

DUAL BAND MICROSTRIP ANTENNA WITH SLIT LOAD DESIGN FOR WIRELESS LOCAL AREA NETWORK APPLICATION

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ABSTRACT

This paper presents a design of dual frequency band operation nearly square patch antenna for IEEE 802.11b,g (2.4Ghz-2.4835GHz) and IEEE 802.11a (5.15GHz-5.25GHz) by using a patch antenna. The patch and ground plane are separated by a substrate; the radiating patch have two pairs of orthogonal slits cut from the edge, this antenna has wide bandwidth in the frequency band of (WLAN) and with a return loss ≤ -10 dB from 2.4 GHz to 2.48 GHz and from 5.12 GHz to 5.32 GHz exhibits circularly polarized far field radiation pattern. The proposed antennas have been simulated and analyzed using method of moments (MoM) based software package Microwave Office 2009 v9.0. The results show that the antenna has dual band frequency operation by using slit load.

KEYWORDS: IEEE802.11a/b/g, Microstrip Antenna, Dual Band, Slit Load, Circular Polarization.

تصميم هوائي الشريحة الدقيقة مزدوج الحزمة باستخدام الفتحات المتعامدة المنتظمة لتطبيقات
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الموجز

في هذا البحث تم اقتراح تصميم هوائي شريطي مزدوج الحزمة لغرض استخدامه في منظومتي

(IEEE 802.11b,g) و (IEEE802.11a). أن التصميم المقترح مبني على أساس هوائي الشريحة الدقيقة ذو الشكل شبه المربع تقريباً ذي الزوجين من الفتحات المتعامدة المتساوية المنتظمة التي يتم قطعها من حافات شبه المربع. جرى في التصميم المقترح قطع زوجين من الفتحات المتعامدة المنتظمة لتحقيق التصغير الإضافي في أبعاد الهوائي المقترح. وجد أن التصميم المقترح يقدم تصغيراً إضافياً في حجم الهوائي مع محافظته على مواصفات البث اللازمة لعمل منظومتي (IEEE 802.11b,g) و (IEEE802.11a)، حيث أن حزمة النطاق الترددي للاستقطاب الدائري (النسبة استقطاب محوري اقل من 3 dB ملائم لتغطية النطاق الترددي المطلوب). تمت محاكاة وتحليل النموذج للهوائي المقترح باستخدام مكتب الموجات المايكروية 2009 الجيل التاسع. النتائج بينت أن نطاق العمل الترددي للهوائي هو مزدوج الحزمة باستخدام الفتحات المتعامدة.

1. INTRODUCTION

Microstrip antenna is a type of antennas which can be used for transmitting and receiving signals. Microstrip or printed antennas are low profile, small size, light weight and widely used in wireless and mobile communications, as well as radar applications. Microstrip antennas can be divided into two basic types by structure, namely microstrip patch antenna and microstrip slot antenna. The microstrip patch antennas can be fed by microstrip line and coaxial probe (Kueathawikun1, 2006).

Recently, wireless local area network (WLAN) has received much attention for the flexibility of network reconfiguration in office room, mobile internet connection and so on. A WLAN provides all the benefits of traditional LAN technologies without the limitations of being tethered to a cable. This provides greatly increased freedom and flexibility (Jim, 2002). There are many commercial WLAN devices in the markets which use 2.4GHz frequency band supporting the speed of 11Mbps. And the demand for faster data communication made consideration of using 5GHz frequency band instead of 2.4GHz frequency band which is widely used as IEEE 802.11b. There are three frequency bands for IEEE 802.11a, which are 5.15GHz ~ 5.25GHz, 5.25GHz ~ 5.35GHz, 5.725GHz ~ 5.825GHz. The IEEE 802.11a standard defines operation at up to 54Mbps. So, it would be very convenient if we have an antenna which can be applied to 2.4GHz and 5GHz operations with suitable gains (Woon, 2002).

This proposed microstrip antenna designed to utilized in 2.4-2.4835 GHz and 5.725-5.825GHz frequency ranges (IEEE 802.11 b/g/a), fed by 50Ω standard miniature adapter (SMA).

2- THE PROPOSED ANTENNA:-

2.1-Rectangular Microstrip Patch Antenna:-

The antenna configuration is rectangular microstrip patch antenna shown in Fig.1. In this case the circular polarization (CP) is obtained because the two modes of resonance (corresponding to the adjacent sides of the rectangle), are spatially orthogonal. The antenna is excited at a frequency in between the resonant frequencies of these two modes in order to obtain the phase quadrature relationship between the voltages (and therefore magnetic currents) of two modes. Corner or diagonal feeding is required to allow both the modes to be excited with a single feed (Sharma, 1983).

