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Design and Analysis of Multiband T Slotted One Quarter Rings Microstrip Antenna for WLAN/WiMAX

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ABSTRACT: A multi frequency one-quarter-rings microstrip antenna design is proposed and simulated using HFSS simulation software. The proposed antenna consists of two quarter rings of different radius with one as perfect ground and other as defect ground structure, with an inverted T-shaped slot. The relationship of the resonant frequency with different dimensions for the single one-quarter-ring microstrip antenna is presented. This designed multi resonant antenna shows that the increase in bandwidth when defect ground is used as compared to normal or conventional ground plane. The model simulation shows that proposed designed antenna operates at six different frequencies of 1.7, 1.9, 2.4, 3.03, 3.5 and 3.6 GHz, respectively for normal ground whereas wide bandwidth of 500 MHz is achieved for 1.9 GHz operating frequency for defect ground structure.

KEYWORDS: Defect Ground Structure, Multi-band, WLAN /WiMAX, open-ended slot, Rectangular Ground Slot, T Slot etc.

I.INTRODUCTION

The Microstrip patch antenna has been investigated since the 1950s [1]. In recent years, the microstrip antenna played important role due to its compact size, light weight, low cost [2]. With the rapid development of the wireless communication in antenna technology, more research focus on the multi resonant and wideband antennas [3]. Many single-feed, single-layer dual and four operating frequency patch antennas are studied about circular and ring patch antenna [4]. By loading slots (eliminating some portion from radiation surface) [5], or two different elements [6], a dual-frequency microstrip antenna is obtained [7]. However, these antenna designs operate at two resonating frequencies only [7]. A single-feed, single-layer triple-frequency microstrip antenna is designed in [8] and for four resonating frequencies [16], and other communication bands are not covered in the studied papers. Further design is optimized by using FR_4 Epoxy (ε_r=4.4) substrate in our proposed design.

People begin to pay more attention to the annular ring microstrip antennas due to their simple structure, compact and smaller in size with circular polarization [9], [10]. Based on this research, more than dual- and four-frequency operations on the annular ring patch antenna have been designed and simulated [16]. Combining two semi-ring elements, multi-frequency operation can also be obtained. By loading slots, a multi-band frequency-tunable annular ring patch antenna [15] is designed and simulated.

A modified multi frequency one-quarter-rings microstrip antenna is proposed in this paper. The proposed antenna consists of two quarter rings in different sizes [16], with an inverted T-shaped slot loaded with perfect ground and defect ground slots. The relationship of the resonant frequency with different dimensions [16] for perfect ground and DGS (Defect Ground Structure) is also considered, which is useful to design the proposed multi frequency microstrip patch antenna. The T-shaped slot is mainly used to suppress the higher-order mode [16]. The measured S_{11}-parameter (Return Loss), and the radiation patterns of the multi frequency microstrip antenna are shown in Table II.

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II.ANTENNA DESIGN

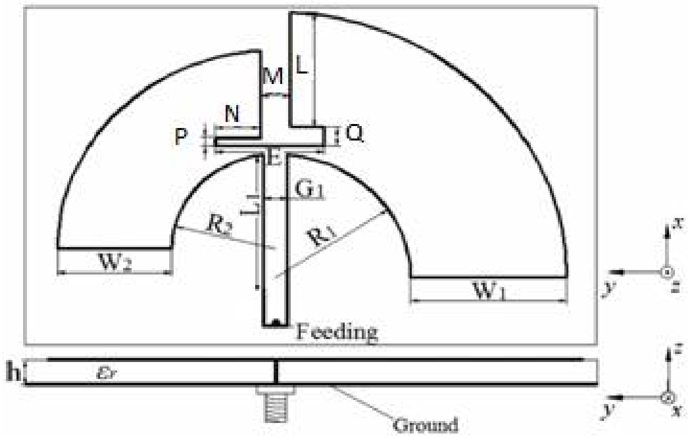

Fig 1(a). Patch Geometry with two one quarter rings

A multi frequency one-quarter-rings microstrip antenna is shown in Fig. 1(a), which consists of two one-quarter rings in different sizes and an inverted T-shaped slot. The proposed antenna is designed using FR_4 Epoxy substrate with a permittivity ε_r=4.4, a loss tangent of 0.06 and a thickness (h) of 1.6 mm respectively. The size of the ground plane is 140 x 180 mm^2.

