Modified Compact Zigzag-Shaped-Slot Multiband Microstrip Antenna with Dumbbelled Defected Ground Structure for WLAN/WiMax Applications.

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Abstract - In this paper, a modified compact zigzag-shaped- slots rectangular microstrip patch antenna with dumbelled shaped defected ground structure (DGS) is designed for WLAN/WiMax wireless applications. The probe-fed antenna consisting of a zigzag-shaped slot, three T-shaped slots on other sides of a rectangular patch, and circular dumbbell-shaped defected ground plane is designed. The antenna was able to generate four separate resonances to cover both the 2.45/5.28-GHz WLAN range and the 3.5-GHz WiMAX range while maintaining a small overall size of 48 x 60mm. The return-loss, impedance values are improved significantly for three resonant frequencies and one extra resonance frequency as previous work. The designed antenna is having good radiation patterns and potentially stable gain around 4–6 dBi over the working bands.

Keywords- Defected ground structure, Slotted Antenna, impedance bandwidth, radiation pattern, zigzag slit.

1. INTRODUCTION

Implementing communication system with compact and small sized structure has been a confront for antenna engineers. Preferred characteristics of a multiband antenna are improved impedance, improved gain, and good radiation patterns. Many engineers have designed numerous antennas employ different shapes of defects in the ground plane. Perpetually, applying defected ground structures (DGSs) is starting to be a successful method in the size cutback of antennas, besides excite additional resonant modes. A DGS unit cell is imprinted out as a defect on the ground plane of a printed circuit board (PCB).

Microstrip Patch antenna designs are future for multiband applications with different shapes of slits and slots. Slot formation techniques are used to reduce the size of a patch antenna and to create multiband operation in a specified frequency range [1-4]. Compact design with slits is introduce in to a conventional patch antenna for multibands [5]. Concentric ring-shaped DGS [6], CPW fed monopole antenna with DGS [7], tripleband operation with DGS [8], and split-ring resonating strcuture [9] are also evolve. Kandwal *et al.* proposed a Z-shaped DGS for bandwidth improvement over the resonant frequencies [10]. Metallic back up behind the defected ground structure is acceptable with a view to suppress the leakages through the defects slots [11]When Radio Frequency signal gets transmitted through a DGS-implemented patch antenna, the signal is effectively coupled connecting the top surface of the patch and DGS [12]. The resonant character of different shapes and sizes of DGS slots and its equivalent circuit parameters and their frequency responses are illustrated in [13]. The presence of a DGS actually perturb the current distribution in the ground plane of the patch antenna and thus oprimize the equivalent parameters over the defected region [14]. Based on slot loading and DGS technique, many probe-feed planar antennas are suggested for multiband operation. However, the required -10dB return loss bandwidth and gain need to be improved.

In this paper, a modified multiband planar antenna with defected ground structure is optimized. Triple T-shaped slits are inserted on three side of the radiating rectangular patch, which provides tri band with good impedance characteristics. Further to this, a zigzag-shaped slot is introduced, to which the antenna resonates at an additional band. The ground plane loaded with a circular dumbbell shaped makes the resonant frequencies shift at all the four bands. Miniaturization of antenna in the work process diminishes the gain of the antenna. Antenna dimensions are modified for multiband applications.

2. ANTENNA GEOMETRY DESIGN

The proposed triband patch antenna is patterned on 48x60x1.6 mm^3, FR4_epoxy with relative permittivity (ε_r=4.4) and loss tangent of 0.02 as shown in Fig. 1. A conventional rectangular patch antenna is chosen with dimensions 28x40 mm. Three T-shaped slits are introduced on either side of the patch for multifrequency operation as shown in Fig. 2.

