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Design and Performance Analysis of Asymmetrical U-Slot Circular Patch Antenna for Wimax and WLAN Applications

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Abstract

The dual U-slot and tri-U-slot patch antennas have been designed to operate in WiMAX and WLAN applications. The radiation parameters such as return loss, radiation patterns, VSWR, and gain of the antennas have been analyzed using CST microwave studio. The proposed antennas have simple structure, simple coaxial feed, inexpensive, ease of fabrication and light weight designed for realizing dual band characteristics. The dual U-slot antenna has the bandwidths of 0.27GHz and 0.47GHz ranging 3.37GHz to 3.64GHz and 5.15GHz to 5.62GHz respectively. The tri-U-slot antenna has the bandwidths of 0.14GHz and 0.66GHz ranging from 3.61GHz to 3.71GHz and 5.18GHz to 5.84GHz respectively. The gains of the dual U-slots antenna have 8.77dBi, 9.47dBi and 8.1dBi and tri-U-slot antenna have the gains of 8.71dBi, 8.66dBi and 9.09dBi at the operating frequencies of 3.67GHz, 5.2GHz and 5.8GHz respectively. The simulated and measured results show that the antennas have stable gains, good impedance matching and directional radiation patterns. The measured and simulated results are in good agreement.

Keywords*: U-slot, WLAN, Circular Patch, WiMAX*

1. Introduction

The patch antennas having u-slot with linear polarizations have been introduced for various wireless communication applications such as mobile phone, WLAN, WiMAX, Bluetooth *etc*. For modern wireless communications need simple, multifunction and low cost antenna. The U-slot antenna presented in paper showed wideband behavior and linearly polarized [2]. Initially, U-slot was used for obtaining only wideband characteristics instead of multiband characteristics. Recently many researches show that multiband characteristics can be achieved by intelligent adjustment of the U-slot [1, 3]. Besides the band characteristics the polarization characteristics can be adjusted by optimization of U-slot. The antenna presented in [4, 5] exhibited circular polarization. The length of the U-slot length has been changed with pin diode which causes to switch between circular and linear polarization state as well as to switch between left hand and right hand circular polarization [6].The dual band and tri-band performances has been obtained by cutting U-slot in the patch.

2. Antennas Configuration

The u-slot was made of two vertical and a horizontal rectangular slot in the patch to obtain broadband performance. The geometry of the antennas having variable dimensions is shown in the Figure1. The final optimized parameters of proposed designs are listed in Table 1 and Table 2. The antennas comprise of dual U-slot and tri U-slot, which were cut in the single layer of circular patch. The dimension of the ground is $50\times50mm^2$ and made of copper plate placed under the patch. Air is used as the substrate of thickness h = 5mm.

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The coaxial probe having SMA connector of inner and outer diameter of 0.6mm and 2mm respectively, this is directly connected to the patch. The thickness of the substrate is the same in both designs.

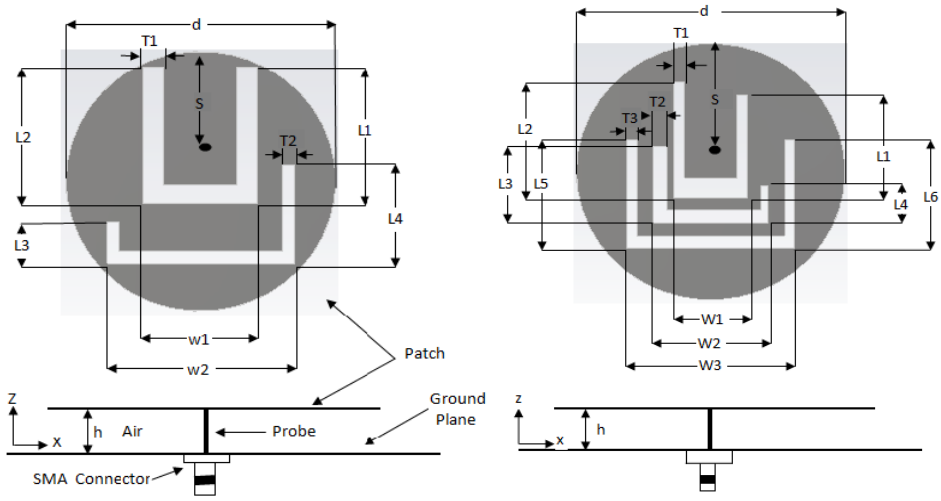

Figure 1. Geometry of (a) Dual U-Slots (b) Tri-U-Slot Patch Antenna

In the proposed designs full ground plane is used which reflects most of the electromagnetic waves back to the patch surface.

