Compact Coplanar Waveguide Fed Ground Meandered Antenna for Wireless Application

Sujith R[1], S Mridula [2], C.K Aanandan[3], K Vasudevan[4] and P Mohanan[5]

Centre for Research in Electromagnetics and Antennas, Department of Electronics, Cochin University of Science and Technology, Cochin, India.

E-mail:- 1. sujithrpkd@gmail.com 2. mridulahari@gmail.com 3. aanand@cusat.ac.in 4. vasudevankdr@gmail.com 5. drmohan@gmail.com

Abstract

A compact Co-Planar Waveguide (CPW) fed antenna operating at 2.4GHz with 300MHz 2:1 VSWR bandwidth is presented. Compared to a conventional quarter wavelength CPW fed monopole antenna, the aperture area reduction of the present antenna is 85%. The prototype antenna fabricated on a substrate of ε_r = 4.4 and thickness 1.6mm is only 22x10x1.6mm^3. This much size reduction and impedance matching is achieved by adjusting the signal to ground plane separation and meandering the ground plane of a 50Ω CPW transmission line.

1. Introduction

The requirement of compact devices in the present scenario has urged antenna designers to develop very compact structures. The uniplanar characteristics of coplanar waveguide (CPW) devices are suitable for compact applications and hence they are used in Monolithic Microwave Integrated Circuits (MMIC). Various CPW fed antennas are reported with modification on signal strips. A meandered antenna is presented [1] to achieve compactness and moderate impedance bandwidth. An elliptical ring on the farther side of a CPW-fed monopole antenna is used to achieve Ultra Wide Bandwidth [2]. The major axis of the elliptical ring is successfully extended to get the wide band performance. A stacked T-shaped monopole of different sizes, to generate two separate resonant modes for the desired dual band operations, is presented in [3]. A narrow slot at the end of a CPW in [4] and a CPW fed monopole antenna in [5] are used to couple electromagnetic energy to dielectric resonators for achieving required impedance matching.

The lateral ground plane, signal strip dimensions and the feed point of a coplanar waveguide is modified to develop a dual band antenna for WLAN application in [6]. A novel dual band CPW-fed hybrid antenna consisting of a CPW-fed inductive slot antenna and a dual inverted-F monopole antenna is also proposed [7]. The ground plane modifications on coplanar waveguide have also been done to achieve good antenna performance. The ground modified antennas presented in [8-9] are either capacitively or inductively fed to achieve single resonance. The ground modified harmonic suppressed antenna [10] is also reported from authors group. All the aforementioned antennas are either large in size or complex in structure, for use in modern communication gadgets.

In this paper, a compact planar antenna obtained by meandering the CPW transmission line ground plane is discussed. This antenna has an overall dimension of 10x 22x1.6mm^3 with very low cross polar isolation level.

2. Antenna Geometry

The geometry of the proposed CPW fed ground meandered antenna is shown in figure1 (a). The strip width (W) and gap (g) of CPW feed line are designed for 50Ω using standard design equations [11].The ground plane is meandered by modifying the transmission line to make it a half wavelength symmetrical radiating element. This is achieved by creating a slit as in the figure(S= 0.5mm, P=1mm, W_s=1mm and g_1=0.65mm) on the ground strip of length L_1. The antenna is fabricated on a substrate of relative permittivity (ε_r) 4.4 and thickness (h) 1.6mm. The

978-1-4244-6051-9/11/$26.00 ©2011 IEEE

overall dimension (10mmX22mm=220mm^2) of the antenna is very less compared to a conventional monopole antenna (36mmX41mm=1476mm^2) fabricated on the same substrate.

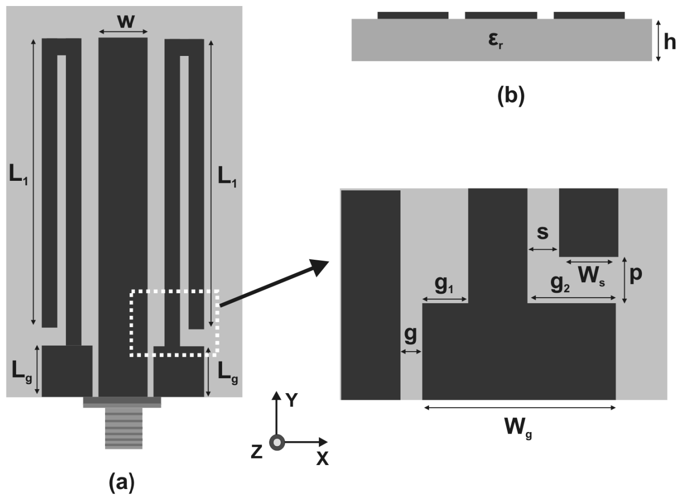


Figure. 1. Antenna geometry (L_1=18, L_g=3, w=3, g_1=0.65, g_2= 1.5, ws=1, p=1, g=0.35, s=1, wg=3.15, h=1.6, εr=4.4(all length are in mm)) a) Front View b) Side View

