# A MINIATURE BROADBAND DIELECTRIC RESONATOR ANTENNA (DRA) OPERATING AT 2.4GHZ

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**ABSTRACT:** This paper presents a study on a broadband DRA using a new feed technique developed at Antenova Ltd, UK. The DRA is designed to operate at 2.4GHz for IEEE802.11b/g applications and has a length of only 0.12λ. Characteristics of the prototype DRA are assessed using both a Finite Integration Technique simulation and experimental measurements.

## INTRODUCTION:

Dielectric Resonator Antennas (DRAs) have emerged as a novel antenna technology, with the features of high efficiency, small size and resistance to proximity detuning [1] [2]. Their radiation arises from a displacement current circulating through a dielectric medium, which is always high-permittivity and low-loss ceramic.

However, one of the snags holding up wide applications of DRAs is their feeding technique. Though there exist a range of feeding methods for DRAs, such as slot-coupled microstrip lines, microstrip lines and probes, it is found that the performance of DRAs is very sensitive to the choice of feeding methods [2], [3]. A slight change of the feeding position will cause a big shift of the antenna's characteristic. Therefore, feeding a DRA becomes a major issue for mass production. Recently, Antenova Ltd. UK has developed a new type of feed technique, for DRAs to achieve the required performance repeatability for mass production [4] , consisting of. an over-shooting microstrip line with tuning stub. Also, the tuning stub provides a good mechanism for broadening the operating bandwidth of DRAs. Both numerical and experimental studies reported in this paper have provided further insight into the operation of the DRA and its associated new feeding technique.

The simulations were performed using the CST Microware Studio™ software package which utilizes a Finite Integration Technique for electromagnetic computation [5]. The antenna was manufactured by Antenova and measured in the Antenna Measurement Laboratory of Queen Mary, University of London. The return loss was measured using a HP8720ES Network Analyser and the radiation patterns were measured in an anechoic chamber.

## DRA DESIGN:

The prototype DRA consists of four layers: the ground plane, the substrate (PCB board), the microstrip feeding line and the ceramic pellet as shown in Fig. 1.

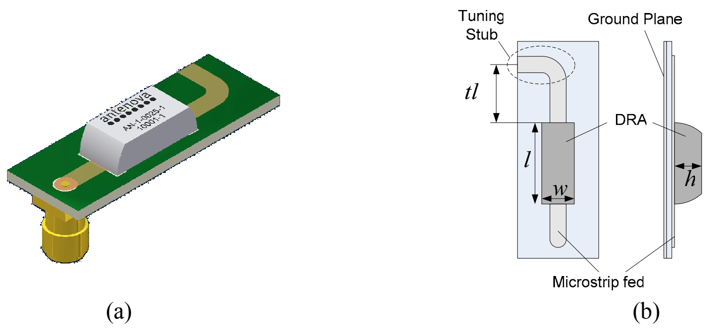


**Fig. 1 Pictures of the Broadband DRA. (a) 3-D model and (b) schematic diagrams.**

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The size of the ground plane and the substrate is 40mm x 15mm. The permittivity of the substrate is 4.7 and it has a thickness of 1.6mm. The ceramic pellet is a top-flattened ceramic half-cylinder of permittivity around 90 with a metal coating on the bottom. The ceramic pellet's length ($l$), width ($w$), and height ($h$) are 15mm, 6mm and 5mm, respectively. A 50Ω-microstrip line having a width of 3mm is connected to the coaxial cable through an SMA connector. In the simulation, all components were modelled as being their true size, including the SMA connector.

Figure 2 shows the simulated and the measured return loss of the prototype DRA. The simulated result agrees reasonably well with the measured one. The measured return loss curve shows that the DRA has -6dB bandwidth of 220MHz with the centre frequency at 2.47GHz. This bandwidth is more than enough to cover IEEE802.11b/g applications.

**Fig. 2 The simulated and measured return loss with *l*=15mm, *w*=6mm, *h*=5mm and *tl*=9.2mm.**

**PERFORMANCE ANALYSIS:**

In order to further understand the operation of the DRA, we have analysed the effects of some of the design parameters in simulation. The permittivity, $\varepsilon_r$ of the ceramic pellet is first studied by changing its value from 80 to 120. The simulated return loss curves of the DRA with different permittivity are shown in Figure 3. Figure 3(b) shows that the prototype DRA is operating like a traditional DRA where the resonant frequency is proportional to the square root (Sqrt) of the permittivity.

