

A Compact Dual-Band Antenna Based on Defected Ground Structure for ISM Band Applications

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Abstract—This paper presents the design and realization of a compact dual-band antenna for industrial scientific and medical (ISM) band applications. The compact geometry of the antenna is achieved by combining two miniaturization techniques like defected ground structure (DGS), and by using the truncated patch structure. The antenna is design on cheap FR4 to minimize the cost, while radiator geometry was kept simple to avoid unnecessary fabrication errors. The antenna is comprising of overall compact size of $18 \times 18 \times 1.6 \text{ mm}^3$. Moreover, the dual-band and stable omni-directional radiation pattern makes the presented antenna a potential candidate for modern day compact devices.

Index Terms—miniaturized, defected ground structure, dual-band antenna, ISM band.

I. INTRODUCTION

Multiband antennas are seeking attention of academia and researcher due to their enormous advantages including covering desire multi bands using single antenna [1]. Due to exponential increase in compact devices, the usage of multiband antennas is also increasing. However, these antennas are made up of complex geometrical structures [2], which results in arising the complexity in fabrication of bulk antennas. Moreover, the multiband multilayer antennas [3] increase the overall size of antenna hence disqualifies it to be used in compact modern-day devices. Simpler design owing the features of multiband with compact size are highly desirable.

Researcher adopted various techniques to design a multiband yet compact size antenna for multiple applications [4–8]. In [4], a frequency switchable dual band antenna is presented; conventional patch antenna is converted into dual band by means of stubs and diodes. However, the presented work suffers the deficiency of narrowband. On the other hand, in [5], a CPW fed meandered line structured antenna is presented for dual band operation. Although a compact size of 216 mm^2 was achieved, antenna lags in covering broadband at lower resonance along with negative gain.

In [6], a Y-shaped antenna with DGS is presented for dual ISM band applications. Although antenna exhibits broad band at both resonances with high gain, but the antenna size is not suitable to be integrate in compact device. On the other hand, the antenna proposed in [7] consist of conventional rectangular patch antenna but it has multiple deficiencies

Table 1. Comparison of proposed work with recent work in literature

Ref.	Dimension (mm ²)	Bandwidth (GHz)	Peak Gain (dB)
[4]	576	2.42-2.46 / 2.51-7.2.55	Not Reported
[5]	216	2.37-2.42 / 4.9-7.3	-2.6/1.2
[6]	936	2.32-2.52 / 4.2-10.3	4.6/3.6
[7]	1200	2.38-2.56 / 5.725-5.85	Not Reported
[8]	450	2.31-2.64 / 5.22-6.78	6.73/8.96
Proposed	324	2.36-2.49 / 4.4-7.4	1.8/2.9

including bigger dimension, narrow band, and negative gain. Another interesting work is presented in [8], where researchers proposed a CPW fed dual band antenna with overall compact size. Simple slots and truncating of patch were done to achieve broadband at ISM bands.

This paper proposes a simple compact and multi band single-element monopole antenna with defected ground structure (DGS), where DGS is utilized to achieve wider bandwidth while slots were etched on radiator to get the second lower band. Rest of the manuscript is divided as follow: Section-II contain the configuration and characteristics of proposed antenna while the discussion is concluded in Section-III.

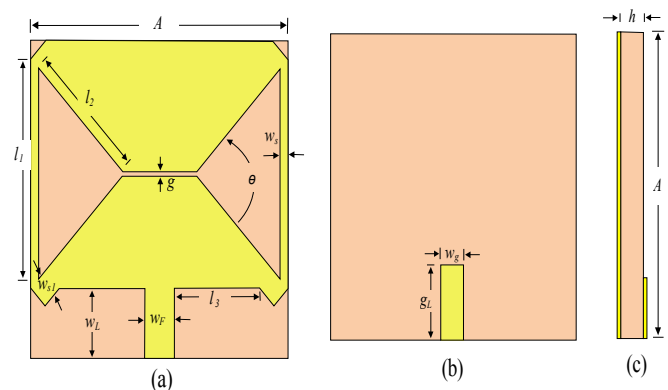


Fig. 1. Geometry of proposed antenna (a) Top view (b) Bottom view (c) Side view

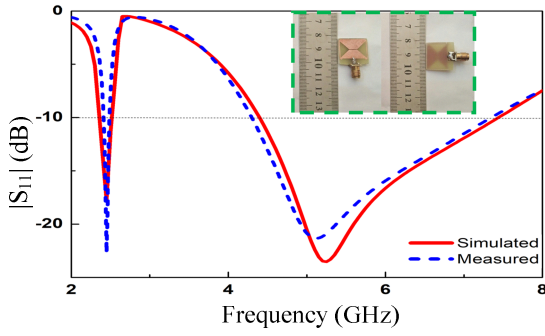


Fig. 2. S-parameters comparison of simulated and measured results.