The ratio of the two orthogonal dimensions W/L should be generally in the range of (1.01–1.10) depending upon the substrate parameters. When the patch is fed along the diagonal, then the two resonance modes corresponding to lengths L and W are spatially orthogonal. The CP is

obtained at a frequency, which lies between the resonance frequencies of these two modes, where the two orthogonal modes have equal magnitude and are in phase quadrature (Kumar, 2003).

This kind of design is the simplest form to generate circular polarization and is very suitable for the WLAN RHCP or LHCP microstrip antenna design (Basim, 2011).

2.2-Rectangular Patch with Slits:-

By embedding suitable slots in the radiating patch, compact operation of microstrip antennas can be obtained. Figure 2 shows slotted patch suitable for the design of compact microstrip antenna. In this figure, the embedded slot is a cross slot, whose two orthogonal arms can be of unequal (Iwasaki, 1996; Jawad, 2008) or equal lengths (Wong, 1997; Kin-Lu, 2002).

The use of four inserted slits at the patch edges of a rectangular patch [30] has been shown to be a promising compact dual-frequency design. The antenna design is shown in Fig2. The four inserted slits are of equal length l and narrow width 1 mm (Kin-Lu, 2002)

This kind of slotted patch causes meandering of the patch surface current path in two orthogonal directions and is suitable for achieving compact circularly polarized radiation or compact dual-frequency operation with orthogonal polarizations (Yang, 1998).

The basic idea of the proposed antenna structure has been extracted from a comparative study of both the conventional square patch antenna, Fig. 1, and the square microstrip antenna with two pairs of orthogonal slits at the edges, Fig. 2 (Qais, 2005). The presence of slits in this antenna is a way to increase the surface current path length compared with that of the conventional square patch antenna, Fig. 1a, resulting in a reduced resonant frequency or a reduced size antenna if the design frequency is to be maintained. It had been found that this antenna structure provides a reduction in size of about 40% (Jawad, 2008).

In the present work, further increase in the slit lengths has been proposed in an attempt to gain further size reduction of the resulting structure as compared to the patch structures cited in Fig. 1 and 2. The dimensions of slots have been optimized to meet the 802.11b/g/a antenna design requirements.

A single 50 Ω probe feed has been used to support producing the RHCP or LHCP requirement of the 802.11b/g/a antenna radiation pattern (Jawad, 2008).

3- THE PROPOSED ANTENNA DESIGN:-

The calculation of the square Microstrip antenna length is based on transmission-line model (Bahi, 1980) The width W of the radiating edge, which is not critical, is chosen first. The length L is slightly less than a half wavelength in the dielectric. The precise value of the dimension L of the square patch has been calculated using expression (Amamam, 1997).

$$L = \frac{c}{2f_0\sqrt{\epsilon_{r\text{eff}}}} - 2\Delta L \quad (1)$$

Where $\epsilon_{r\text{eff}}$ is the effective dielectric constant, and ΔL is the fringe factor (Balanis, 1997).

For the frequency of 5.25 GHz and using (FR-4) with a relative dielectric constant of 4.2 and loss tangent of 0.017, with substrate height of 1.575 mm, this yields nearly square patch antenna length Fig. 1, of $L=15.38$ mm and $W=16.11$ mm. The ratio of the two orthogonal dimensions W/L is 1.047, lies in the range of generating two spatially orthogonal resonance modes (Iwasaki, 1996).

The feed-point of the antenna, it is defined in terms of input impedance Z_{in} of the antenna and the characteristic impedance Z_0 of the feed line. The feed point position should be placed at the location where the input impedance of the antenna matches the characteristic impedance of the feed (Iwasaki, 1996). The patch can be fed by a coax line from underneath. The impedance varies from zero in the center to the edge resistance approximately as (Thomas, 2005).

$$R_i = R_e \sin^2 \frac{\pi x}{L} \quad 0 \leq x \leq \frac{L}{2} \quad (2)$$

Where R_i is the input resistance, R_e the input resistance at the edge, and x the distance from the patch center.

By shifting the feed-point along the diagonal to $x = -0.4875$ cm and $y = -0.475$ cm, from the center of the patch; a perfect match with a 50Ω feed line is obtained. The feeding point position is 0.323% from the diagonal long (Basim, 1996).

