

A Wide Multiband T-Slotted, Semicircular Microstrip Patch Antenna for WLAN/WiMAX Applications

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Abstract— A multifrequency semicircular microstrip antenna is designed and simulated in this paper using HFSS simulation software. The proposed antenna consists of two quarter rings in 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 physical size parameters for the single one-quarter-ring microstrip antenna is also reported. This designed multiresonant antenna proves increase in bandwidth when defect ground is used as compared to normal or conventional ground plane. The simulation show that proposed designed antenna operates at six different frequencies of 1.7, 1.93, 2.3, 3.03, 3.57 and 3.67 GHz, respectively for normal ground whereas wide bandwidth of 500 MHz is achieved for 1.9 GHz operating frequency..

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 a more and more important role due to its low profile, lightweight, low cost, etc. [2]. With the rapid development of the wireless communication in antenna technology, more and more research focuses on the multiresonant and wideband antennas [3], but complex manufacturing procedures are needed by using stacked, slot patches. Many single-feed, single-layer dual-frequency patch antennas are studied before this proposed research [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 only operate at two [7] or four [16] frequencies, and more communication bands are not covered. A novel single-feed, single-layer triple-frequency microstrip antenna is designed in [8]. Further design is optimized by using FR_4 Epoxy ($\epsilon_r=4.4$) substrate in our proposed design.

People begin to pay more attention to the annular ring microstrip antennas due to their simple structure, compact low profile, simple size reduction, and circular polarization operation [9], [10]. Many analyses about the annular ring microstrip antenna using the cavity model and full-wave analysis are studied [11]–[13]. 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 [14], 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 semicircular 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 physical size parameters [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].

II. ANTENNA DESIGN

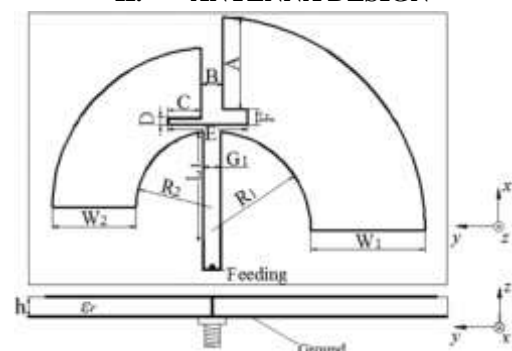


Fig 1(a). Patch Geometry with semicircular .

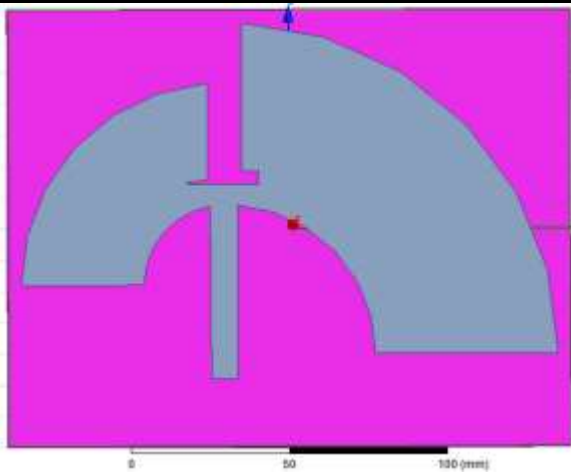


Fig 1(b). Simulated Design Patch Geometry on HFSS

Table 1. Geometry parameters

| | | | | | | |
|------------|------|------|------|------|----|----|
| Symbol | W1 | R1 | W2 | R2 | G1 | L1 |
| Value (mm) | 51 | 47.7 | 39.2 | 25.6 | 5 | 45 |
| Symbol | A | B | C | D | E | F |
| Value(mm) | 39.7 | 11 | 6.5 | 1 | 23 | 4 |

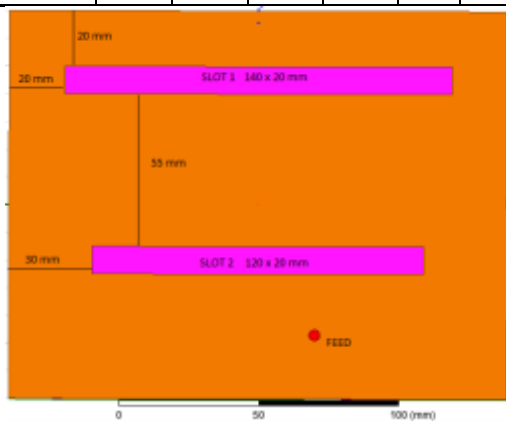


Fig 2. Proposed design for DGS (Defect Ground Structure).