Table 1. Parameters of Dual U-Slot Antenna

L_1	14mm	L_4	11mm	W_1	23mm	d	16.5mm
L_2	15mm	T_1	2.5mm	W_2	15mm	h	5mm
L_3	3.8mm	T_2	1.5mm	S	3.8mm		

Table 2. Parameters of Tri-U-Slot Antenna

L_1	13mm	L_4	3.8mm	T_1	3mm	W_1	11mm	S	5mm
L_2	15mm	L_5	15mm	T_2	2mm	W_2	17mm	d	20mm
L_3	10mm	L_6	15mm	T_3	2mm	W_3	23mm	h	5mm

3. Results and Discussion

CST Microwave Studio, commercial electromagnetic simulation software has been used to perform the simulation of the proposed antenna designs. The antenna performance depends on different parameters. By changing the parameters of the proposed designs variation in the antenna characteristics have been observed by numerous simulations perform in CST simulator in order to confirm the results. The antennas have been parametrically studied and investigated the relations between the lengths, broadness and positions of the U-slots on the patch surface. The return loss of the antennas is demonstrated in the Figure 2. The measured reflection coefficient of tri-U-slot antenna is shown in Figure 4 which shows good agreement with the simulated return loss. The sharp edge of each curves represent the desire frequency band. The proposed antennas have good impedance matching as their return loss is sufficiently below -10db at all resonance frequencies. The dual U-slot antenna has the bandwidth of 0.27GHz ranging from 3.37GHz to 3.64GHz. The bandwidth is sufficient to accommodate in the WiMAX standard. The second band of dual U-slot antenna has the bandwidth of 0.47GHz ranging from 5.15GHz to 5.62GHz. This would allow WLAN and WiMAX operations. On the

other hand the first band of tri-U-slot antenna has the bandwidth of 0.14GHz ranging from 3.61GHz to 3.75GHz, which falls in the WiMAX and IMT operations. While the second band of tri-U-slot antenna has the bandwidth of 0.66GHz ranging from 5.18GHz to 5.84GHz, which is suitable for WLAN and WiMAX applications.

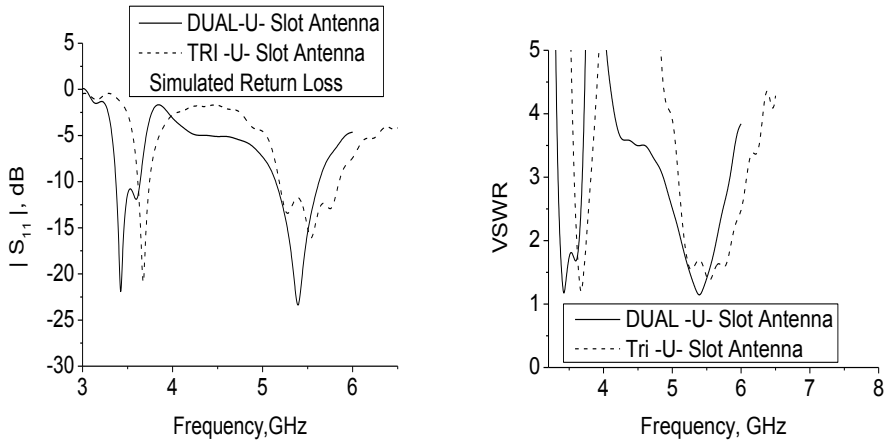

Figure 2. Simulated Reflection Coefficient and VSWR of Dual U-Slot and Tri-U-Slot Antenna

The VSWR of proposed designs are shown in the Figure2. The VSWR of dual U-slot have 1.10, 1.08 and 1.11 at the resonance frequencies of 3.6GHz, 5.2GHz and 5.8GHz respectively. The tri-U-slot has the VSWR values of 1.10, 1.15 and 1.15 at the central frequencies of 3.6GHz, 5.2GHz and 5.8GHz respectively.