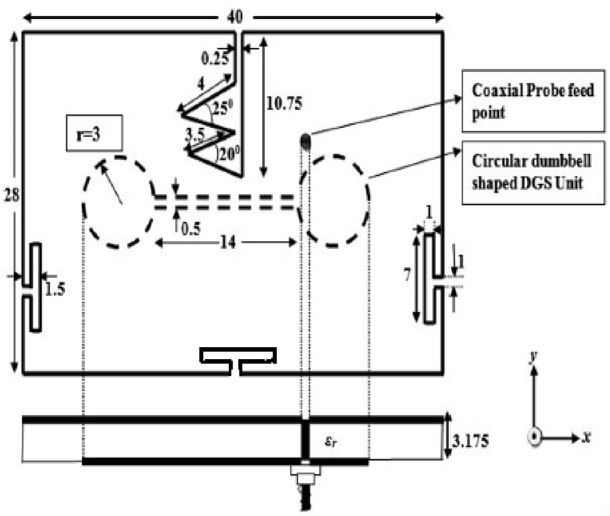

Fig. 1. Geometry of the proposed antenna.

A circular- shaped dumbbell DGS is chosen as the defect element on the ground plane as illustrated in Fig 3. By controlling the dimensions of T-shaped rectangular slits placed on either sides of the radiating patch along with DGS, the antenna work at multibands. The antenna consists of three similar T-shaped slits with length 7 mm and width 1 mm at a spacing of 0.5 mm from the side. The optimized zigzag slits with angles $25^{o}$and 20^{0} of and are placed at the center of broad dimension of the patch. The dumbbell DGS with radius 3 mm is carved on the middle of the ground plane.

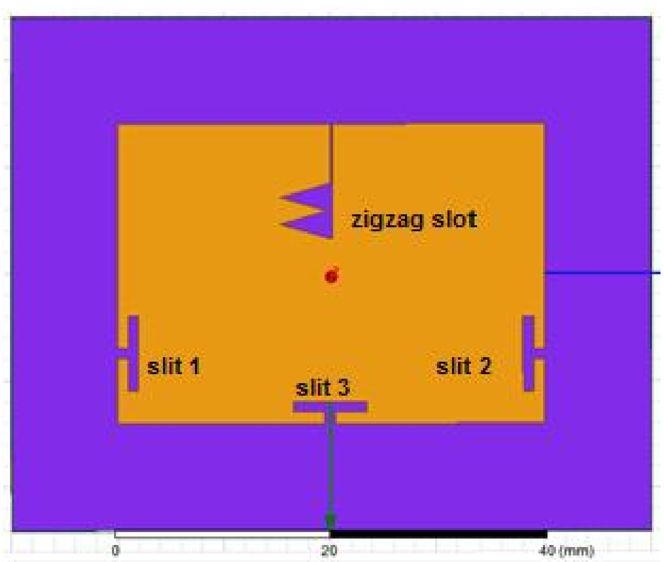

Fig. 2 Patch with zigzag and T slots.

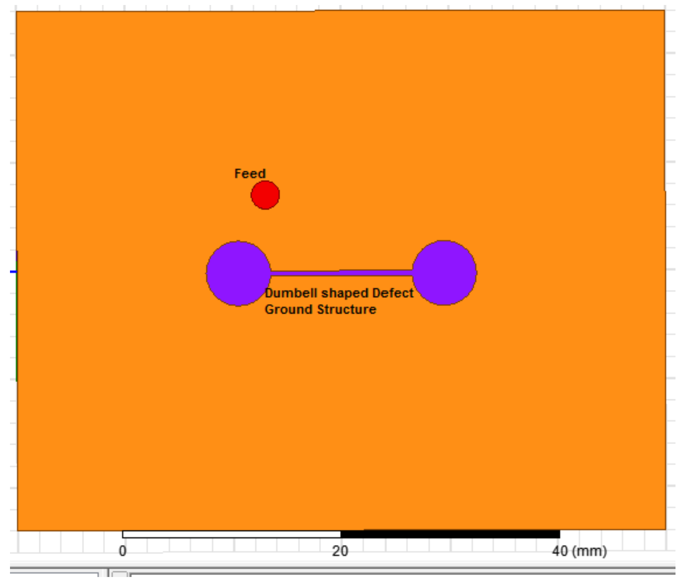

Fig 3 Ground dumbbell shaped structure.

