GHz respectively. The dual band operation of the proposed antenna is due to two exited modes (TM01& TM11).for the proposed antenna TM11 is the fundamental as well as the dominant mode. The two modes have the similar broadside radiation characteristics and same polarization planes.

Keywords: *Microstrip Antenna; Wireless Local Area Network; Dual Frequency Band.*

1.0 Introduction

Radar and modern communication systems such as synthetic aperture radar (SAR), global position system (GPS) and wireless local area networks (WLAN) often require low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a large spectrum of frequencies [1].

Dual band or multi frequency operations are main requirement of this type communication. A single antenna is highly desirable if it can operate at these two bands. The antenna should be in the planar form, lightweight and compact, so that it can easily be embedded in the cover of communication devices. For reduce the transmission line length and the radiation losses a simplified feeding circuit are also an important component.

Microstrip (patch) antennas offer many advantages not commonly exhibited in other antenna configurations. For example, they are extremely low profile, lightweight, simple and inexpensive to fabricate using modern day printed circuit board technology, compatible with microwave and millimeter-wave integrated circuits (MMIC), and have the ability to conform to planar and non-planar surfaces. In addition, once the shape and operating mode of the patch are selected, designs become very versatile in terms of operating frequency, polarization, pattern, and impedance [2] Using the Dual Band Microstrip Antenna concept in this paper dual band circular Microstrip antenna is designed simulated on IE3D software. It works based on method of movement (MOM).

Main disadvantage of Microstrip patch antenna is the bandwidth limitation which is due to the resonant characteristic of the patch structure [3]. Bandwidth limitations is the main problem of microstrip patch antenna, for overcome this bandwidth limitations a new method is evolved. Dual-frequency microstrip antenna is the alternate method for bandwidth enhancement, which required in various applications for the operation of two separate sub bands. For generating a dual frequency behavior in the single-fed microstrip antenna, by creating or etching slots on the radiating element of the microstrip patch antenna [4]

The slot loading in the radiating patch creates a strong modification of the resonant modes, particularly when the slots are configured to obstruct and cut the current lines of the unperturbed modes as shown in this work.

2.0 Antenna Desing and Results

Fig: 1. shows the geometry and configuration dual frequency circular microstrip antenna with a rectangular slot. Antenna has a circular patch on ground plane with a rectangular slot and has inset feed. The antenna was fabricated on an h=1.6 mm FR4 epoxy substrate with the dielectric constant εr=4.4 and loss tangent tan δ=0.02. The design parameters (W=75mm, L=80mm, R=25mm, A=36.5mm, B=5mm, C=24.5mm, D=2 mm, G=3mm).

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The dominant and fundamental mode responsible for the first resonance in the circular microstrip antenna is TM11 mode. For the dominant and fundamental mode TM11, the expression for the resonant mode is given by [15]

$$(f_r)_{11}=\frac{1.8412\,c0}{2\pi Re\sqrt{\varepsilon r}} \qquad (1)$$

Where c0 is the velocity of light in free space, R is the radius of the circular micro strip antenna, εr is the dielectric constant of the substrate. The resonant frequency of equation (1) does not take into account fringing. fringing makes the patch look electrically larger and it was taken into account by introducing a radius correction method Similarly for the circular patch a correction is introduced by using an effective radius Re, to replace the actual radius R , given by [16]

$$Re=R\left\{1+\frac{2h}{\pi R\varepsilon r}\left[\ln\left(\frac{\pi R}{2h}\right)+1.7726\right]\right\}^{1/2} \qquad (2)$$

Where h is the height of the dielectric substrate. After the radius correction, the resonant frequency for the dominant mode TM_{11} is modified by eq. (2) and is expressed as

$$(f_r)_{11}=\frac{1.8412\,c0}{2\pi Re\sqrt{\varepsilon r}} \qquad (3)$$

Hence, putting all the numerical values of the design parameters into eq. (2) and eq. (3), the theoretical first resonance frequency (f1) was found to be 1.609 GHz.

