ACPW-Fed Planar Dual Band Antenna with DGS and DMS for WiMAX and WLAN Application

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Abstract- A novel compact Asymmetric coplanar waveguide fed planar antenna with DGS and DMS for dual band application is presented in this paper. The proposed antenna composed of spur like defect in both ground and strip and it is fed by Asymmetric coplanar waveguide (ACPW). The antenna is printed on FR4 substrate and with dielectric constant 4.4 has compact size of 21×15.35×1.6 mm³. The antenna operates on two bands at 3.4 GHz and 5.5 GHz which is for WiMAX and WLAN respectively. The planar design, simple feeding technique and compactness make it easy for the integration of the antenna into circuit boards. Details of the antenna design simulated and experimental results are presented and discussed. Simulation tool, based on the method of moments (Mentor Graphics IE3D version 15.10) has been used to analyze and optimize the antenna. Various features such as optimum size, simple con-figuration and low fabrication cost make the antenna suitable for wireless networks.

Index Terms- Asymmetric coplanar waveguide (ACPW), Dual band Antenna, Defected Ground structure (DGS), Defected Micro strip structure (DMS)

I. INTRODUCTION

The sudden growth of wireless internet for high data rate communication has fostered tremendous attention towards the design of compact WLAN antennas. In recently many engineers are focused on how to design a miniaturized multi band antenna which is easily integrated on portable wireless communication gadget, Especially for WLAN (2.4-2.48, 5.15-5.35, and 5.72-5.85 GHz) and the WiMAX (2.5-2.69, 3.40-3.69, and 5.25-5.85 GHz) in wireless communication. Thus different types of multi band designs have been reported serving to various user requirements such as [1–25]. For example dual band design which is embedded by EBG for WLAN reported in[1]. Triple band slot antenna with U-shaped open stub for WLAN and WiMAX is proposed in [2]. A compact monopole antenna with double mender line proposed for WLAN[3]. These designs, however, have complex structures which make them difficult to integrate with WLAN systems. Some CPW fed designs occupy a little bit more areas [4], so it’s difficult for integration. Planar antennas have the advantage of easy integration with active circuits[5-8]. In this article prime focus on miniaturization, so we use combination of slow wave structures (DGS and DMS) and asymmetric coplanar waveguide feeding. The present work describes compact Asymmetric Coplanar waveguide fed dual band antenna, which composed of exciting strip, a lateral ground plane and L shaped tuning stub. Mentor Graphics IE3D electromagnetic solver is used for the simulation and analysis of the structure. The resulting antenna operates at dual band which around 3.4 GHz and 5.5 GHz and is for WiMAX and WLAN respectively. Asymmetrical coplanar waveguide fed configuration obtained by removing the ground plane at the left of CPW fed antenna[9-10].

In this article, we propose a dual band asymmetric coplanar strip fed antenna with slow wave structures (DGS and DMS) for WLAN/WiMAX operations. Defected Ground structure is an etched periodic or non-periodic cascaded or non cascaded configuration located in the ground plane of a planar transmission line (e.g., micro strip, coplanar, conductor backed coplanar wave guide etc..) which disturbs the
shield current distribution in the ground plane causes resonance. Similarly DMS is located in the strip which disturbs the current in the conducting strip. This disturbance will change characteristics of a transmission line such as line capacitance and inductance. In a word, any defect etched in the ground plane or conducting strip of a planar transmission line can give rise to increasing effective capacitance and inductance The defect in the proposed antenna in the form of spur line which is described by slot of width \(W_g\) and length \(L_g\) shown in Fig 1. In general slot gap provides the capacitive effect and narrow line exhibits an inductive effect. The lumped equivalent model of Defected resonator is a LC tank circuit. The values of \(L\) and \(C\) is obtained by 3dB cut off frequency \(f_c\) and pole frequency \(f_p\) in GHz

\[
C = \frac{5f_c}{\pi(f_c^2-f_p^2)} \text{pF} \tag{1}
\]

\[
L = \frac{250}{C(\pi f_p^2)} \text{nH} \tag{2}
\]

II. ANTENNA STRUCTURE AND DESIGN

The geometry of the proposed Asymmetric coplanar waveguide ACPW-fed Antenna with defect in the ground and strip is shown in Fig. 2 with all dimensions are in mm. This antenna has a simple structure with only one layer of dielectric substrate (FR4 epoxy glass fiber substrate \(\varepsilon_r = 4.4\) and loss tangent \(\tan \delta = 0.02\) and another layer metalized ground plane and a strip.. The gap ‘g’ between centre conductor and ground plane of ACS is 0.35 mm

![Fig.1](image1)

(a) Configuration of spur line , (b) Equivalent circuit of spur resonator

\[
C = \frac{5f_c}{\pi(f_c^2-f_p^2)} \text{pF} \tag{1}
\]

\[
L = \frac{250}{C(\pi f_p^2)} \text{nH} \tag{2}
\]

III. RESULT AND DISCUSSION

A prototype of the proposed dual antenna is fabricated and measured, and its photograph is shown in Fig. 4. The return loss of the proposed dual band antenna is measured by Agilent E8363B vector network analyzer(VNA). The comparison between simulated and measured results are given in Fig. 5. It can be seen that good agreement between simulated and measured
results at 3.5GHz(3.3-3.6GHz)and 5.5GHz(5.38-5.7GHz). The fabrication tolerance is the cause of small shift between resonance in the lower band of resonance which is slightly shifted from 3.4 to 3.5. The parametric analysis of the proposed antenna with and without DGS and DMS is carried and given in Fig. 6. It can be seen that with application of DGS and DMS, the prominent resonances at 3.4GHz and 5.5 GHz obtained.

