Dual band Rectangular Dielectric Resonator Antenna with Partial Ground Structure for WiMAX/WLAN applications

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Abstract

Dielectric resonator antennas are emerging as an efficient and feasible alternative of all other antennas due to its effervescent characteristics. In this research paper, versatile rectangular shape DRA with extended microstrip feed line mechanism is implemented to get a dual band response. In this work, transverse electric fields is excited to get high radiation efficiency and proper impedance matching. Proper selection of dimensions of feed line and ground plane excites a pair of fundamental TE^x_{111} and TE^x_{113} lower order modes at design frequencies. Proposed structure is a highly efficient design which yields an radiation efficiency of 99% at 3.5 GHz and 92% efficiency at 5.2 GHz band. A simulated gain of 1.9 and 4.5 dBi is obtained at resonating frequencies. Presented structure is simulated by using FDTD method that is utilized by CST MWS software. The proposed antenna is an efficient candidate for 3.5 GHz, WiMAX (Worldwide Interoperability for Microwave Access) and 5.2 GHz WLAN (Wireless Local Area Network) applications.

Keywords

WIMAX, WLAN, Dielectric Resonator Antenna, Partial Ground Structure, Extended feed line

1. Introduction

Severe Acute Respiratory Syndrome Corona Virus 2 (SARS COV-2) has completely destroyed every single most outlook of human kind. Due to the pandemic situation, exponential increment in demand for efficient multiband radiators can be observed. Wireless technologies demands antennas for WLAN, WiMAX, existing 4G/4GLTE and upcoming 5G frequencies [1]. Present day frantic situation has put a question mark on viability of 5G and IoT communication technologies in various parts of the world. IoT and relates sensor technologies enhances usage of wireless sensors for various applications [2-3]. Although no frequency ranges have been determined for 5G yet, but as per estimation 5G will support lower (sub 6G) and upper millimetre wave (above 20 GHz) ranges. Dielectric Resonator Antennas presented righteous features such as high radiation efficiencies (97%) with high Q, high gain, small size, light weight and low cost [6-10].

A variety of Multiband DRA antennas have been proposed in literature by various researchers. UWB technology is gaining momentum due to large bandwidth availability which subsequently provides high data rates [11]. FCC assigned IEEE 802.11 and 802.16 standards for narrow frequency bands [12]. Techniques involved among band creations are either change in shape or change in feed mechanism. Various aperture coupled designs have been reported to provide high efficiency multiband antennas , Use of Parasitic slots, MIMO hybrid structures, Cross-Shaped DRA, Y shape and fan blade shape with vertical pairs of strips have been reported [14-20]. In thisstructure, a simplest possible combination of extended microstrip feed line with Partial ground structure and

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Rectangular DRA is implemented for WiMAX and WLAN band resonator for commercial usage. Rest of the paper is divided into four segments. Segment 2 is design and development of antenna. Segment 3 discuss results and Section 4 includes Comparison of presented paper with literature proposed till date. Section 5 comprise of Conclusion.

1. Design and Development of Antenna

Delineated research work in this article comprise of Rectangular Dielectric Resonator Antenna (RDRA). Exclusive reason for opting rectangular geometry is numerous advantages offered by this geometry. Length, width and height of antenna is chosen in such a manner so that desired frequency response can be generated. Proposed design is specifically simulated to work in fundamental lower order mode i.e. TE^{x}_{111}mode. Material availability and excellent frequency response of FR4 substrate makes it a valid choice for substrate material for the presented design. Dielectric constant with dimensions 47.5 x40 x 1.6 mm is applied as a substrate material in antenna. Design of the antenna is shown in Fig. 1. It can be observed from the design that a partial ground structure is applied in order to obtain multiband response of antenna. A rectangular DRA of material Alumina is placed upon substrate. Application of extended microstrip feed generates lower order modes that WiMAX and WLAN frequency of radiations at 3.5 and 5.2 GHz can be resonated. Figure 1 reflects geometrical aspects of proposed design.

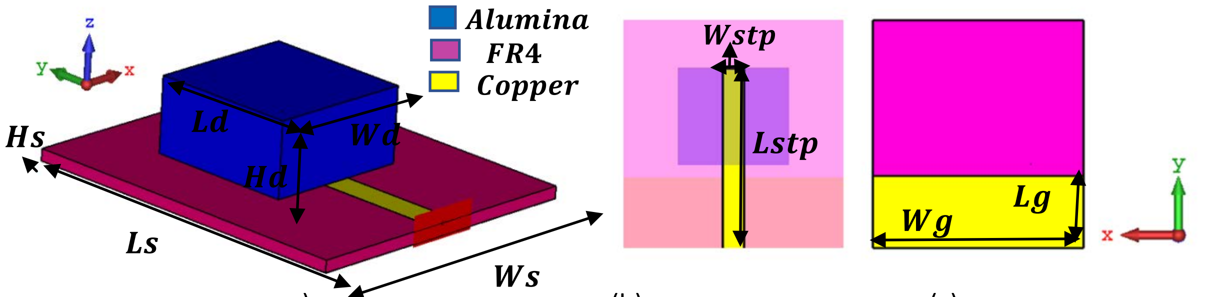


Figure. 1: (a)Panoramic View with DRA dimensions , Wd, Hd, Ld=10mm instituted upon a substrate of dimension Ls=47.5,Ws=40 and Hs =1.6mm. 1(b) represents Microstrip line width and Length $Lstp$ =37.5, Ws =4 mm. 1(c) Partial ground plane of dimension Lg= 15, Wg =40 mm.