The slit lengths of the antenna in Fig. 2 are tuned to the resonance (design) frequency in the x and y -directions and are set to result in a value of about 7.5 mm, with a slot width a of 1 mm. This results in a patch length of the antenna structure of Fig. 2 to be $L = 22.90$ mm, using the same substrate. The resulting size reduction offered by this antenna is of about 35% as compared with the conventional nearly square microstrip antenna (Jawad, 2008)

The proposed antenna structure has been modeled using a full-wave numerical Method of Moment (MoM). EMSight™, of the Applied Wave Research (AWR), includes a full-wave electromagnetic solver that uses a modified spectral domain method of moments to accurately determine the multi-port scattering parameters for predominately planar structures (AWR, 2009). In the presented design; this software package was applied to simulate the typical characteristic of the proposed antennas.

4- SIMULATION RESULTS:-

The proposed antenna structure had been modeled at the design frequencies of the IEEE 802.11b/g/a. It has been supposed that the antenna element to be located parallel to x - y plane and centered at the origin (0, 0, 0). The computed input return losses of the antenna patch is shown in Fig. 3. E-plane and H-plane RHCP and LHCP radiation patterns at the IEEE 802.11b/g frequency of 2.45 GHz are shown in Fig. 4a, where E-plane and H-plane RHCP and LHCP radiation patterns at the IEEE 802.11a frequency of 5.21 GHz are shown in Fig. 4b. It is clear that this antenna supports the required RHCP electric field radiation pattern. The resulting axial ratio as a function of frequency is depicted in Fig. 5. It can be seen that the axial ratio in the broadside direction is below 3 dB.

The computed gain around the IEEE802.11b/g and IEEE802.11a has 7 dB and 5 dB respectively. As the gain response implies, the proposed antenna possesses an average gain of about more than 4 dB throughout the required bandwidths of IEEE802.11b/g/a antenna.

5- CONCLUSIONS:-

A nearly square dual-band single probe-fed microstrip patch antenna with four inserted slits at the patch edges has been investigated. The realized impedance bandwidths (return loss ≤ -10 dB) and the circular polarization bandwidth (axial ratio ≤ 3 dB) satisfy the bandwidth requirements for the IEEE802.11b/g/a operation.

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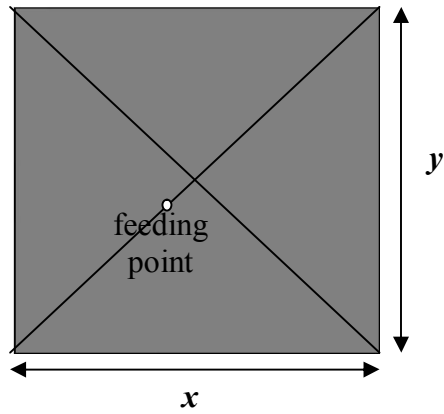


Figure 1 The nearly square patch antenna.

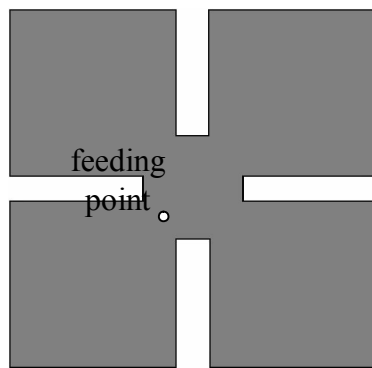


Figure 2 The nearly square patch antenna with two pairs of orthogonal slits.

