Design of a Compact Multiband Microstrip Antenna

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***Abstract*— A compact microstrip multiband antenna on a modified ground plane which can operate over the bands starting from 900 MHz to 5.35 GHz which includes the GSM (880-960) GPS (1568-1592 MHz), DCS (1710-1880 MHz), and PCS (1850-1990 MHz). UMTS (1920-2170 MHz), IEEE 802.11 b/g (2400-2484) and WLAN IEEE 802.11a band (5.15-5.35) is reported in this paper. The overall dimension of the antenna is 33 x 33 mm^2 including the top patch with a dimension 22 x 22 mm^2. The experimental results of the antenna are presented in this paper. The results confirm that the antenna exhibits wide band characteristics and covers 7 bands of operation.**

***Keywords*— multi band, microstrip antenna, compact, modified ground plane, microwave.**

I. INTRODUCTION

There is an increase in demand for compact wide band microstrip antennas with improved performance for wireless communication applications. MSAs are widely used for this purpose because of their planar structure, low profile, light weight, moderate efficiency and ease of integration with active devices. Almost all the important wireless applications lie in the band starting from 900 MHz to 5.5 GHz which includes the GSM (880-960) GPS (1568-1592 MHz), DCS (1710-1880 MHz), and PCS (1850-1990 MHz). UMTS (1920-2170 MHz), IEEE 802.11 b/g (2400-2484) and WLAN IEEE 802.11a bands (5.15-5.35 GHz, 5.725-5.825 GHz). However MSAs with normal Ground Plane (GP) offers narrow operating bandwidth [1]. Various techniques have been proposed by researchers to improve the compactness, bandwidth, gain etc. of MSAs [2-10] by meandering or truncating the patch edges, adding parasitic patches, cutting slots on the radiating patch, using shorting pins etc.

Many compact antennas with broadband and multi-band performances including dipole antenna, monopole antenna, and planar antenna configurations have been reported [11–16] Multi band operation can be achieved by means of adding rectangular or L shaped slots. These are printed antennas with moderate radiating characteristics and can be operative at dual- and multiple frequency bands. Moreover, for the antenna fabrication designs, the slot structures require to provide a broadband and multi-band systems including 2.4- and 5-GHz wireless local area network (WLAN) bands, but without the worldwide interoperability for microwave access (WiMAX). Recently several interesting designs of the slot antennas with diverse geometric configurations for the bandwidth enhancement and the size reduction functions have been widely studied [17–21].

In this paper a novel design of compact multiband antenna has been proposed. A modified ground plane (MGP) has been used for this purpose. This MGP has a rectangular ring with a double sided comb structure. The ring structure with the strips helps in bringing down the resonant frequency as well as increase the bandwidth.

II. ANTENNA GEOMETRY AND DESIGN

The geometry of the proposed proximity coupled microstrip antenna is shown in Fig 1. Fig 1(a) shows the modified GP, Fig 1(b) shows the geometry of the top patch and Fig 1(c) shows the cross sectional view of the antenna. The MGP has a double sided comb like structure on the sides of a rectangular ring structure. The overall dimensions of the MGP are d3 x d3 mm^2. The inter strip spacing is d2 mm and the width of the strip is d1 mm. The strip length and ring length are d mm. The ring width is also d3 mm.