(a) (b)

**Fig. 3 The simulated return loss of the DRA with *l*=15mm, *w*=6mm, *h*=5mm and *tl*=9.2mm for different permittivity, $\varepsilon_r$.**

The E-field distribution of the DRA is also studied by simulation. Fig. 4 shows the E-field in the side view of the antenna and it is noticed that there is a 180º phase change across the antenna. It has confirmed that the DRA is operating at $TM_{11\delta}$ mode.

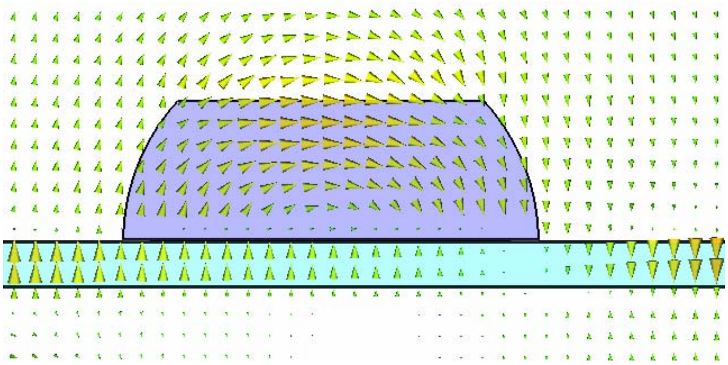


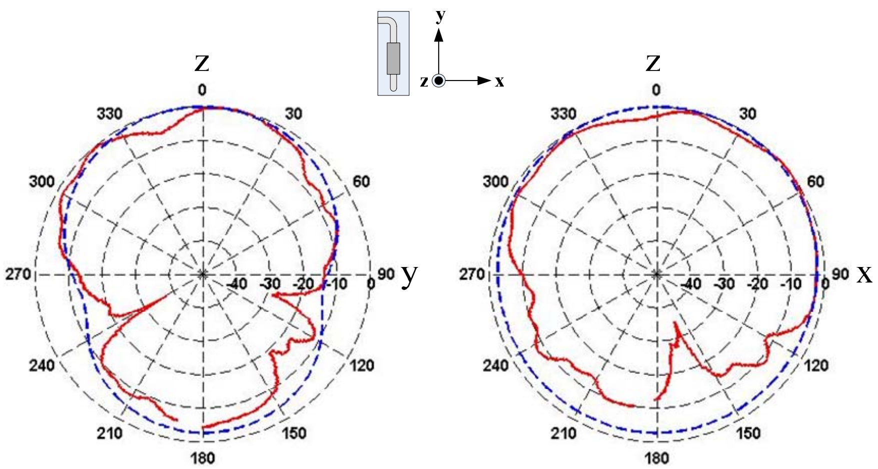
**Fig. 4 The simulated return E-field in the side view.**

The tuning stub has been introduced at the end of the microstrip line in the prototype DRA to improve the impedance matching, hence the positioning tolerance of the ceramic pellet. The effect of the distance of the tuning stub from the DRA *tl* has been investigated by simulation and the results are shown in Figure 5. It is realized that the optimal value of *tl* is found to be around 7.4mm, where the widest bandwidth and the greatest return loss at the resonant frequency can be achieved. Interestingly, it is noticed that the operating bandwidth is not very sensitive to the variation of *tl*. A good operating bandwidth is still maintained while *tl* varied from 5.4mm to 9.4mm.

**Fig. 5 The simulated return loss of the DRA with *l*=15mm, *w*=6mm, *h*=5mm and permittivity, $\varepsilon_r$ around 90.**

**RADIATION PATTERNS:**

The radiation patterns of the prototype DRA were measured inside an anechoic chamber with the transmitting field provided by a quad ridge horn with dual-polarisation capability. Figure 6 shows that E-plane and the H-plane of the DRA.




**(a)** **(b)**

**Fig. 6 Simulated (---) and measured (–) radiation patterns of the prototype DRA at 2.47GHz for (a) E-plane (y-z plane) and (b) H-plane (x-z plane).**

The front lobe of the simulated and measured radiation patterns agree to each other quite well. The simulated *H*-plane patters are quite omni-directional which is similar to traditional dipole or monopole. However, there are significant discrepancies between the simulated and measured results at the back lobe of the radiation patterns. This is mainly due to the present of the long coaxial cable connected to the antenna during the measurement in the anechoic chamber.

## CONCLUSION:

A new type of DRA feed method developed at Antenova Ltd, UK has been investigated both numerically and experimentally to reveal the principle of its operation. It has been shown that this simple feed method has improved the positioning tolerance of the ceramic pellet, making it very suitable for mass production. The size of the DRA is very small, with a length of only 0.12λ. The combination of both features make this type of DRA very attractive for use in small mobile terminals.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