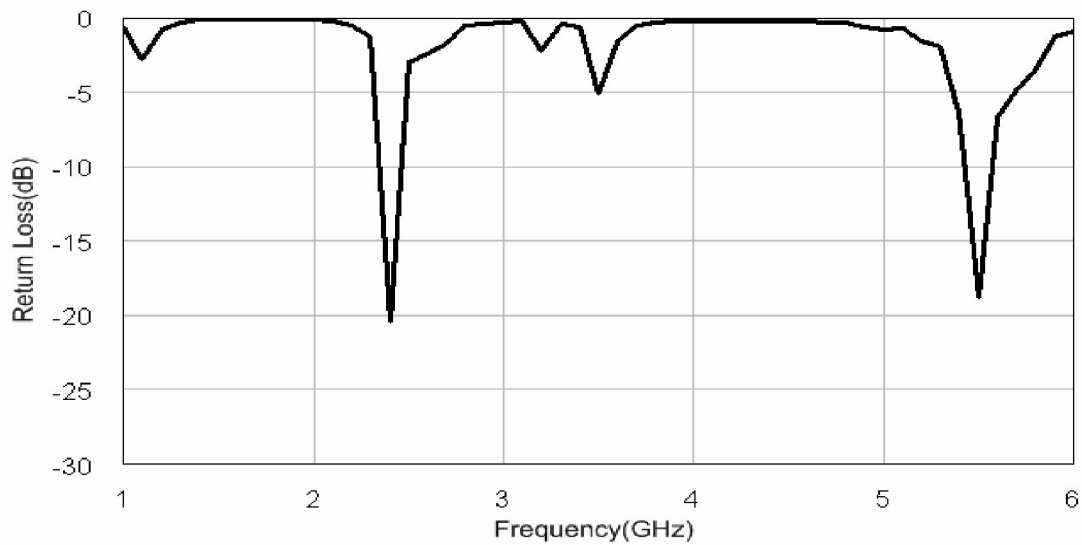


Figure 3 The calculated input return loss for the modeled patch element

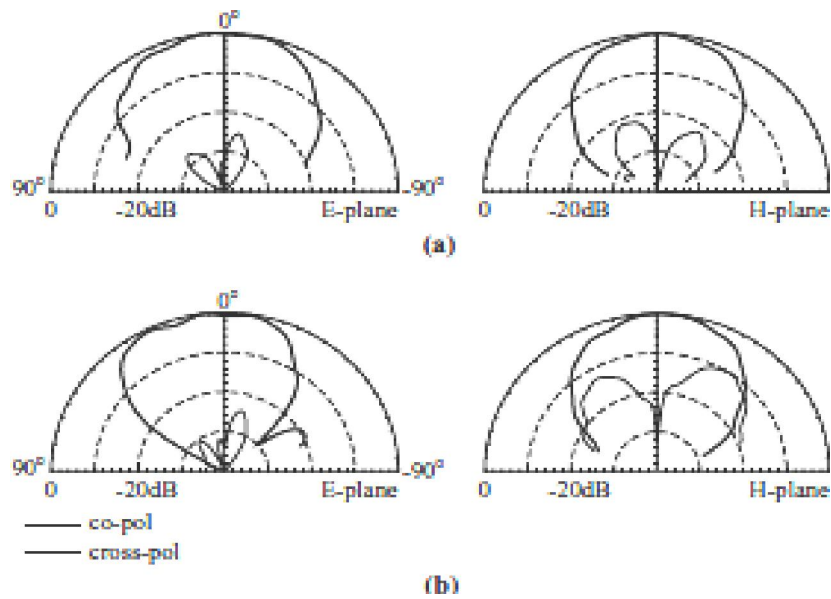


Figure 4 *E*-plane (*y-z* plane) and *H*-plane (*x-z* plane) radiation patterns. (a) $f=2.45$ GHz. (b) $f=5.21$ GHz.

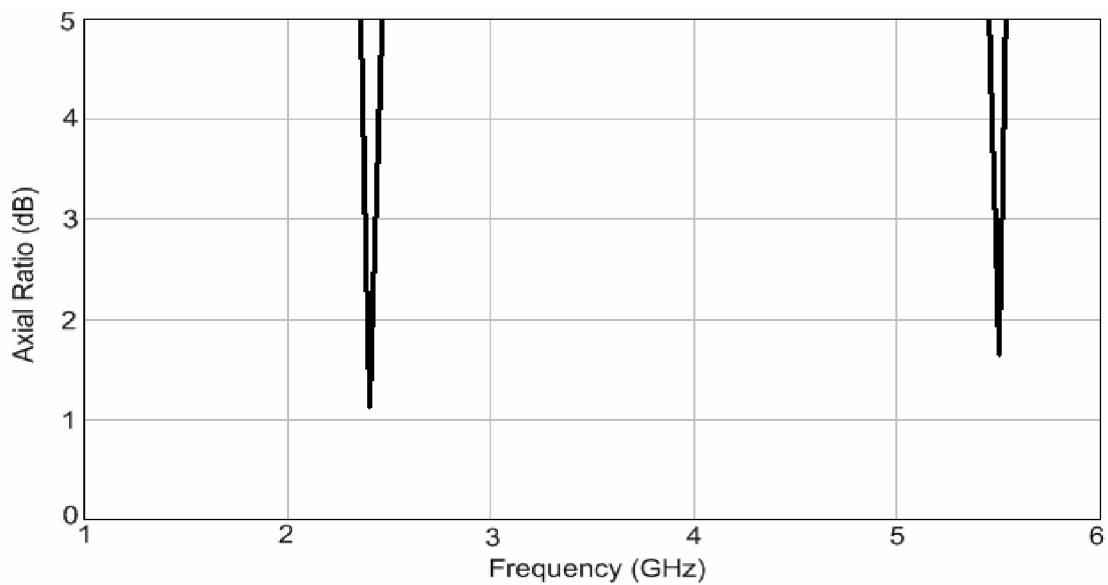


Figure 5 The computed axial ratios around 802.11 a/b/g frequencies