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Low SAR Ferrite Handset Antenna Design

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ABSTRACT

Further research on the low SAR ferrite coated monopole handset antenna concept shows that different metallization geometries are non-unique regarding their influence on antenna multi-band performance. Simulation models with new metallization geometries are described and the techniques are extended to a balanced antenna previously developed by Antenova Ltd. Recent results of the ferrite adapted version illustrate the control of the multi-band structure while maintaining an overall low SAR performance and reasonable radiation efficiencies. Further research is identified and conclusions reached.

INTRODUCTION

Continuing research on the use of ceramic materials in mobile handset antennas [1-3] has demonstrated much design innovation featuring the inclusion of magnetic material, the control of resonator modes, the maintenance of low SAR and techniques for obtaining multi-band operation from a single block of material. PIFAs, meanderline antennas and various other types of planar metal antennas [4] are capable of multi-band operation and are cheap to manufacture but their near fields are more easily perturbed than ceramic coated antennas by the proximity of the handset circuit components and the operator's hand and head. The proximity effects significantly degrade the free-space radiation efficiencies of these 'metal only' antennas and furthermore it is difficult to reliably reduce the antenna's SAR.

With the certain prospect of more communication functions being demanded of mobile handsets there is even greater constraints on the allocation of handset space for additional antennas. As such there is increasing interest in multi-band antenna operation and in particular the reduction of SAR in those bands radiating most power; notably the lower frequency bands.

This present paper reports further progress towards a low SAR, multi-band, material coated antenna system and commences with the examination of additional designs for the control of the multi-band performance. Following this, it examines a recently reported balanced dielectric handset antenna at 1800MHz [5]. Simulations, using MicroStripes TLM tool, show how this configuration can be adapted with the inclusion of magnetic material and further improved such as to provide multi-band coverage together with high efficiency and a low SAR capability.

MULTIBAND LOW SAR ANTENNA DESIGN

There are many ways of exciting the lowest mode in a ceramic antenna but the use of a monopole exciter in this present research creates a pattern null in the direction of the user's head and consequently lowers the SAR significantly. The

performance is further enhanced by the presence of magnetic material as has been demonstrated previously [1-3]. Recent work examined the dual mode behaviour of a ferrite loaded dielectric resonator on a 40 x 40 mm ground plane [1], and by combining it with two wrap around open metal rings led to an increase in bandwidth and the creation of a tri-band antenna with monopole type radiation patterns [2]. The antenna was then incorporated onto a 40 x 100 mm mobile handset ground plane and by varying the relative permeability and permittivity μ' and ϵ' together with the monopole length, position, width and gap of the rings, the fourth band (UMTS) was achieved, resulting in the realisation of a quad-band material loaded antenna [3]. In order to maintain the nulls in the radiation patterns, which were disturbed by the asymmetric feed position on the longer ground plane, the block face overlooking the ground plane was metallised, leaving a 0.1mm gap at the block base to electrically isolate the metallisation and the lower ring from the ground plane. The final quad-band antenna design consisted of $\epsilon_r = 6$, $\mu_r = 6.6$, $\tan\delta_\epsilon = \tan\delta_\mu = 0.03$ and covered the GSM 1800, 1900, UMTS and Bluetooth bands at a $-6\text{dB } S_{11}$ level with efficiencies of 36.8, 36.1, 19.1 and 27.5% respectively [3]. The antenna was also simulated in the presence of a homogeneous spherical phantom. This resulted in an efficiency drop of 5%, unlike conventional PIFA and meander line antennas where reductions of 40% are observed [4]. The maximum 10g SAR was 0.11 W/Kg at 1.9 GHz compared to values varying between 1 and 2 W/Kg for the aforementioned types of antennas. The quad-band antenna was also modelled for $\tan\delta_\epsilon \sim 0$, $\tan\delta_\mu = 0.06$, in order to check the antenna performance against material variation and reproduced the same satisfactory results.