Fig 1: Geometry of Antenna

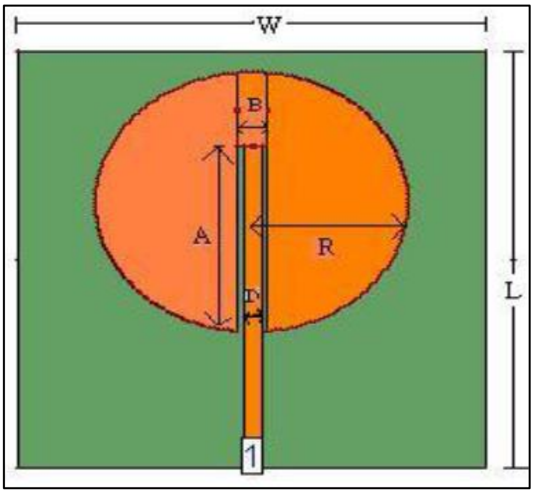


Fig 2: Return Loss (dB) vs. Antenna Frequency

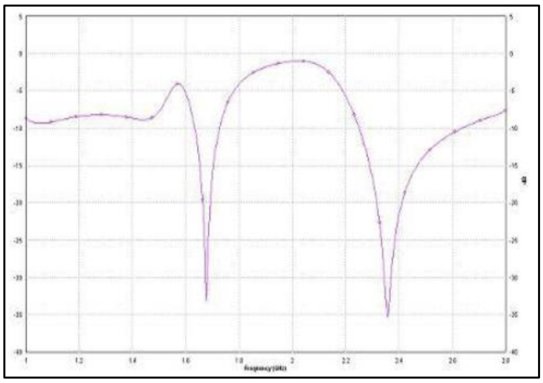


Fig 3: VSWR vs. Frequency

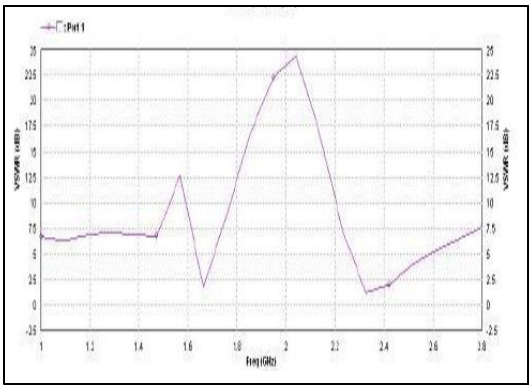
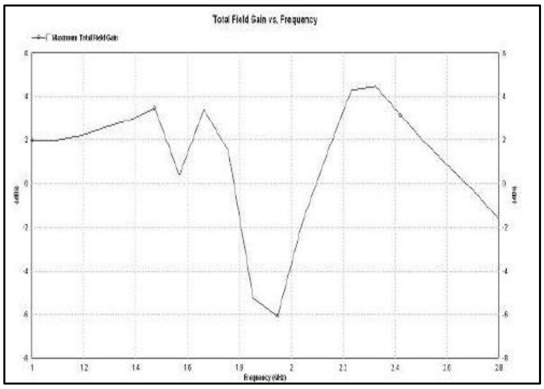


Fig 4: Total field Gain vs. Frequency



The antenna resonates at 1.6098 GHz (TM11 mode) and 2.239 GHz (TM01 Mode) at the return loss values of –29.43 dB and –55.90 dB respectively, which is shown by Fig.2.shows the return loss (|S11|) (dB) vs. frequency of the dual frequency circular microstrip antenna with a rectangular slot on the tip of the circular patch . The first resonance (f1=1.609 GHz) band extends from 1.569 GHz to 1.66 GHz at –10 dB having the percentage bandwidth of 6% and the second resonance (f2=2.239 GHz) band extends from 2.18 GHz to 2.29 GHz at –10 dB having the percentage bandwidth of 6%. According the dual band rule percentage bandwidth is 68%.which is very large and efficient. This is 1.133GHz.

Fig. 3 Depicts the VSWR vs. frequency of the two resonance frequencies. The values of the VSWR at 1.609 GHz and 2.239 GHz are 5.7 and 1.2 respectively. This depicts that there is good impedance matching between microstrip transmission line and the circular radiating element at the two resonant frequencies of 1.609 GHz and 2.239 GHz.

Fig.4 Depicts the Total gain vs. frequency of two resonance frequencies. The values of the gain at 1.609 GHz and 2.239 GHz are 0.6 and 4.5 respectively. The gain is sufficient at 2.239 GHz.

Fig: 5. Directivity vs. Frequency

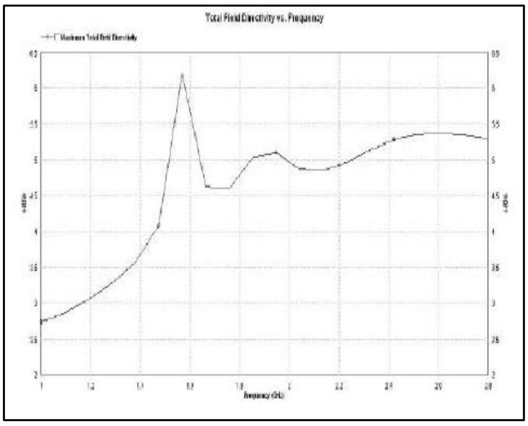
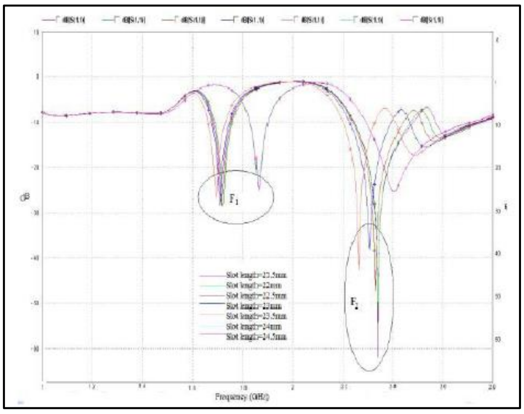


Fig 6: Effect of Variation of Slot Length



(C) On the Resonant Frequencies of the Antenna

Fig.5 Depicts the directivity vs. frequency of two resonance frequencies. The values of the gain at 1.609 GHz and 2.239 GHz are 4.06 and 5.46 respectively. The directivity is sufficient at both frequencies.