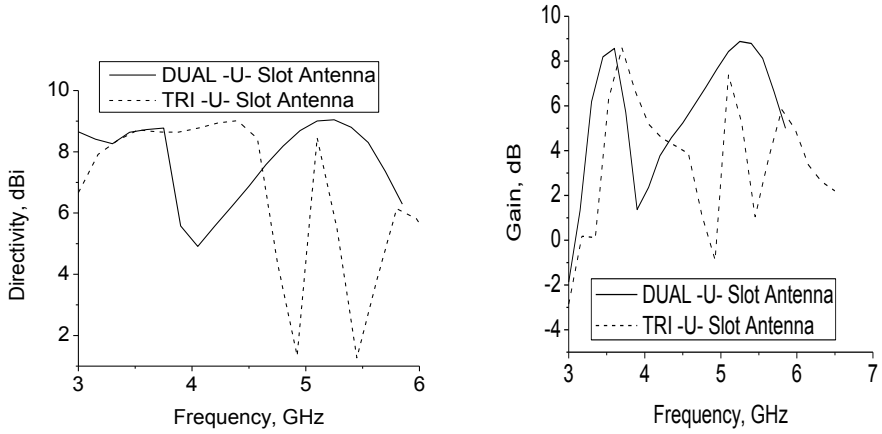

Figure 3. Directivity and Gain of Dual U-Slot and Tri U-Slot Antenna

The gain and directivity of the proposed designs are shown in the Figure3. The directivities of the dual U-slot antenna at the resonance frequencies of 3.6GHz, 5.2GHz and 5.8GHz are 8.773dBi, 9.473dBi and 8.103dBi. While that of tri-U-slot antenna have the directivities of 8.712dBi, 8.655dBi and 9.091dBi at the central frequencies of 3.6GHz, 5.2GHz and 5.8GHz.

The parameters which are capable of improving the gain of the antenna are the dielectric constant, distance of the u-slot from the lower side of the patch, broadness and the length of the u-slot. The effect on the return loss of dual-U-slot antenna for different values of L_3 and S are shown in Figure 5. And the frequencies shifting for different values of S and position of third slot of tri-U-slot antenna are shown in Figure6.

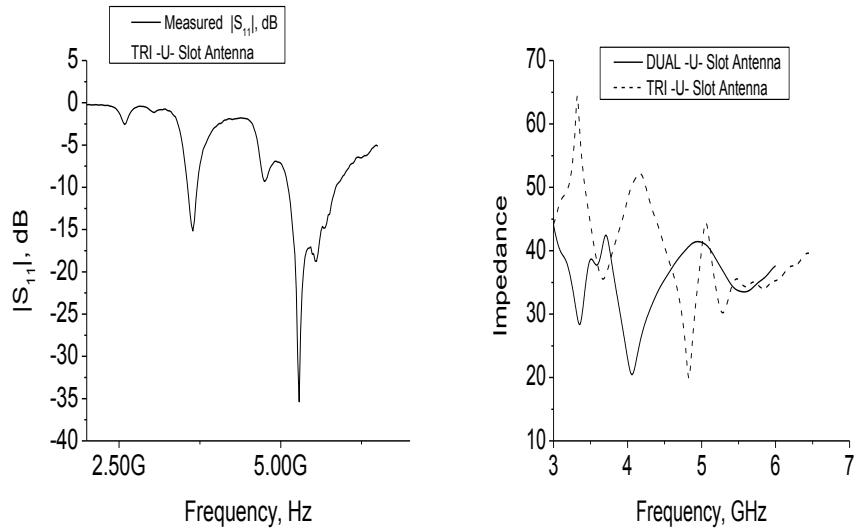

Figure 4. Measured Reflection Coefficient of Tri-U-Slot Antenna and Simulated Input Impedance of Dual U-Slot and Tri-U-Slot Antenna