Fig.6. Comparison of return loss with and without DGS and DMS

A shorted L shaped tuning stub of length S is used for tuning the resonance at particular band of operation. The Fig. 7 shows the comparison for various lengths of tuning stub S. The application of tuning stub of length S= 7mm which brings down the resonances at 3.4 and 5.5 GHz

Fig.7. Comparison of return loss with various stub length

The current distribution of proposed antenna for both resonating frequencies 3.4GHz and 5.5GHz are shown in Fig 8. The currents are more perturbed across the defects which is causes the resonance in both frequencies. From the figure it is clear that in lower resonant frequency current more perturbed across the ground plane than the conducting strip

Table 1: Comparison between size and Peak gain of proposed antenna with published literature

<table>
<thead>
<tr>
<th>Published Lituratures</th>
<th>Antenna purpose</th>
<th>Peak Gain(dBi)</th>
<th>Size(mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA</td>
<td>Dual</td>
<td>3.5</td>
<td>21x15.35</td>
</tr>
<tr>
<td>Ref[2]</td>
<td>Triple</td>
<td>3.6</td>
<td>35x19</td>
</tr>
<tr>
<td>Ref[6]</td>
<td>Dual</td>
<td>1.21</td>
<td>37.5x24</td>
</tr>
<tr>
<td>Ref[7]</td>
<td>wide</td>
<td>3.3</td>
<td>28x12.5</td>
</tr>
<tr>
<td>Ref[9]</td>
<td>Dual</td>
<td>2.2</td>
<td>30x28</td>
</tr>
<tr>
<td>Ref[12]</td>
<td>Dual</td>
<td>3.5</td>
<td>35x15</td>
</tr>
<tr>
<td>Ref[13]</td>
<td>Triple</td>
<td>3.9</td>
<td>31x12.6</td>
</tr>
</tbody>
</table>

Table 1. shows the comparison of proposed ACS fed antenna with some of the already published literature for similar application. It can be seen that the proposed antenna has more than 40% average area reduction comparing with most of the other existing geometries. The peak gain of the antenna also moderate and sufficient comparing with all other antennas in the
In Ref[2] and Ref[13] are proposed a triband antenna have slightly good gain with cost of more area. So the proposed antenna is a suitable for present and future wireless communication standards asymmetric because of asymmetry in proposed antenna feeding configuration. The polarisation of the antenna is also experimentally determined and it is found that antenna is polarised along X axis for dual band of operation.

Fig. 9 and Fig. 10 shows Measured E and H plane radiation patterns. The radiation patterns is Omni directional at lower and upper resonance in H plane. In E-plane, radiation pattern are bidirectional. The cross polarization levels are minimum compared to co-polarization levels for both E and H plane. The patterns are slightly asymmetric because of asymmetry in proposed antenna feeding configuration. The polarisation of the antenna is also experimentally determined and it is found that antenna is polarised along X axis for dual band of operation.

Fig. 9 Measured E-plane radiation pattern (a) 3.5GHz (b) 5.5GHz

Fig. 10 Measured H-plane radiation pattern (a) 3.5GHz(b)5.5GHz

Fig. 11 shows the lumped equivalent model of the proposed antenna by cascaded RLC tank circuit The parameters L and R is extracted from mentor graphics IE3D modua and C value is calculated by the equation 1 and optimized by data fitting .The Table 2 shows the calculated and extracted values of lumped circuit elements.
Fig. 12 shows comparison of equivalent circuit simulation return loss of proposed antenna with EM simulation. Here it can be found that a good conformity between the circuit simulation and EM simulation.

![Lumped Equivalent Model of Proposed antenna](image1)

**Fig. 11. Lumped Equivalent Model of Proposed antenna**

**Table 2: Circuit parameters of Equivalent Circuit**

<table>
<thead>
<tr>
<th>Circuit/Parameters</th>
<th>R(Ω)</th>
<th>L(nH)</th>
<th>C(pF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>47.3</td>
<td>0.31</td>
<td>7.02</td>
</tr>
<tr>
<td>2</td>
<td>48.08</td>
<td>0.14</td>
<td>5.36</td>
</tr>
</tbody>
</table>

![Comparison between return loss of proposed antenna for EM simulation and circuit simulation](image2)

**Fig. 12. Comparison between return loss of proposed antenna for EM simulation and circuit simulation**

Fig. 13 shows measured and simulation gain of the antenna as a function of frequency for first band and second band of resonance separately. It shows that antenna peak gain is about 2.4 dBi for the lower band and 3.5 dBi for upper band. So the proposed antenna is useful candidate for future WLAN application.

![Gain of the antenna](image3)

**Fig. 13. (a) Measured and Simulated gain of the antenna in first band (b) Measured and Simulated gain of the antenna in second band**

VI. CONCLUSION

The antenna shows no much significant variations in radiation characteristics over the dual band of operation. By creating defect in ground plane and strip using spur lines, Proposed antenna exhibit good return loss (~30dB), good VSWR (around 1), better impedance matching at 50 Ohm with ACPW structure. Therefore, the proposed antenna is the suitable structure for WiMAX/WLAN application. Moreover, the simple and uniplanar structure makes it ease of design and mass production. By changing the length width and position of defect the antenna
can be made to work multi band. It can be predicted that will be useful for other slot antennas.

REFERENCES