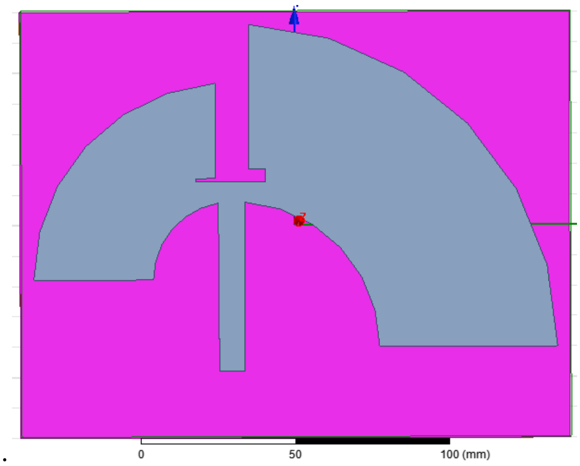

Fig 1(b). Simulated Design Patch Geometry on HFSS

A simulated design microsrip patch antenna geometry is shown in Fig. 1(b), which consists of two one-quarter rings in different sizes and an inverted T-shaped slot.

Table I. Geometry parameters

Symbol	**W_1**	**R_1**	**W_2**	**R_2**	**G_1**	**L_1**
Value (mm)	51	47.7	39.2	25.6	5	45
Symbol	**L**	**M**	**N**	**P**	**E**	**Q**
Value(mm)	39.7	11	6.5	1	23	4

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W_1, W_2, R_1 and R_2 respectively represent the width and the inner radius as shown in Table I. A single one-quarter annular ring structure has a dominant operating mode, TM_{11} transverse magnetic wave which has magnetic field component transverse to the direction of communication [17].

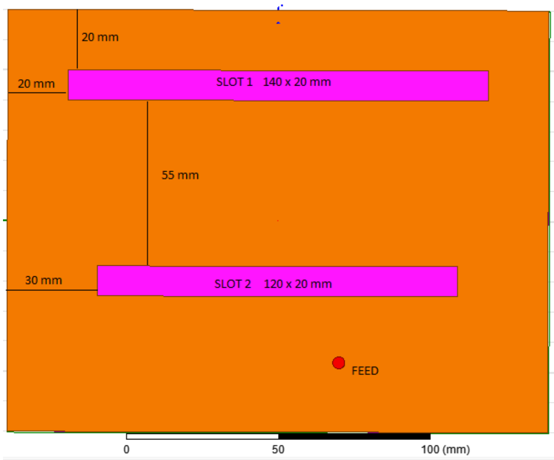

Fig 2. Proposed design for DGS (Defect Ground Structure).

The resonant frequencies may be shifted by introducing the length and width of the slots (140x 20 mm and 120x20 mm) in ground plane. With addition of DGS, the current distribution gets disturbed and affects the impedance and current flow in the antenna. Two slots are cut with the simulation a test confirms the increase in bandwidth when Defect Ground Structure is implemented, comparison in bandwidth is mentioned in table II. Simulated result shows that there is no significant change in the resonating frequency when DGS is applied.

III. SIMULATION & RESULTS

The designed antennas are simulated by using Ansoft HFSS software. The probe feed technique is chosen as its direct contact mechanism with the antenna, and mainly of the feed is isolated from the patch, which minimize unwanted radiation.