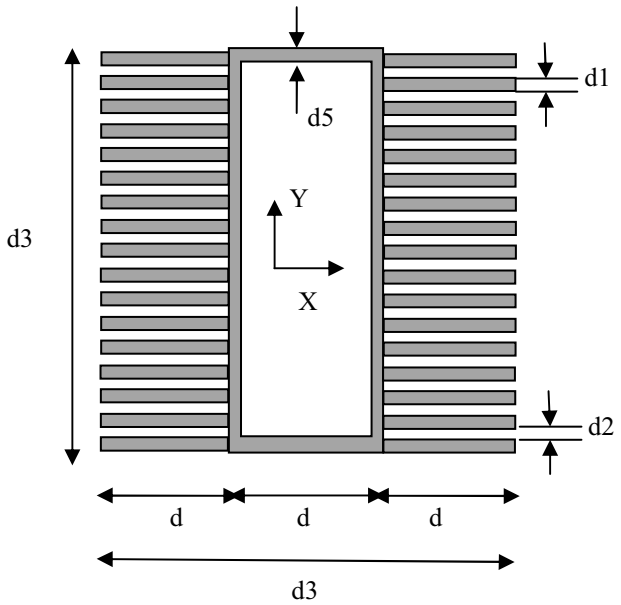

Figure 1 (a) The double side comb structure on the ground plane

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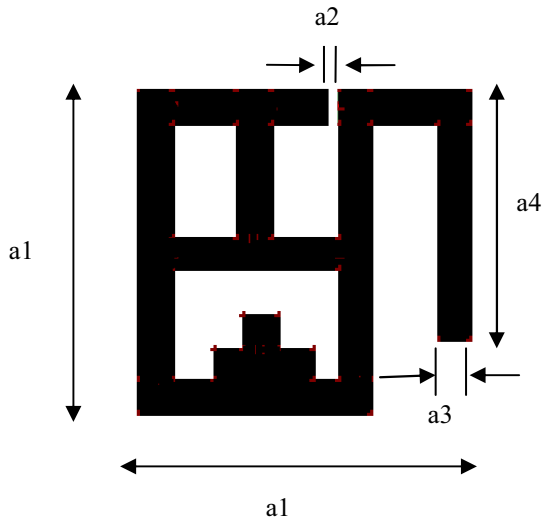

Figure 1(b) Top patch geometry

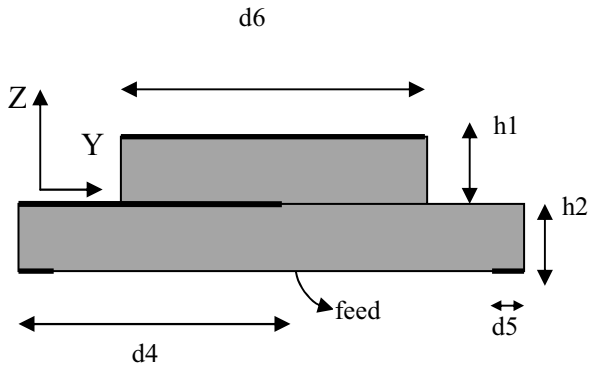

Figure 1(c) Cross sectional view of the antenna

The width of the feed is w1=3mm and its length d4 is fixed as d3/2 i.e., half the length of the MGP. The ring has a uniform width of d5=1mm. The patch and the feed line are fabricated on a substrate of ε_r =4.4 and height h1=h2=1.6mmThe dimension of the top patch is a1 x a1 mm^2. The top patch is made of strips of width a3 mm, a small gap a2 mm provided at the top and the strip of length a4 mm is can increase or decrease the resonance frequencies.

III. ANTENNA PERFORMANCE AND ANALYSIS

The antenna dimensions required to achieve the multiband operation was d3=33 mm (size of GP), strip width d1=1.5 mm, total number of strips was fixed as 44, the top patch overall dimension is a1=22 mm, the strip width throughout the patch geometry is a3=2.2 mm, top gap a2=0.1 mm and the strip length on the right side is a4=16.4 mm.

The no of strips and the strip width in the ground plane were optimized to give maximum compactness. As the no of strips were increased the performance/ compactness increases and remains the same beyond a particular value of 44. Similarly as the strip thickness decreases the compactness of the top patch and its performance improves and becomes a constant beyond a strip thickness d1=0.15 mm. The shape of the top patch was obtained by dividing the rectangular region in to cells of equal dimensions. The cells were randomly removed using a random walk procedure and after obtaining an abstract shape the patch were finetuned by introducing gaps and varying lengths of open ends. A gap of a2=0.1 mm for a length of a4=16.4 mm improved the return loss characteristics and the resonances at required frequencies. There is a slight offset given to the staircase like structure inside the lower partition of the patch.

The proposed antenna was fabricated and experimentally tested. The return loss characteristics of the antenna over a normal rectangular GP of size 33 x 33 mm^2 and that of the MGP of the same size are shown in Fig 2 and 3. On comparison of the two figures it can be seen that the antenna on a normal GP has very narrow band characteristics and on the MGP it displays a wide band characteristics. The antenna on MGP covers the frequencies from 1.7 – 2.5 GHZ which includes the GSM, GPS, DCS, PCS, UMTS, IEEE 802.11 b/g bands, a small band from 3.1 to 3.2 GHz and from 4.9 – 5.35 GHz which is the WLAN IEEE 802.11a band. The performance of the antenna in terms of bandwidth and compactness has been greatly improved by means of introducing a MGP. The first two use full bands in the antenna as shown in Fig.2 is merged to form a single large band in the case of antenna with an MGP as shown in Fig.3. The other useful band around 5 MHz is tripled in Fig. 3.

