TWO ELEMENT U-SLOT LOADED CIRCULAR MICROSTRIP ARRAY ANTENNA FOR WLAN APPLICATIONS

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ABSTRACT

This paper presents the two element U-slot loaded circular microstrip array antenna for dual band operation. The antenna operates between 2.6 to 7.00 GHz. The antenna has been fabricated with a volume of 9 X 5 X 0.16 cm³. The maximum bandwidth of 44.90% is achieved. With a peak gain of 5.24 dB is obtained in primary band. The antenna exhibits a broadside and linear radiation characteristics. The results are presented and discussed. This antenna may find its applications in WLAN communication system.

Keywords: Two Element, Circular, Microstrip Antenna, Size Reduction.

1. INTRODUCTION

In today’s era microstrip antennas (MSAs) have become the attractive candidate for the antenna designers because of their inherent features such as light weight, low profile, compatibility with MMICs [1] etc. The patch antennas are receiving increasing interest in modern communication systems such as WLAN, WiMAX, HIPERLAN/2 etc, because of their many advantages over traditional microwave antennas in terms of achieving dual, triple and multiple bands which are realized by using different techniques such as, cutting slots of different geometries like rectangular, L-shape, E-shape, circular shape, square shape [2-7] etc. In many applications, the wide bandwidth and gain are the essential needs to use the antenna for specific applications. During past years, many efforts have been put forth to realize bandwidth widening techniques of microstrip antennas, which include the use of impedance matching, multiple resonators and a thick substrate [8, 9] etc. But, the two element array antenna having a U shaped slots on the circular radiating patch and plus shaped slots on the ground plane is used for enhancing the bandwidth and gain. This kind of study is found to be rare in the literature. The slot loading technique provides the freedom to design the required slot irrespective of their size or shape and can be suitably loaded at the desired place on the geometry of the antenna for broadening the bandwidth of the antenna [9]. Also, the array technique, gives the
flexibility to design the required feed line between the array elements to energize, which helps in enhancing the gain of the antenna [10].

2. DESIGN AND EXPERIMENTAL RESULTS

The antenna is fabricated using low-cost glass epoxy substrate material of thickness \( h = 1.6 \) mm and dielectric constant \( \varepsilon_r = 4.2 \). Artwork of the antenna is sketched using computer software Auto-CAD 2006 to achieve better accuracy. The antenna is etched using photolithography process.

![Fig. 1: Top view Geometry of TUCMAA](image1)

Figure 1 shows the top view geometry of the two element, U-slot loaded circular microstrip array antenna (TUCMAA). The antenna has two circular patches of radius \( R \) are designed for the resonant frequency of 3.5 GHz, using the basic equations available in the literature. The U shaped slot of horizontal and vertical arm lengths \( h \) and \( v \) are placed on the two circular patches.

![Fig. 2: Bottom view Geometry of TUCMAA](image2)

Fig. 2 shows the bottom view geometry of TUCMAA. The two plus shaped slots which are \( D \) mm apart and each having a width 2 mm are incorporated on the ground plane such that the midpoint of these slots lie exactly below the center of the each radiating patch. The \( L \) and \( H \) are the horizontal and vertical arm lengths of the plus shaped slots. The dimensions \( D, R, h, v, L \) and \( H \) are taken in terms of \( \lambda_0 \), where \( \lambda_0 \) is the free space wavelength in millimeter corresponding to the designed frequency of 3.5 GHz. The parallel feed arrangement is used in the present study, because it has the advantage over series fed arrangement, that is, its wideband performance. The feed arrangement shown in this figure is a contact feed and has the advantage that it can be etched simultaneously along with the antenna elements. The microstrip line feed arrangement is designed using the relations available in the literature [12]. A 50 \( \Omega \) feed line of length \( L_{50} \) and width \( W_{50} \) is connected to 100 \( \Omega \) line of length \( L_{100} \) and width \( W_{100} \) to form a two way power divider. A quarter wave transformer of length \( L_{tr} \) and width \( W_{tr} \) is connected between 100 \( \Omega \) feed line and midpoint of the radiating elements to establish perfect impedance matching. A 50 \( \Omega \) semi miniature-A connector
is used at the tip of the 50 Ω feed line. The various parameters of the proposed antenna are enlisted in Table 1.

