Design of dual and triple band antennas using U-slots on stacked patches

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ABSTRACT
A different kind of approach to design dual and triple band antennas using U-slots on stacked patches is designed. Present approach is based on employing U-slots on stacked patches and the design is simulated using concerto software. It is observed that each U-slot included will include a notch in corresponding matching band. By changing certain feed position only we can achieve desired application with in single antenna. Same has been implemented by rotating planes of U-slots. This antenna can be used for several applications in X-band.

Keywords: Multiband antennas, slot antennas, stacked patches, U-slot antennas, X-band applications

1. INTRODUCTION
The rapid increase in communication standards has lead to greater demands for antennas with low profile, low size, low cost of fabrication and ease of integration with feeding network. Numerous applications were developed after designing of multiband antennas with desired slots which makes antenna conformal with arrays, reduces the size of the antenna to about 37% and also avoids the usage of two or more antennas for multiband responses. In [1], a new approach to get dual band and triple band antennas is verified using U-slots and the same has been verified by various feeding technique finally results of simulated and fabricated models is compared. In [2], dual band printed microstrip antennas using single layer and multi-layer patches have been reported. Triple band performance has been reported for a square patch antenna using spurline filter and perturbation technique. In [3], Multi band 1 patch with shorting wall and slot was proposed in order to achieve different wireless applications wideband was achieved by using a slot on top patch. In [4], microstrip antennas (MSA) are loaded with monolithic stubs, shorting pins or slots, the electrical resonant length of the patch gets modified and hence tunable or multiple frequency antennas can be realized. In [5], a modified structure with a placard shaped slot having two stubs centered in the square patch is proposed to lower the frequencies of the dual band operation. In [6], a multi band microstrip antenna operating at frequency 2.4GHz and 5.2GHz is presented. The dimensions of the single elements of the operating frequencies were calculated using the transmission line model. Two elements of inset fed microstrip antenna were used for each frequency band. In [7], microstrip line fed, printed isosceles triangular slot antennas, with a small rectangular slot for broad band operation, were proposed and experimentally investigated. Experimental result indicate that a 2.1 VSWR is achieved over a bandwidth of 2.9GHz, between 2.33 and 5.23GHz, which is nearly 4.6 times that of a conventional microstrip-line-fed, printed isosceles triangular slot.

This paper presents a multi-band antenna design approach based on inserting U-slots on rectangular stacked patches. The MSA designed is being fed by a wireedge into the substrate with input impedance of 50 Ω. This design uses two different substrates with Er=2.23 and Er=1 for bottom and top substrate respectively. Several results are presented and discussed to show the versatility of this antenna, developed by simple changes. The proposed antenna has many applications and can be used for any application in X-band range, by changing feed positions and by selecting slot dimensions.

2. DESIGN CONSIDERATIONS
The proposed antenna is designed using two different substrates. A substrate of Er=2.23 for bottom patch and of Er=1 (air). Two patches of different dimensions has been designed on two substrates. Dimensions of the patches and U-slots are mentioned in the table below. Height of substrates for both patches are mentioned in the table.
Table 1: dimensions of stacked patch antennas with U-slots

<table>
<thead>
<tr>
<th></th>
<th>( W_t )</th>
<th>( L_t )</th>
<th>( W_b )</th>
<th>( L_b )</th>
<th>( U_{xt} )</th>
<th>( U_{yt} )</th>
<th>( U_{nt} )</th>
<th>( U_{bt} )</th>
<th>( U_{xb} )</th>
<th>( U_{yb} )</th>
<th>( U_{ab} )</th>
<th>( U_{bb} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>With no slots</td>
<td>16</td>
<td>15</td>
<td>12</td>
<td>13.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>With 1 U slot on bottom patch</td>
<td>16</td>
<td>15</td>
<td>12.5</td>
<td>13.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>6</td>
<td>5.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>With U-slots on both patches</td>
<td>16</td>
<td>15</td>
<td>12.5</td>
<td>13.5</td>
<td>6</td>
<td>6.5</td>
<td>0.25</td>
<td>0.5</td>
<td>6</td>
<td>5.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

DESIGN MODELS USING CONCERTO:

![Fig1: Design with no slot on patches](image1)

![Fig2: Single U-slot on bottom patch](image2)
5. RESULTS & DISCUSSION

Simulation is the process to verify the performance of the device for the given specifications under the specified conditions before actual manufacture of the device. So by using Simulator tool Concerto, we can first simulate the particular design of a multi band antenna and verify required parameters. We can observe the performance of the antennas by verifying the outputs and finally fabricate the antenna following the same specifications and thus minimizing the costs. Further, a perfect optimization was done, in order to find the best feeding point of the structure. Several points were tested in order to get an overview of the defined functioning of the antenna. At first the feeding point was chosen on the negative Y-axis and is adjusted slowly to get the best return losses.
Fig 10: Simulated results for 3D gain at $f=11.42$ Ghz in concerto software

Fig 11: Return loss of design with U-slots on both patches

Fig 12: Simulated results for 3D gain at $f=6.46$ Ghz in concerto software

Fig 13: Simulated results for gain at $f=9.48$ Ghz in concerto software

Fig 14: Simulated results for gain at $f=11.6$ Ghz in concerto software

Fig 15: Return loss of design with 2 U-slots and slot rotated to 90°

Fig 16 Simulated results for 3D gain at $f=7.32$ Ghz in concerto software

Fig 17: Simulated results for gain at $f=5.8$ Ghz in concerto software
Fig 18: Simulated results for gain at $f=8.8\text{Ghz}$ in concerto software

Fig 19: Return loss of design with 2 U-slots and slot rotated to 180°

Fig 20: Simulated results for 3D gain at $f=6.7\text{Ghz}$ in concerto software

Fig 21: Simulated results for 3D gain at $f=8.22\text{Ghz}$ in concerto software

Fig 22: Simulated results for gain at $f=11.78\text{Ghz}$ in concerto software

Fig 23: Return loss of design with 2 U-slots and slot rotated to 270°

Fig 24: Simulated results for 3D gain at $f=6.32\text{Ghz}$ in concerto software

Fig 25: Simulated results for 3D gain at $f=9.38\text{Ghz}$ in concerto software
6. APPLICATIONS
Can be used for military communications satellites and various X-band applications such as radar applications including continuous-wave, pulsed, single-polarization, dual-polarization, synthetic aperture radar, and phased arrays.

7. CONCLUSION
A new approach to obtain multi-band response has been presented, using U-slots to improve bandwidth (each U-slot included will introduce a notch in matching band) Same model was implemented by rotating the planes of U-slot and radiation patterns, return losses are observed and the best model is evaluated comparing various parameters. In the same model cross-polarisation is reduced by designing a antenna with opposite slots. The antenna has many applications in X-band and this single antenna can be used for versatile applications in the range due to multiband response.

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