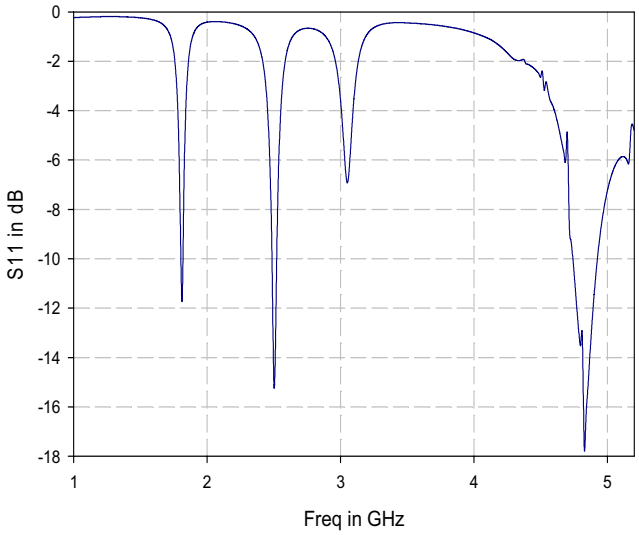

Figure 2 Measured return loss characteristics of the patch on a rectangular GP

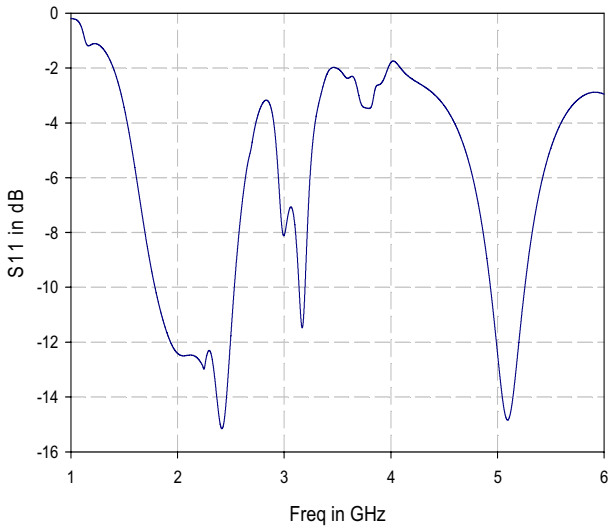

Figure 3 Measured return loss characteristics of the patch on a MGP

The radiation patterns of the proposed antenna on the MGP for both the bands are shown in Fig.4. It can be seen that the antenna exhibits an omni-directional pattern in the XZ plane for both the bands and exhibits a null around 90 and 270 degrees in the XY plane.

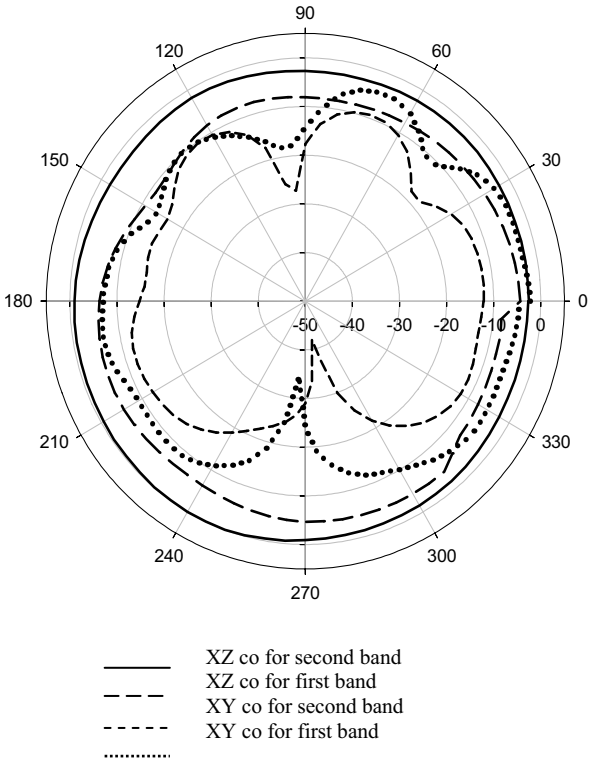

Figure 10 Radiation patterns for the multi band MSA

IV. Conclusions

A novel compact multiband microstrip antenna was designed and tested. The antenna dimensions were 33 x 33 mm^2 inclusive of the patch and the GP. This antenna with its bands from 1.7 to 2.5 and 4.5 to 5.35 GHz covered the GSM, GPS, DCS, PCS, UMTS, IEEE 802.11 b/g and WLAN IEEE 802.11a band (5.15-5.35 GHz).

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