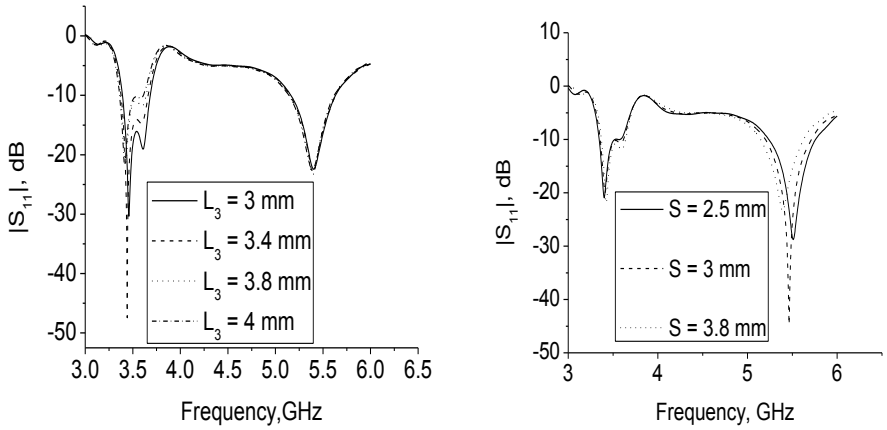

Figure 5. Simulated Reflection Coefficient for the L_3 and S of Dual U-Slot Antenna

These parameters are adjusted and bring improvement in the gain of the antenna. The simulated gains have sufficiently high for desire performance of the antennas. The improvement in the gain and directivity of the antenna is because of using air substrate. The gains of the antenna are also affected by the dimensions of the patch and the ground. When the ground and patch have same dimensions, the antennas gains decrease and with increasing the size of the ground the gains increase. The size of the ground affects the antennas gain up to 50mm. So higher gains are obtained on considering 50x50mm^2 dimension of the ground plane. The simulated gains of dual U-slot antenna have calculated which are 8.77dBi, 9.47dBi and 8.1dBi at the resonance frequencies of 3.6GHz, 5.2GHz and 5.8GHz respectively.

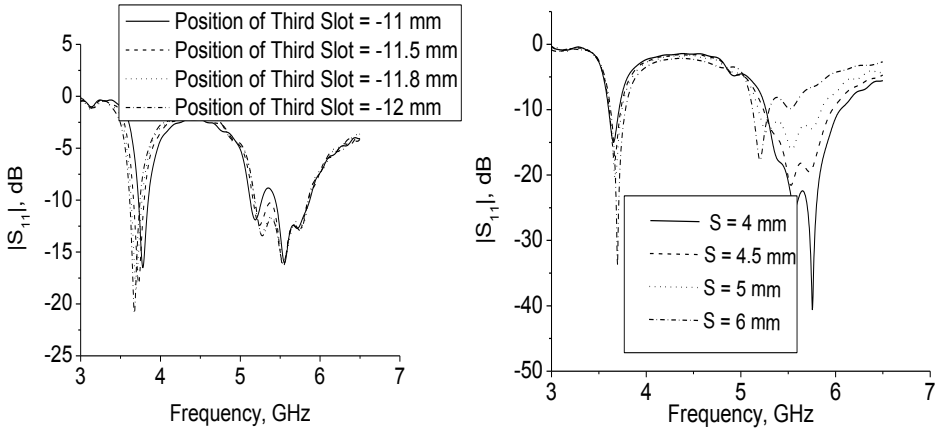

Figure 6. Simulated Reflection Coefficient for the Position of the Third Slot and S of Tri-U-Slot Antenna