2. Results and Discussion

Figure 2(a) represents simulated reflection coefficient parameters of the proposed antenna. It can be observed from the figure that antenna has reflection coefficient below -10 dB for frequencies 3.5 GHz and 5.2 GHz. It can be observed from the Figure 2(b) that a typical 2:1 ratio of VSWR has been achieved by proposed structure which again indicates excellent tuning of the radiator. Figure 2(c) represents impedance graph of the structure. It is evident from the Figure 2(c) Generation of dual consecutive resonant modes resulted in Dual band antenna. Further it is evident from Figure 2(c), that at frequency 3.5 GHz dominant TE^{x}_{111} mode is generated. Next resonance is generated at 5.2 GHz where TE^{x}_{113} mode can be visualized.

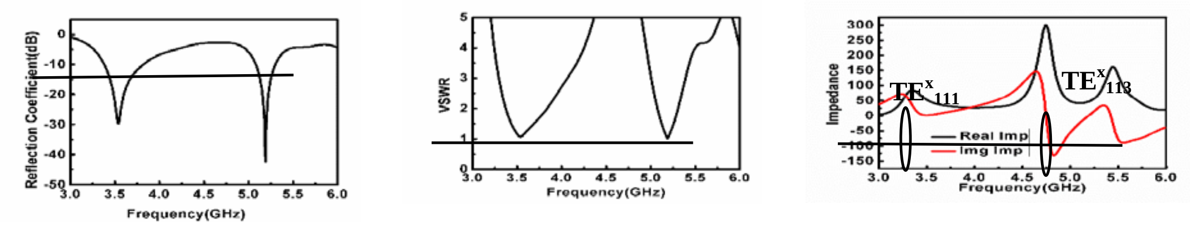


Figure 2: (a) Dual band reflection coefficient of the antenna (b) VSWR ratio of antenna (c) Real and Imaginary part of the Impedance showing generated modes of the structure.

Figure 3 represents the plot of electric field inside RDRA. Antenna is theoretically designed to radiate at a frequency of 5.2 GHz. As can be seen from Figure 2(c) real part of impedance is plotted against a line segment drawn at 50 GHz. It can be observed from this figure that fundamental mode of the antenna in simulation, is in the considerable agreement with the theoretical calculation. Figure 3(a) represents the fundamental mode TE^x_{111} of the DRA. Further other modes TE^x_{113} can be seen from Figure 3(b). Dual band response in the antenna is obtained by inculcating perturbation in the structure. Partial ground structure along with extended microstrip line lowers the resonant frequency of the fundamental mode of the antenna. Due to perturbation, first resonating mode TE^x_{111} is shifted to 3.5 GHz that consequences in electrical shortening of antenna. Extended micro stripline increases capacitive part of the impedance, which in turn form a tank circuit at 3.5 GHz and 5.2 GHz. These two modes can be observed from Figure 3(a) and 3(b).

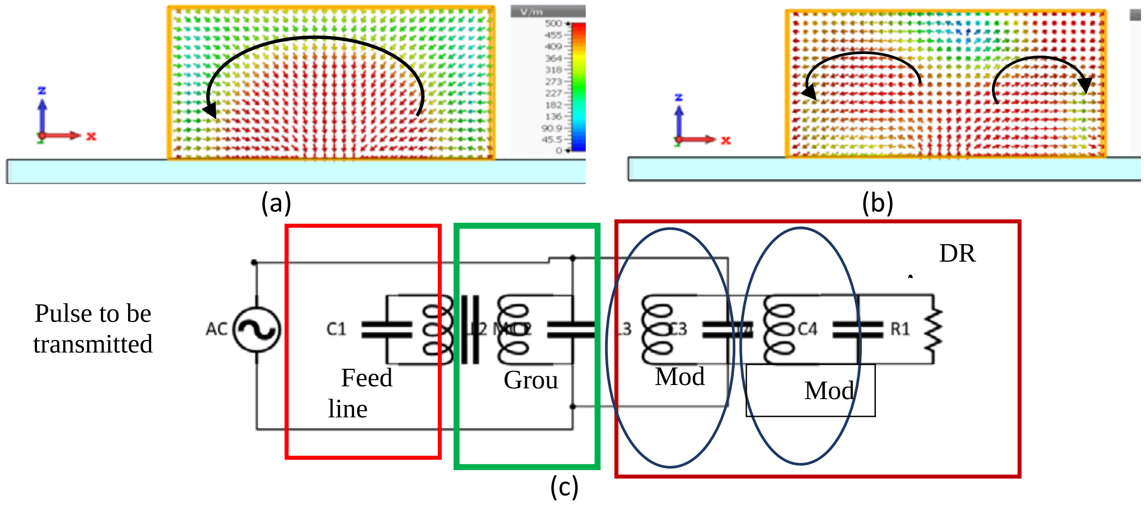


Figure 3: (a) E-field at 3.5 GHz , TE^x_{111} mode of the DRA (b) E-field at 5.2 GHz , TE^x_{113} mode of the DRA (b) Equivalent circuit of proposed structure