3. Results and Discussions:

The evolution of the antenna together with the reflection characteristics are shown in figure 2. The structure begins with a normal coplanar waveguide transmission line (Figure 2(a)) which has no resonance from 1 to 10 GHz as shown in figure 2(d). This is acting as an open ended CPW. The above system can be transformed to a radiator using the geometry in figure 2(b) (Antenna 1). Antenna 1 is obtained by inserting slot in the ground plane symmetrically. This produces a resonance at 2.3GHz as shown in the figure 2(d). However, this resonance is radiating but not matched. The matching may be improved by increasing the ground plane dimension without affecting the overall compactness resulting in Antenna 2 (figure 2(c)). Since the effective radiating length of antenna 2 is reduced, a matched resonance is obtained at 2.44GHz. Even though the matching is improved, antenna 2 has low bandwidth. The performance of the antenna can be improved further by modifying the ground plane as in figure 1 resulting in the optimized structure (Antenna3).

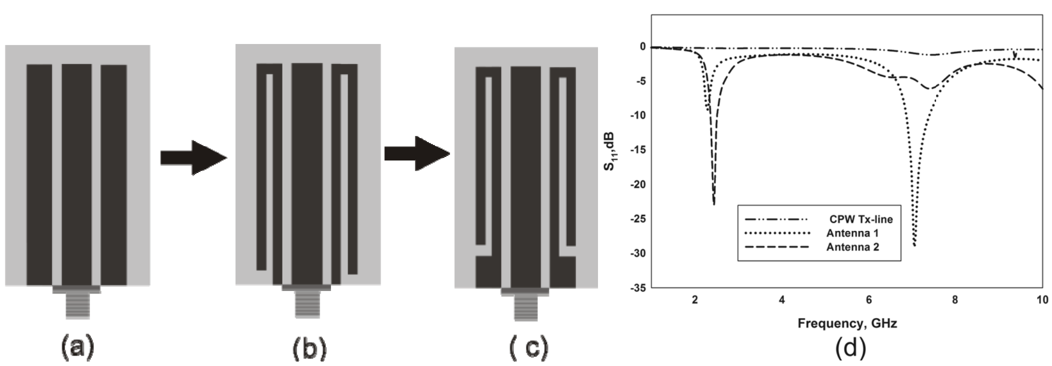


Figure 2 Antenna Evolutions (a) CPW Tx-Line (b) Antenna 1 (c) Antenna 2 (d) Reflection characteristics

The simulated (Ansoft HFSS) and measured (HP8510C Network Analyzer) reflection characteristics of the optimized antenna shown in figure 3 are in good agreement. The antenna operates from 2.38GHz-2.68GHz with

12% bandwidth. The measured 300MHz bandwidth is wide enough to cover the 2.4GHz band for WLAN application. Moreover, the frequency can be tuned by changing the length of the symmetrically meandered ground strips. It is found that the total length of the meandered strip ($2L_1+W_s+P$) on one ground plane is nearly $0.50\lambda_g$, where λ_g is the wavelength in substrate corresponding to the resonant frequency.

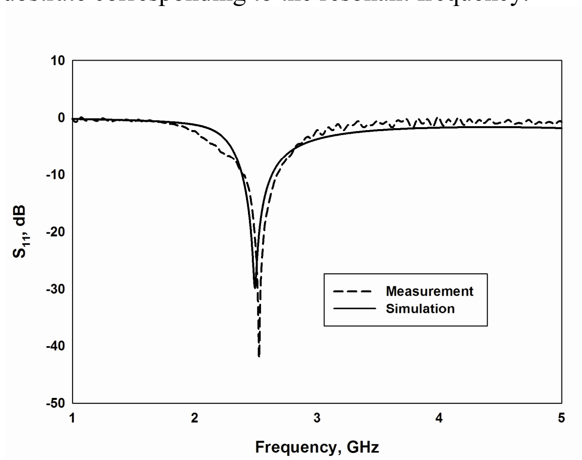


Figure 3. Reflection characteristics of Antenna 3

From the simulation studies, it is found that the vertical electric field component(Y-directed) on both the lateral ground plane dominates the horizontal component, resulting in y-polarized antenna. The radiation pattern of the antenna is shown in figure 4. A nondirectional pattern in the H-plane and a figure of eight pattern in the E-plane are observed as in a CPW fed monopole antenna. The electric field components along y-direction are added together at the far field resulting a cross polar isolation better than 15dB along the bore sight direction.