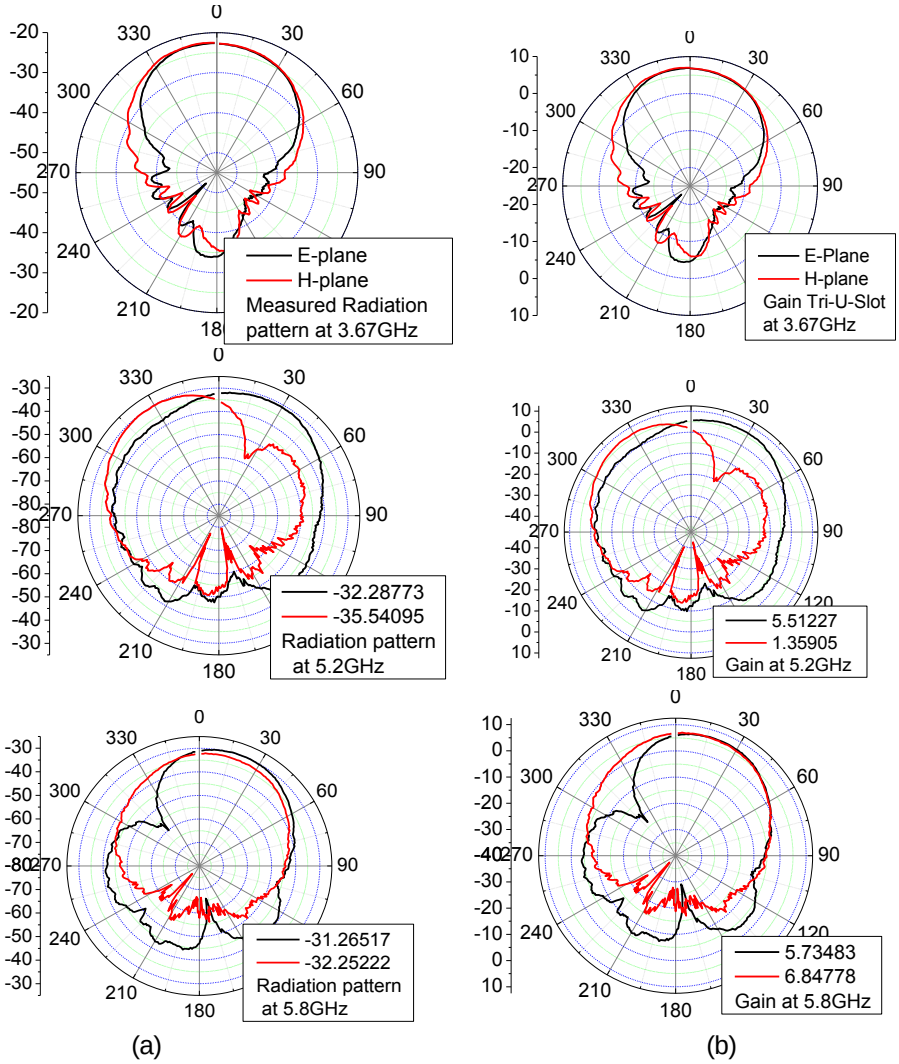

Figure 7. Measured Radiation Patterns E-Plane and H-Plane (B) Measured Gains E-Plane and H-Plane at 3.67ghz, 5.2ghz, and 5.8ghz

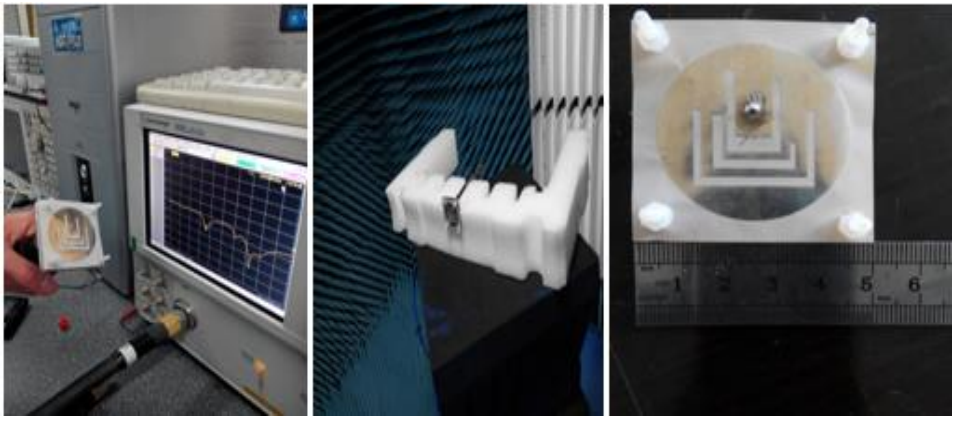

Figure 8. Photograph of Tri-U-Slots Antenna Prototype

The measured gains and radiation patterns E-plane and H-plane of tri-U-slot antenna at the resonance frequencies of 3.6GHz, 5.2GHz and 5.8GHz are demonstrated in the Figure 7. The photographs of tri-U-slot antenna are shown in the Figure8.

4. Conclusion

The proposed designs have simple geometries of a single-layer single-patch dual band patch antennas. The antennas have stable radiation patterns throughout the operating frequencies. The dual U-slot and tri-u-slots patch antennas have been design to cover the upper and lower band of WLAN and WiMAX operating frequencies. In order to achieve the required gain the proposed design can be used to form an array. The fabricated antenna has been analyzed in term of radiation patterns, gain and return loss which is suitable for wireless applications.

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