<table>
<thead>
<tr>
<th>Antenna Parameters</th>
<th>Dimensions in (mm)</th>
<th>Antenna Parameters</th>
<th>Dimensions in (mm)</th>
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<tbody>
<tr>
<td>R</td>
<td>26.6</td>
<td>v</td>
<td>λ₀/10</td>
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<td>L₅₀</td>
<td>21.84</td>
<td>Wₜₜ</td>
<td>0.15</td>
</tr>
<tr>
<td>W₅₀</td>
<td>3.2</td>
<td>D</td>
<td>λ₀/1.96</td>
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<td>L₁₀₀</td>
<td>21.88</td>
<td>Aₜₜ</td>
<td>90</td>
</tr>
<tr>
<td>W₁₀₀</td>
<td>0.74</td>
<td>Bₜₜ</td>
<td>50</td>
</tr>
<tr>
<td>Lₜₜ</td>
<td>10.92</td>
<td>H</td>
<td>λ₀/9.96</td>
</tr>
<tr>
<td>h</td>
<td>λ₀/10</td>
<td>L</td>
<td>λ₀/8.32</td>
</tr>
</tbody>
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The Vector Network Analyzer (Germany make, Rohde and Schwarz, ZVK model 1127.8651) is used to measure experimental return loss of TUCMAA. The experimental impedance bandwidth over return loss less than -10 dB is calculated using the formula,

\[
\text{Bandwidth (\%)} = \frac{f_2 - f_1}{f_C} \times 100 \%
\]

where, \( f_2 \) and \( f_1 \) are the upper and lower cut off frequencies of the resonating bands when their return loss reaches -10 dB and \( f_C \) is a centre frequency of \( f_2 \) and \( f_1 \).

Figure 3 shows the return loss versus frequency of TUCMAA. It is clear from this figure that, the antenna resonates for dual bands with their respective bandwidths are \( \text{BW}_1 = 6.45\% \) (3.0-3.2 GHz) and \( \text{BW}_2 = 44.90\% \) (4.37-6.9 GHz). The resonating bands \( \text{BW}_1 \) and \( \text{BW}_2 \) are due to the fundamental resonance of the patches and the currents along the edges of the U- slots. This increase in the bandwidth is due to the combined effect of the plus shaped slots present on the ground plane that help in widening the bandwidth of the antenna. Also, these slots in addition cause the first band \( \text{BW}_1 \) to resonate at 3.1 GHz, which is less than the designed frequency i.e. 3.5 GHz, shows the
virtual size reduction of about 6.01%. Furthermore, the bandwidth of the second band \( BW_2 \) is enhanced to a maximum of 44.90%.

![Fig. 4: Radiation pattern of TUCMAA](image)

The co-polar and cross-polar radiation pattern of TUCMAA measured in its operating bands is as shown in Figures 4. From this figure, it can be observed that, the pattern is broadside and linearly polarized, the cross polar level is maximum -15 dB down when compared to its co–polar power level indicates the directional nature of radiation.

The gain of TUCMAA is calculated using the absolute gain method given by the relation,

\[
(G)dB = 10 \log \left( \frac{P_r}{P_t} \right) - (G_i)dB - 20 \log \left( \frac{\lambda}{4\pi R} \right) dB \quad (2)
\]

where, \( G_i \) is the gain of the pyramidal horn antenna and \( R \) is the distance between the transmitting antenna and the antenna under test (AUT). The power received by AUT, \( P_r \), and the power transmitted by standard pyramidal horn antenna \( P_t \) are measured independently. The TUCMAA gives a peak gain of about 5.24 dB in its operating band.

3. CONCLUSION

From the detailed study, it is found that, the TUCMAA can be made to operate between 2.6 to 7.00 GHz by loading two U- slots on the radiating patch and plus shaped slots on the ground plane. The maximum bandwidth of 44.90% is achieved by this antenna. The TUCMAA gives a peak gain of 5.24 dB with a virtual size reduction of 6.01 % with broadside radiation characteristics. The proposed antenna is simple in its geometry and is fabricated using low cost glass epoxy substrate material. This antenna may find applications in this antenna may find its applications in WLAN communication system.

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REFERENCES


**BIO-DATA**

**Dr. Nagraj K. Kulkarni** received his M.Sc, M.Phil and Ph. D degree in Applied Electronics from Gulbarga University Gulbarga in the year 1995, 1996 and 2014 respectively. He is working as an Assistant professor and Head, in the Department of Electronics Government Degree College Gulbarga. He is an active researcher in the field of Microwave Electronics.