Fig.6 represents the effect of variation of slot length (C) on the two resonance frequencies. As the value of the length of the slot increases from 21.5 mm to 24.0 mm, the first resonance frequency (f1) is slightly affected but the second resonance frequency (f2) is considerably affected. The second resonance frequency (f2) shifted left i.e. decreased with the increase of the slot length (w). At w=24.5 mm the second resonance frequency (f2) is at 2.239 GHz, for which this antenna can be used in the wireless local area network (WLAN) domain.

Fig.7 Depicts the Total Radiation and Antenna efficiency of two resonance frequencies. The values of the Radiation efficiency at 1.609 GHz and 2.239 GHz are 56% and 82% respectively and the Antenna efficiency are 51% and 80% respectively the radiation and antenna efficiency is sufficient at both frequencies. Fig.8 Depicts the Total Z-parameter vs. frequency of two resonance frequencies. The values of the gain at 1.609 GHz and 2.239 GHz are 26 and 0.67 respectively. The gain is sufficient at both frequencies.

Fig 7: Radiation and Antenna Efficiency

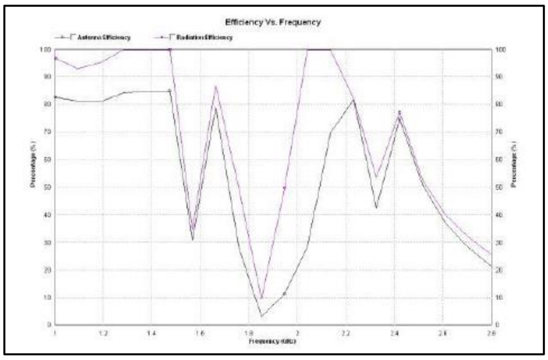
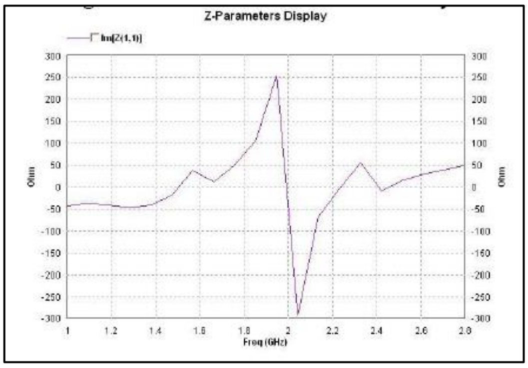


Fig: 8. Z-Parameter of Antenna



3.0 Conclusion

In this paper we try to minimize the return losses with the help of varying rectangular slot length by using IE3D simulator version 10.2. Our result indicates the bandwidth around the two operating frequencies (1.607 GHz and 2.239 GHz) are sufficient for the dual band wireless operations. The BW is very large as per dual band rule. Here we assume all environmental conditions are standard. In future this work can we extended in many ways like increasing bandwidth, increasing gain and minimize different losses and finally optimizing performance of antenna.

References

[1] G. –M. Zhang, H. -J. Song, B. –Z. Wang, Q. –Y. Qin 2007, A Novel dual-band microstrip antenna for WLAN applications, International Conference on Microwave and Millimeter Wave Technology

[2] B. F. Wang, Y. T. Lo, Microstrip Antenna for Dual-Frequency Operation," IEEE Trans. Antennas Propag., AP-32(9), 1984, 938- 943

[3] H. Nakano, K. Vichien, Dual-frequency square patch antenna with rectangular notch, Electron. Lett., 25(16), 1989, 1067–1068

[4] S. Maci, G. Biffi Gentili, G. Avitabile, Single-Layer Dual- Frequency Patch Antenna, Electron Lett., 29(16), (1993), 1441- 1443

[5] M. L. Yazidi, M. Himdi, J. P. Daniel, Aperture Coupled Microstrip Antenna for Dual Frequency Operation, Electron Lett., 29(17), 1993, 1506-1508

[6] S. Maci, G. Biffi Gentili, P. Piazzesi, C. Salvador, A Dual Band Slot-Loaded Patch Antenna, IEE Proc.-Microw. Antennas Propag, 142(3), 1995, 225-232

[7] Y. M. M. Antar, A. I. Ittipiboon, A. K. Bhattacharyya, A dualfrequency antenna using a single patch and an inclined slot, Microwave Opt. Technol. Lett, .8(6), 1995, 309–311

[8] H, -M. Chen, Reactively loaded microstrip antenna for dual-frequency operation, IEEE Antennas and Propagation society International Symposium, 3, 1999, 1648-1651, 11-16

[9] J.-H. Liu, Dual frequency operation of rectangular microstrip antenna with bent-slot loading, IEEE Asia Pacific Microwave Conference, 2000, 1343-1346

[10] K. P. Ray, Girish Kumar, Tuneable and Dual-Band Circular Microstrip Antenna with Stubs, IEEE Trans. Antennas Propag., 48(7), 2000, 1036-1039

[11] J. –Y. Jan, Single-layer single-feed dual-frequency circular microstrip antenna with an offset, 2003