A multifrequency one-semicircular microstrip antenna is shown in Fig. 1, which consists of semicircular in different sizes and an inverted T-shaped slot. The multifrequency semicircular microstrip antenna is designed using FR_4 Epoxy substrate with a permittivity $\epsilon_r=4.4$, 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 mm². W1, W2, R1 and R2 respectively represent the width and the inner radius as shown in table of the multifrequency semicircular microstrip antenna. A single semicircular annular ring structure has a dominant operating mode, which is the TM₁₁ [17].

The resonant frequencies may be shifted by changing the length and width of the slots (140x20 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 [18]. Two slots are cut with the simulation a test confirms the increase in bandwidth

when Defect Ground Structure is implemented, comparative bandwidth is mentioned in table II. But results shows that there is no significant change in the resonating frequency when DGS is applied.

III. SIMULATION & RESULTS

The The designed antennas are simulated by using commercial 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. Through simulations, the position and dimensions of the slots are optimized for multiband operation.

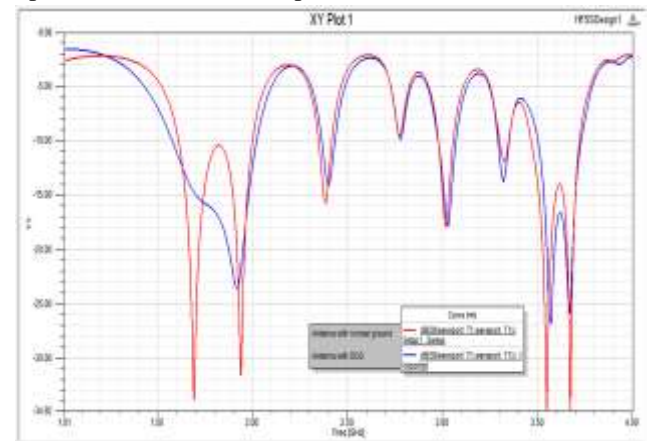


Fig.3: Return loss vs. frequency for proposed design Conventional Ground (Red) and with DGS(Blue).

Table. II: Combined results for both designs

| Geometry | Resonating Freq (GHz) | S11 (dB) | Gain (dBi) | Bandwidth (MHz) |
|--------------------------------------|-----------------------|----------|------------|-----------------|
| Antenna with conventional Ground | 1.7 | -33.8 | 2.84 | 200 |
| | 1.93 | -31.6 | 3.01 | 200 |
| | 2.4 | -15.8 | 3.8 | 70 |
| | 3.0 | -17.7 | 7.1 | 80 |
| | 3.54 | -33.6 | 3.28 | 250 |
| 3.67 | -34.4 | 7.6 | | |
| Antenna with Defect Ground Structure | 1.93 | -23.6 | 3.48 | 530 |
| | 2.4 | -14.2 | 0.3 | 70 |
| | 3.0 | -17.9 | 0.9 | 90 |
| | 3.5 | -26.9 | 4.5 | 50 |
| | 3.6 | -25.9 | 5.6 | 220 |

Table II provides the results of proposed antenna to the existing probe-feed proposed multiband planar antennas. The presented antenna gives with a slight decay in the measured gain. The variation in the length of the DGS

slot would acutely 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. Miniaturization in the height of the antenna from 3mm to 1.6 mm is obtained by introducing FR_4 substrate and also with a change in the resonant frequencies.

The measured results of the proposed multiband antenna are 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.

T Slot-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 S-bands.

IV. CONCLUSION

To A modified multi frequency semicircular microstrip antenna is proposed in this paper. The proposed 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 physical size parameters for the single quarter-ring microstrip antenna is also reported, and it contributes to the antenna design. The multi frequency capability is obtained by adjusting the parameters of the proposed structure. The proposed antenna operates at 1.7, 1.93, 2.3, 3.03, 3.57 and 3.67 GHz, respectively. The S11 is studied, and the radiation patterns at six resonant frequencies are similar. The multi frequency capability will be useful in applications of personal communication systems, such as the indoor base station.

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