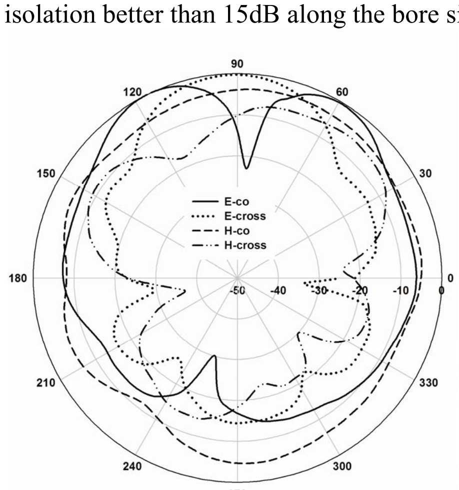
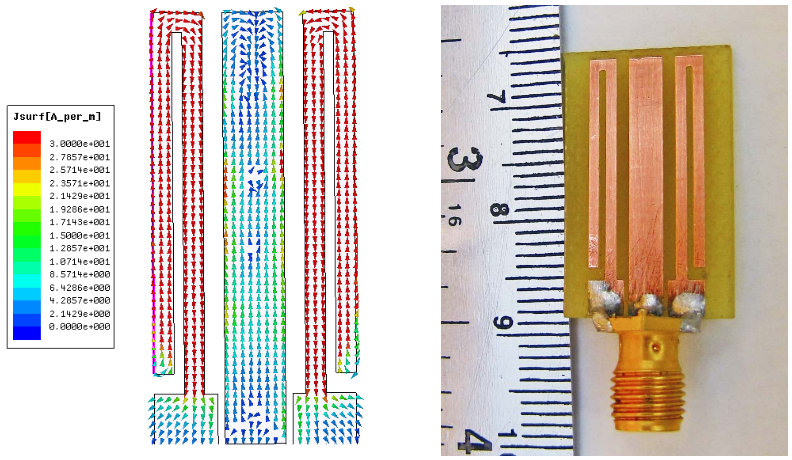


Figure 4. Radiation pattern at 2.5GHz

The current distribution of the antenna at resonant frequency is shown in figure 5(a) which clearly confirms the half wavelength variation along the meandered strips. A prototype of the fabricated antenna is shown in figure 5(b).This ground meandered antenna has a size reduction of more than 85% compared to a standard CPW fed quarter wavelength monopole antenna. The average gain of the antenna is 1.3dBi in the operating frequency band.



(a) (b)

Figure 5. (a) Simulated current distribution at 2.5GHz. (b) Prototype of the fabricated antenna

4. Conclusion

A compact coplanar waveguide fed antenna operating in the 2.4GHz WLAN band with 300MHz 2:1 VSWR bandwidth is presented and discussed. The antenna offers a size reduction of more than 85% compared to a standard CPW fed quarter wavelength monopole antenna. Moreover, the antenna provides a 15dB cross polar level along the bore sight direction with an average gain of 1.3dBi and an efficiency of 75%.

5. References

1. Horng-Dean Chen, “Compact CPW-fed dual frequency monopole antenna”, Electron. Lett., December 2002, vol.38, No.25, pp 1622-1624.
2. Y.-J. Ren and K. Chang,”Ultra-wideband planar elliptical ring antenna”, Electron. Lett., April 2006, Vol. 42, No.8, pp 447-449.
3. Yen-Liang Kuo and Kin-Lu Wong, “Printed Double-T Monopole Antenna for 2.4/5.2 GHz Dual-Band WLAN Operation”, IEEE Trans. Antennas Propag., September 2003, Vol. 51, No.9, pp 2187-2192.
4. M. S. Al Salameh, Yahia M. M. Antar and Guy Séguin, “Coplanar-Waveguide-Fed Slot-Coupled Rectangular Dielectric Resonator Antenna”, IEEE Trans. Antennas Propag, Oct 2002, Vol.50, No.10, pp 1415-1419.
5. Yi-Fang Lin, Chia-Ho Lin, Hua-Ming Chen, and P. S. Hall, “A Miniature Dielectric Loaded Monopole Antenna for 2.4/5 GHz WLAN Applications”, IEEE Microwave and Wireless Components Letters, November 2006, Vol. 16, No. 11, pp 591-593.
6. Rohith K Raj, Manoj Joseph, C.K.Aanandan, K.Vasudevan and P.Mohanan,”A New Compact Microstrip-fed Dual-band Coplanar Antenna for WLAN application”, IEEE Trans. Antennas Propag., Dec 2006, Vol. 54, No.12, pp 3755-3762.
7. X.C. Lin and C.C. Yu, “Dual-band CPW-fed hybrid antenna” Electron. Lett., May 2007, Vol. 43, No.11, pp 599-600.
8. Y.-F. Lin, P.-C. Liao. P.-S. Cheng, H.-M. Chen,C.T.P. Song and P.S. Hall,”CPW-fed capacitive H-shaped narow slot antenna”, Electron. Lett., August 2005,Vol. 41, No.17, pp 438-439.
9. Cheng-Chieh Yu and Xian-Chang Lin,”A Wideband Single Chip Inductor-Loaded CPW-Fed Inductive Slot Antenna”, IEEE Trans. Antennas Propag., May 2008, Vol. 56, No.5, pp 1498-1501.
10. R Sujith, S Mridula, P Binu, D Laila, R Dinesh and P Mohanan, “Compact CPW-fed ground defected H-shaped slot antenna with harmonic suppression and stable radiation characteristics”, Electron. Lett, June 2010, Vol.46, No.12, pp 812-814.
11. R. Garg, P. Bhartia, I. Bahl, and A. Ittipiboon, Microstrip Antenna Design Handbook. Norwood, MA: Artech House, 2001.