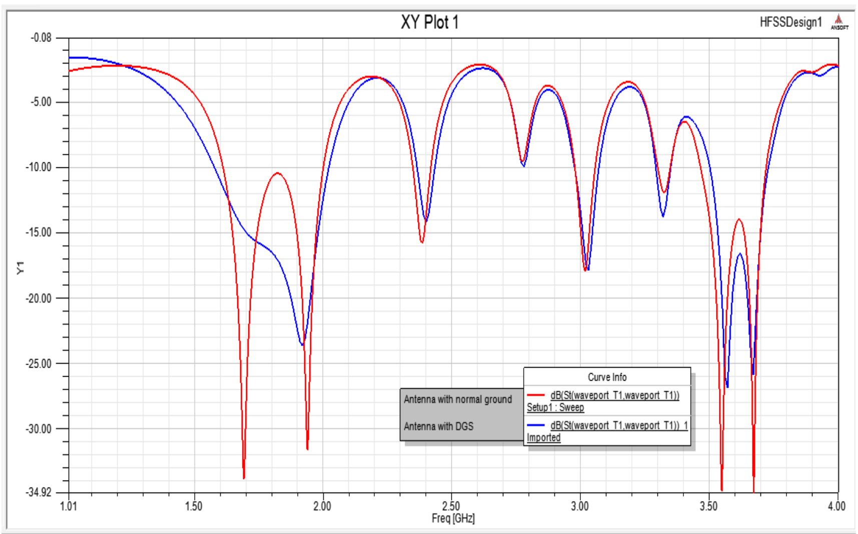

Fig.3 Return loss vs. frequency for proposed design Conventional Ground (Red) and with DGS (Blue).

Through simulations, the position and dimensions of the slots are optimized for multiband operation. Figure 3 shows the obtained result of return loss (S_{11}) vs frequency.

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TABLE II. COMBINED RESULTS FOR BOTH DESIGNS

Geometry	Resonating Freq (GHz)	S_{11} (dB)	Gain (dBi)	Bandwidth (MHz)
Antenna with conventional Ground	1.7	-33.8	2.84	200
	1.9	-31.6	3.01	200
	2.4	-15.8	3.8	70
	3.0	-17.7	7.1	80
	3.5	-33.6	3.28	250
	3.6	-34.4	7.6	
Antenna with Defect Ground Structure	1.9	-23.6	3.48	450
	2.4	-14.2	0.3	70
	3.0	-17.9	0.9	90
	3.3	-13.9	5.4	63
	3.5	-26.9	4.5	220
	3.6	-25.9	5.6	

Table II shows the results of proposed antenna to the existing probe-feed proposed multiband planar antennas. The presented antenna consisting of defect ground structure gives reduction in gain as compared to conventional ground plane. The variation in the length of the DGS slot would severely affect the impedance matching, whereas less change is seen other than the first and second operation frequency bands. DGS show a vital role in shifting the frequencies and improving bandwidth for the working bands [13]. Miniaturization in the height of the antenna from 3mm to1.6 mm is obtained by introducing FR_4 substrate and also with a change in the resonant frequencies.

The measured result of the proposed multiband antenna operates at 1.7 GHz, 1.93 GHz, 2.4 GHz, 3.0 GHz, 3.54 GHz and 3.67 GHz respectively. The antenna radiates robustly for six resonant modes in the broadside direction.

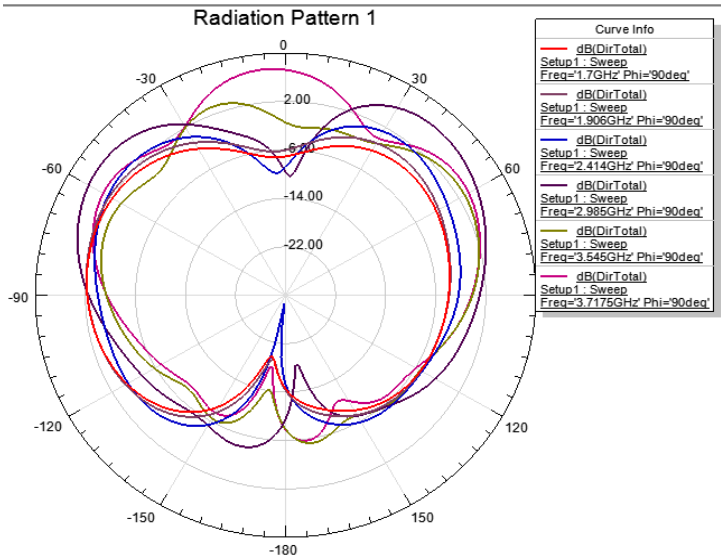

Fig.4 Radiation pattern for designed antenna with conventional ground plane.