3 SIMULATION AND RESULTS

The designed antennas are simulated by using commercial Ansoft HFSS software. The probe feed technique is chosen due to its direct contact mechanism with the antenna, and mainly of the feed is isolated from the patch, which minimize unauthentic radiation. The probe point is selected on the diagonal of the radiating patch to match four bands constantly. Through simulations, the position and dimensions of the slots are optimized for multiband operation.

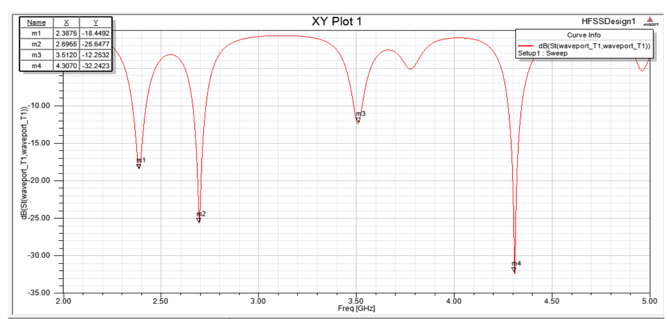

Fig.4 Return loss Vs frequency

By varying the dimensions of the dumbbell-shaped, the resonant frequencies may be shifted by changing the length and width of the patch. With addition of DGS, the current distribution gets disturbed and influences the impedance and current flow of the antenna. It can also be control electromagnetic waves propagating through the substrate layer. Dumbbell-shaped corners on the DGS introduce excitation of multi-resonant modes accompany with good impedance over the operating bands. Though, the gain of the antenna is reduced for the antenna structure when DGS is apply to a conventional patch antenna. It is significance mentioning that the geometry of the ground plane also affect the characteristics of the antenna.