Figure 4(a) represents simulated gain of the antenna with respect to frequency. It can be observed from the figure that for both resonating dual bands a respectable value of gain is obtained. At 3.5 GHz 1.98 dB and at 5.2 GHz 4.5 dB gain is obtained. Figure 4(b) represents radiation efficiency of antenna. It is interesting to observe that presented DRA reflects exceptionally high radiation efficiency in the operating bands. Radiation efficiency of 98% is obtained for Wi-MAX band and 92% is obtained for WLAN band.

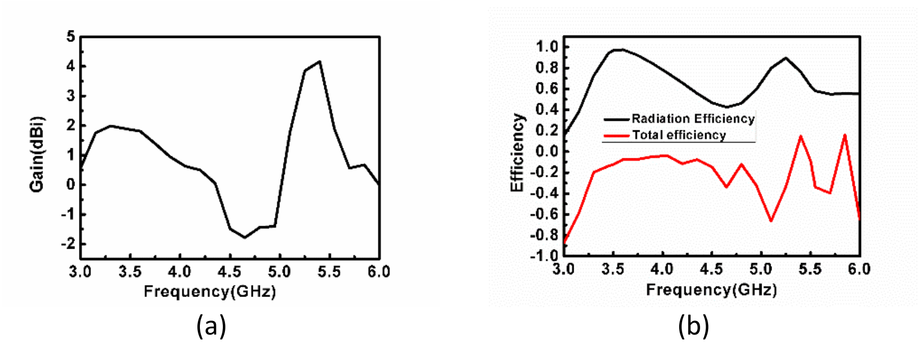
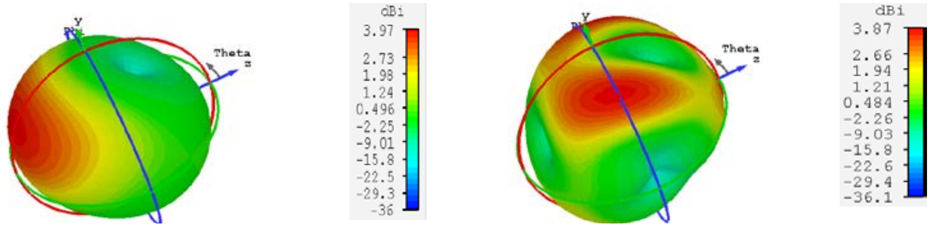


Figure 4: (a)Frequency v/s Gain plot (b) Efficiency (radiation, Total) of antenna

Figure5 represents the radiation pattern achieved by the proposed antenna. It is evident from the pattern that at 3.5 GHz antenna is behaving as magnetic monopole antenna and very good cross and co pol levels are obtained but at 5.2 GHz , antenna shows dual lobe characteristics due to scattering of high frequency fields.



(a) (b)

Figure 5: Radiation Pattern of antenna at (a) 3.5 GHz (b) 5.2 GHz.

4. Comparison Table

Table 1 represents anassessment of the proposed antenna structure with pre-proposedliterature work. Simple design of antenna makes it easy to fabricate. High gain and compact dimensions makes it stand out among other geometries.

Table 1

Comparative Analysis of present structure with pre-proposed literature

Reference No	Resonant bands	Resonator Shape	Dimensions	Frequency of bands	Technique used to create Multiband
19	Dual band	Rectangle	40x40x8	3.4-3.58, 5.1-5.9	Triangular ring shape aperture
20	Dual band	Cylindrical	50x50x13	2.48-2.98, 4.66-5.88	Inverted pentagon shape aperture with Quarter Stub
22	Dual Band	Fan blade shape	80x80x10	3.2-3.8, 4.4-5.0	Fan blade shape DRA with orthogonal Mode Generation
24	Quintuple	Rectangle	30x30x9.813	2.4/5.2,3.5,4.1,4.8	Vertical Metallic strip Pairs
Presented Structure	Dual band	Rectangle	40x47.5x 11.6(Compact Dimensions)	3.5/5.2	Partial ground structure with extended strip line with sustainable gain

5. Conclusion

This research work proposed rectangular geometry of ceramic resonator that is designed and developed for dual band applications. Presented structure is implemented with extended feed line and partial ground structure. Feasibility offered due to rectangle geometry of ceramic material is utilized in DRA. Partial ground structure yields multiband characteristics at WiMAX and WLAN band frequencies respectively. A high gain of 4.5 at WLAN and high efficiency of 98% at WiMAX is obtained through this design. Proposed antenna is a suitable candidate for multiband application due to its easy fabrication simple design and high efficiency and gain.

6. References

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