Having realised a quad-band antenna with good efficiency and low SAR, alternative designs involving reduced metallization and complexity have now been explored. The proposed surrogate quad-band design is shown in Figure 1 along with its corresponding S_{11} .

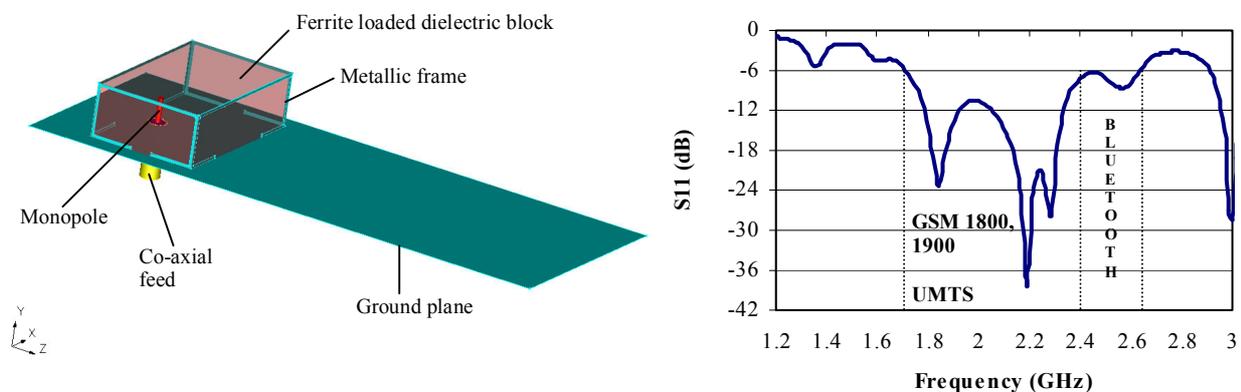


Figure 1 – Proposed quad-band handset antenna and corresponding return loss

The new design consists of a metal frame placed 0.1 mm above the ground plane, surrounding the ferrite loaded dielectric block which now consists of $\epsilon_r = 7.25$, $\mu_r = 7.2$, $\tan\delta_\epsilon = \tan\delta_\mu = 0.03$. The thickness of the strips is 0.5mm and their gaps along the x and y-axis are 16mm and 4mm respectively. As before, the frequency bands covered are: GSM 1800, 1900, UMTS and Bluetooth at -6dB return loss. The efficiencies are 33.8%, 42%, 24.5% and 26% respectively, which are similar to the previous design, if not increased in some instances.

The radiation patterns of this quad-band antenna are shown in Figure 2 for the yz and yx planes. For all bands there are clear pattern nulls in the $-y$ direction, corresponding to the position of the head. The advantage of this design compared

to that in [3] is that the null is controlled by the position of the monopole, which is offset by 6mm from the centre of the block, rather than some form of metallization that could potentially couple to the phone circuitry and affect the nature of the near field and consequently SAR. It is evident that no particular metallization design is unique in performance but different arrangements offer alternative features.