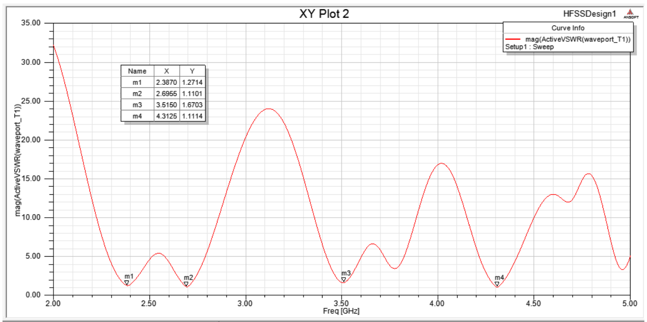

Fig.5 VSWR Vs frequency

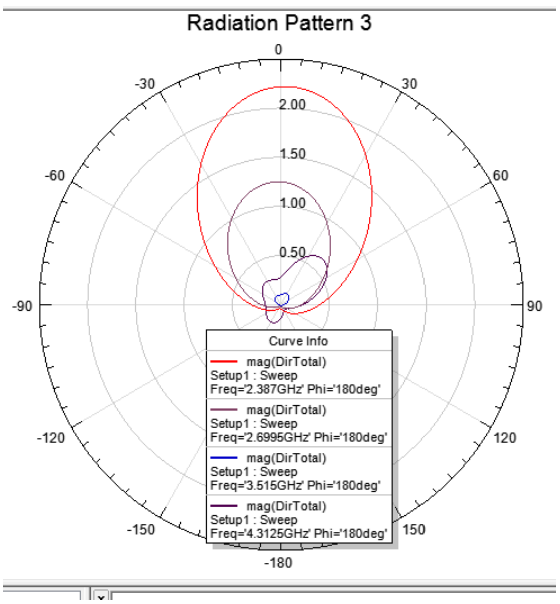

Fig.6.1 x-y axis radiation pattern for resonance frequency

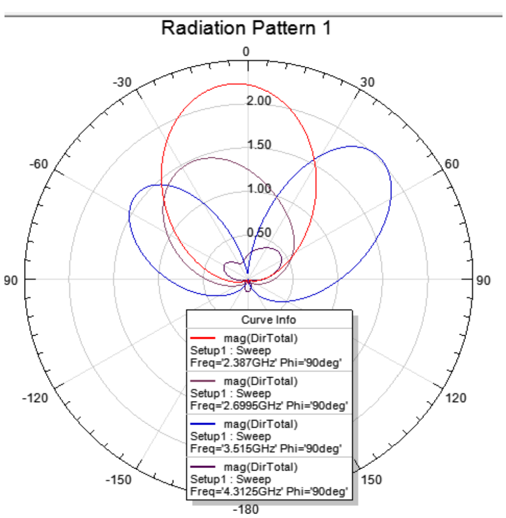

Fig.6.2 y-z axis radiation pattern for resonance frequency

Table I SIMULATED RESULTS

Results	**F 1** **2.38 GHz**	**F2** **2.69 GHz**	**F3** **3.51 GHz**	**F4** **4.30GHz**
S_{11}	-18.4 dB	-25.64 dB	-12.2 dB	-32.2dB
VSWR	1.27	1.11	1.67	1.11
Directivity	2.25 dBi	1.5 dBi	2 dBi	0.5 dBi
B/W	70 MHz	70 MHz	50 MHz	70 MHz

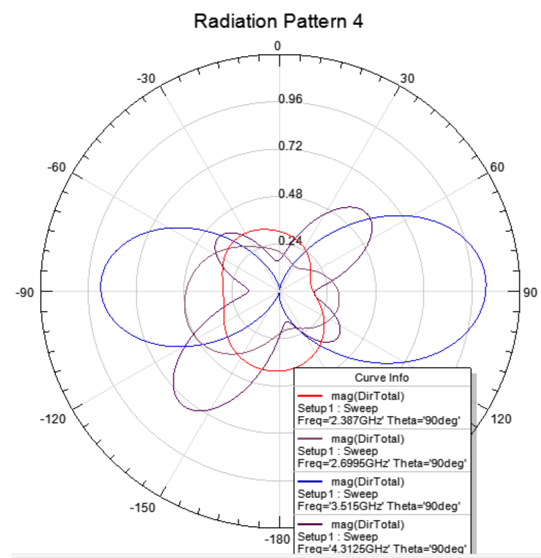

Fig.6.3 x-z axis radiation pattern for resonance frequency

Table I provides the results of proposed antenna to the existing probe-feed multiband planar antennas in the available literature. The presented antenna gives with a slight decay in the measured gain. The variation in the length of the DGS slot would seriously affect the impedance matching, whereas less change is seen for the first and second operation bands. DGS show a vital role in shifting the frequencies and improving bandwidth for the working bands. Miniaturization of the antenna is obtained by introducing DGS and with a change in the resonant frequencies.

The measured radiation patterns of the proposed multiband antenna in the horizontal plane (HP) and vertical plane (VP) at 2.38 GHz, 2.69 GHz, 3.51 GHz and 4.30GHz respectively, are shown in Fig. 6.1, 6.2 and 6.3. The antenna radiates robustly for four resonant modes in the broadside direction. Moreover, the antenna has separate broadside radiation patterns at all the four bands.

4 CONCLUSION

Slit-loaded multiband patch antenna with defected ground structure is designed and simulated for wireless applications. The simulated resonant frequencies of the modes and respective results of the patch antennas were observed to be in good agreement. The difference between the bandwidths at different frequency bands is undersize.. The gain values at the operating frequencies of structure are also measured. Simulated radiation patterns are in good agreement. This study proves the tradeoff between compactness through DGS with gain. The proposed antenna is applicable for wireless communication systems with good bandwidth especially working in L- and C-bands.

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