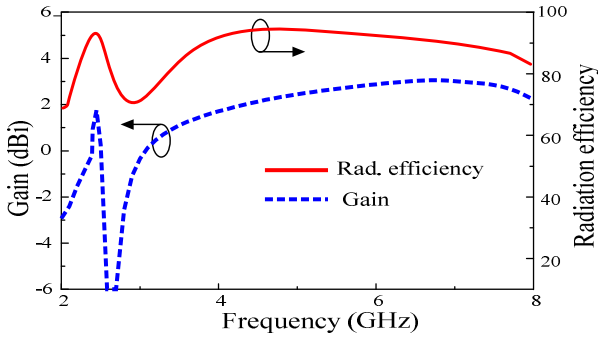


Fig. 3. Gain and radiation efficiency of proposed antenna.

II. ANTENNA CONFIGURATION AND CHARACTERISTICS

The geometry of the proposed antenna is depicted in Fig. 1. The antenna radiator is engraved on cheap commercially available FR4-proxy having standard thickness of 1.6 mm. The top and bottom layer are made up of copper with thickness of 0.035 mm. The antenna simulations were performed using electromagnetic solver Higher Frequency Structural Software (HFSS). The designing steps can be divided into following:

- A conventional antenna resonating at 5.8 GHz is designed.
- To overcome the deficiency of narrow band an inverted U-shaped DGS is deployed, which sufficiently enhances the bandwidth of the antenna.
- In the last step a novel modified dumbbell shape slot is etched on radiator which results in achieving lower resonance.

Furthermore, various parameters of the antenna were optimized to adjust the both bands on desire frequencies. The optimized parameters of the proposed antenna were enlisted here: $A = 18$ mm, $h = 1.6$ mm, $l_1 = 11.92$ mm, $l_2 = 5.86$ mm, $l_3 = 6$ mm, $g = 0.2$ mm, $\theta = 90^\circ$, $w_s = 0.54$ mm, $w_{s1} = 1.4$ mm, $w_f = 2$ mm, $w_l = 4$ mm, $w_g = 2$ mm, and $g_l = 4$ mm.

To validate the findings, the presented work is fabricated using standard chemical etching the fabricated prototype along with S-parameters is depicted in Fig. 2. A good agreement between simulated and measured results is observed. The antenna resonates at dual band of 2.45 GHz and 5.24 GHz with an impedance bandwidth of 130 MHz (2.36–2.49 GHz) and 3000 MHz (4.4–7.4 GHz), respectively.

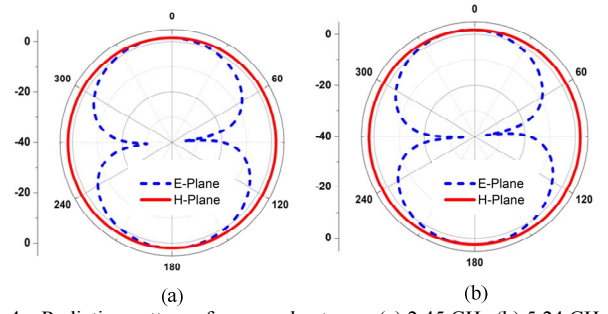


Fig. 4. Radiation pattern of proposed antenna: (a) 2.45 GHz (b) 5.24 GHz

Figure 3 presents the maximum gain and efficiency vs frequency plot of the proposed antenna; it can be observed that antenna exhibits a good and stable gain of more than 1.7dB at both operating frequencies having simulated efficiency of more than 90% in resonating region. Furthermore, Fig. 4 depicted the radiation pattern at both resonances. The proposed antenna shows a nearly omnidirectional pattern in E -plane ($\theta = 0^\circ$) while an eight-shape radiation pattern is observed in H -plane ($\theta = 90^\circ$).

III. CONCLUSION

Concluding the aforementioned discussion, a dual-band antenna based on DGS is proposed for future portable devices. The antenna possesses compact size of 18 mm \times 18 mm \times 1.6 mm and simple geometrical structure which avoid unnecessary fabrication errors for bulk size antenna. The antenna covers both lower (2.4 – 2.48 GHz) and upper (5.725 – 5.875 GHz) ISM band, along with these bands the proposed work also covers the WLAN band of 5.8 GHz which increases its potential for modern day devices.

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