OPTIMISATION OF A BROADBAND DIELECTRIC ANTENNA

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I. INTRODUCTION

This paper presents a design optimisation on a broadband dielectric antenna being developed at Antenova Ltd. UK. With the apprehension of its operating principle, some design parameters are optimised to achieve a smaller dielectric size and an even wider impedance bandwidth. The optimized antenna covers four frequency bands, DCS 1800, PCS 1900, WCDMA 2100 and IEEE802.11 2400, with a smaller dielectric (ceramic) pellet, which is only 1/4 of the original one.

II. PROTOTYPE ANTENNA

- **Dielectric substrate:**
  FR4 with a thickness of *H*=1.5mm, a relative permittivity ε_r=4.7, a length of L_S=80mm and a width of *W*=35mm.
- **Ground plane:**
  With a width of *W*=35mm and a length of L_g=63mm; On **back side** of the substrate.
- **Feed line & Metal coating:**
  50Ω microstrip line with a width of 2.6mm; on top side of the substrate, connected to a metal coating beneath the dielectric pellet with a width DR_w=7mm and length DR_l= 15.2mm
- **Dielectric pellet:**
  A top flattened half-cylinder with radius 7.6mm (1/2 *DR_l*) and height 7mm (*DR_w*), fabricated from a kind of ceramic with high permittivity around 90

Simulation software: CST Microwave Studio™ package.

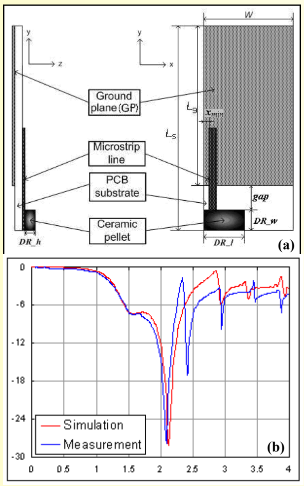

Fig. 1. (a) Geometry of the prototype antenna (b) Simulation and measurement return loss

Fig.1 shows a good agreement between the simulated and measured return losses

- **1st resonant frequency:** 2.11GHz; **2nd resonant frequency:** 1.6GHz
- **Bandwidth:** 1.433GHz to 2.25GHz (44%)

The measured **radiation patterns** are very close to those obtained in the simulation. The *H*-plane pattern is omni-directional, similar to that of the traditional monopole.

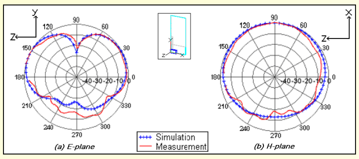

Fig. 2. Simulated and measured radiation patterns of the prototype antenna

Operating principle: The primary resonance (2.11GHz) is determined by the planar monopole and the width of the ground plane, with a ceramic pellet as load; while the secondary resonance is due to the radiation of the length of the ground plane. The overlap of the two resonances provides the wide bandwidth [1].

III. PARAMETER INVESTIGATION

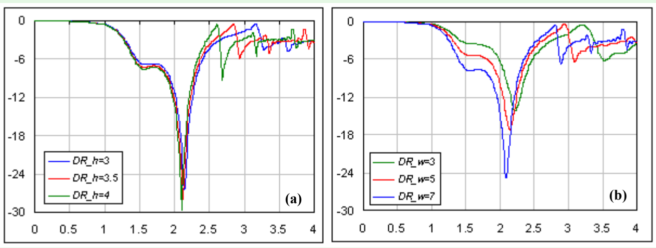

Fig. 3. (a) Return losses for antenna with different *DR_h* (3mm~4mm)
(b) Return losses for antenna with different *DR_w* (3mm~7mm)

The curves in Fig.3 (a) show that reducing the height of the ceramic pellet affects the return loss only slightly, so the *Dr_h* can be reduced to some extent without significantly degrade of the antenna's performance. In Fig.3 (b), the reduction of the ceramic width increases the resonant frequency of the major resonance and decreases the resonance of the second one at lower frequency. Therefore, if we want to reduce the size of the ceramic pellet drastically, other parameters need to be modified to enhance the minor resonance at lower frequency to make sure that this antenna still cover the 1800MHz band.

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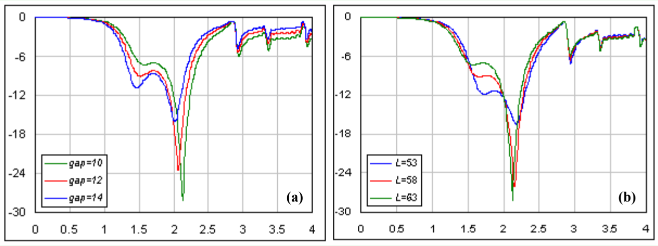

Fig. 4. (a) Return losses for antenna with different *gap* (10mm~14mm)
(b) Return losses for antenna with different *L* (53mm~63mm)

Fig. 4 illustrates the effects from the gap width and ground plane length. Both of them can enhance the second resonance, with the expense of the reduction of the upper frequency. Consequently, the optimisation is a trade-off between the ceramic size and other design parameters.

IV. OPTIMISATION DESIGN

Based on the parameter investigation above, an optimised design was obtained to achieve even wider bandwidth with a smaller dielectric (ceramic) pellet. The fabricated antenna has the parameters: *L*=70mm, *Dr_h*=3mm, *Dr_w*=2.5mm, *gap*=13mm, as shown in Fig. 5.(a). In this design, the size of the ceramic pellet is reduced substantially, compensated by adjusting the ground plane and gap width were reduced for compensation.

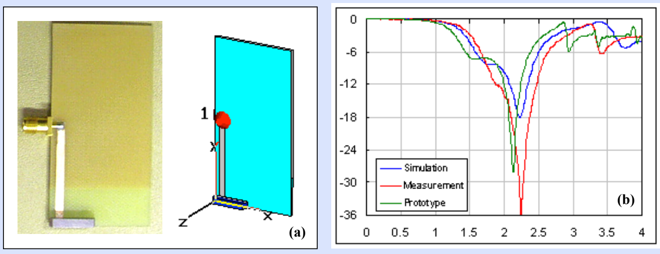

Fig. 5. (a) Photo and Model of the optimised design
(b) Return losses for simulated prototype antenna, simulated optimised antenna and measured optimised antenna

Fig. 5 (b) illustrates a good agreement between the simulated and measured results, especially the resonant frequency at 2.22GHz. The -6dB bandwidth of the optimised design has been moved to 1.65GHz ~ 2.63GHz, including the IEEE 802.11b/g 2400 band, as well as the originally DCS 1800, PCS 1900 and WCDMA 2100 bands. The simulated radiation patterns are similar to those of the prototype design.

CONCLUSIONS

The design parameters of a tri-band dielectric antenna operating at 1500 ~ 2200MHz for the wireless application have been studied in this paper. Based on the knowledge of the effects of each design parameter, an optimised design has been obtained to provide an even wider bandwidth from 1.65 GHz to 2.63 GHz, with a ceramic pellet almost a quarter of the size of the original. This size reduction lowers the cost as well as the weight of the antenna, both of which are important in commercial applications.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Scott Tyler of Antenova Ltd., John Dupuy of the Department of Electronic Engineering, Queen Mary, University of London, for their help in the fabrication and measurement of the antennas. The authors would like to acknowledge Computer Simulation Technology (CST), Germany, for the complimentary license of the Microwave Studio™ package.

REFERENCES

[1] Z.Wang, C.C.Chiau and X.Chen, "Study and Optimisation of a Broadband Dielectric Antenna", *International Workshop on Antenna Technology: Small Antennas and Novel Metamaterials*, March 7-9, 2005

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