T slot-loaded multiband patch antenna with defected ground structure is designed and simulated for wireless applications. The difference between the bandwidths at different frequency bands is shown (Table II). The gain values at the operating frequencies of structure are also shown in Table II. Simulated radiation patterns are in good agreement. The proposed antenna is applicable for wireless communication systems with good bandwidth especially working in L- and S-bands.

The radiation pattern of the simulated design is omnidirectional and obtained values of gain at different resonating frequencies are shown in Table II.

From the above radiation pattern Fig 4 gain is obtained as 7.1 dBi and 7.6 dBi at the resonating frequency of 3.0 and 3.7 GHz. The radiation pattern from the above polar plot signifies that the pattern is omnidirectional which confirms the application of antenna in WLAN/WiMAX wireless applications.

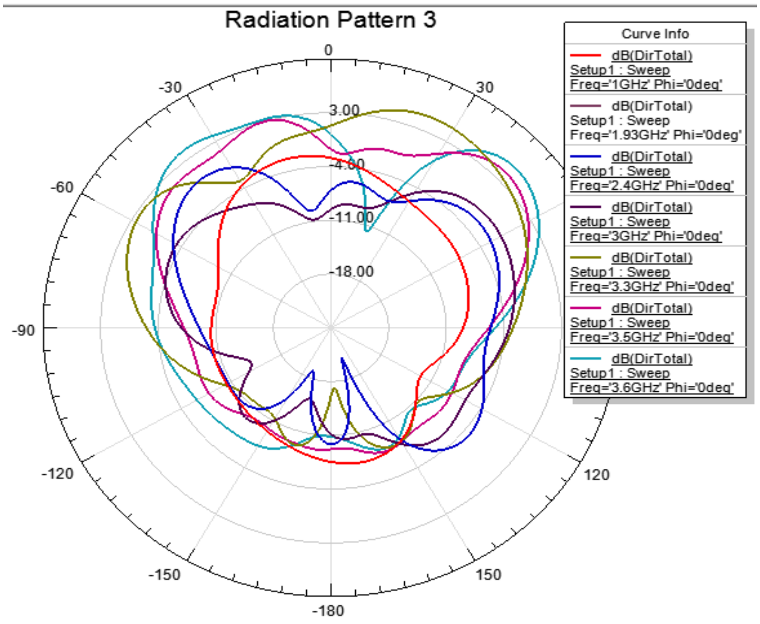

Fig.5 Radiation pattern for designed antenna with Defect Ground Structure.

The simulated radiation patterns for the DGS microstrip antenna are plotted in Fig. 5. With the obtained gain pattern for E plane, the antenna has gain of 5.4 dBi and 5.6 dBi at the resonating frequency of 3.3 and 3.6 GHz.

IV. CONCLUSION

A modified multi frequency one-quarter-rings microstrip antenna design is proposed and simulated using HFSS software. The designed antenna consists of two one-quarter rings in different sizes, with an inverted T-shaped slot loaded. The inverted T-shaped slot is mainly used to suppress the higher-order mode. The resonant frequencies of the proposed antenna are evaluated by two one-quarter rings. The relationship of the resonant frequency with different dimensions for the single quarter-ring microstrip antenna is presented. The multi frequency capability is obtained by adjusting the dimensions of the proposed structure. The S_{11} (return loss) for six frequencies is obtained during simulation for the designed antenna which operates at 1.7, 1.93, 2.4, 3.03, 3.54 and 3.67 GHz. The multi frequency capability will be useful in applications of personal communication systems, such as the indoor base station and WLAN/WiMAX wireless applications.

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