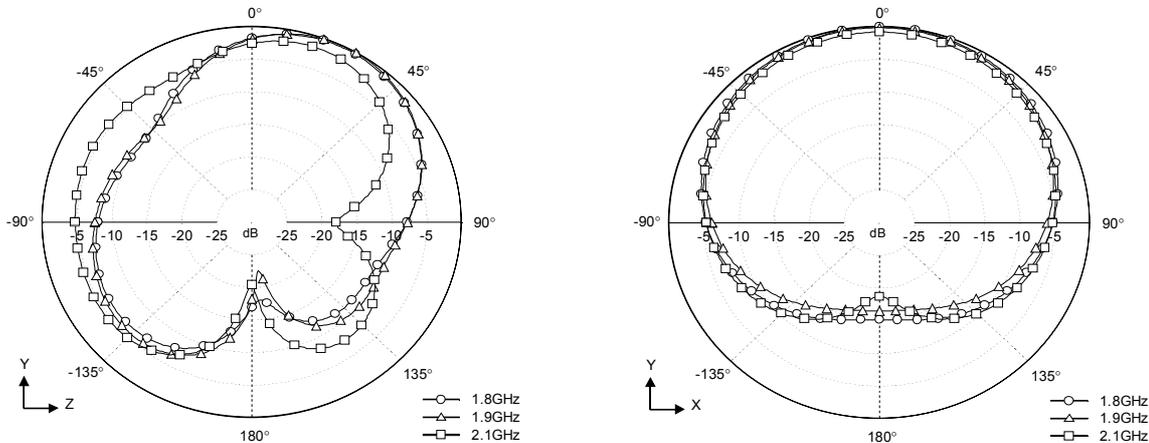


Figure 2 – Radiation patterns for quad-band handset antenna

In the presence of the head, the pattern nulls are maintained and the antenna efficiency becomes 31.7%, 38.9%, 20.7% and 27.5% for 1.8GHz, 1.9GHz, 2.1GHz and 2.45GHz respectively. This corresponds to a maximum efficiency decrease of 4% caused by the presence of the head, compared to a 40% drop of the PIFA. The corresponding 10g SAR values for the first three bands are: 0.026W/Kg, 0.045W/Kg, and 0.054W/Kg. These values are lower than the previous design and are attributed to the reduced metallization.

INCLUSION OF MATERIAL MIX INTO ANTENNOVA ANTENNA DESIGN

In an effort to explore the merits of the material loaded antenna and to extend to the GSM 900 band, it was decided to implement the material in an antenna with a different configuration. The new antenna was based on Antenova Ltd’s commercial GSM Radionova Radio Antenna Module, which is a high dielectric antenna covering the GSM 900, 1800 and 1900 bands. Amongst other benefits, it is claimed [5] to be diverse and efficient, resist detuning and have a low SAR. With no available data regarding the dimensions or actual performance of the antenna, its metal configuration was replicated and placed on top of a 30x20x10mm block made out of material with $\epsilon_r = 6.6$, $\mu_r = 6.05$, $\tan\delta_\epsilon = 0.0001$ and $\tan\delta_\mu = 0.06$. The antenna configuration and its corresponding return loss are shown in Figure 3.

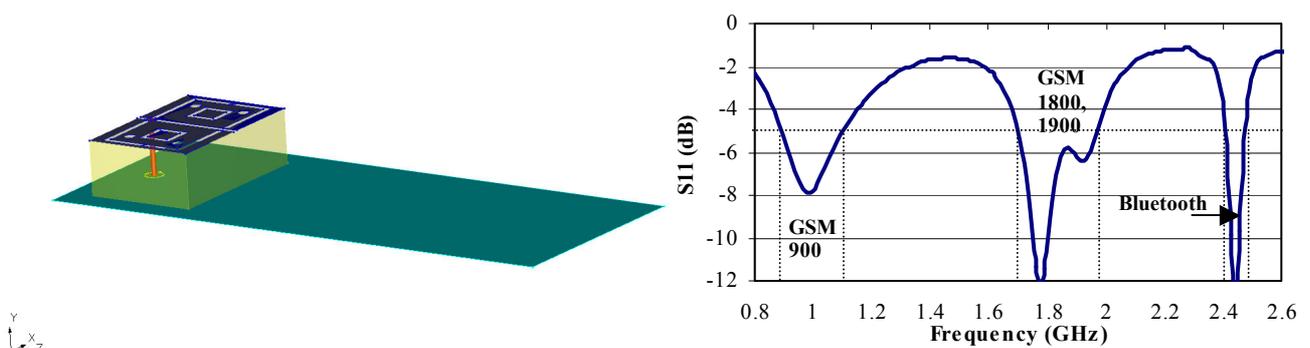


Figure 3 – Antenova configuration multi-band handset antenna and corresponding return

Simulation results indicate the coverage of GSM 900, 1800, 1900 and Bluetooth bands at -5dB with efficiencies of 15.6%, 44.3%, 39.7% and 6% respectively. Further enhancement of this performance is anticipated with continuing research. The yz and yx radiation patterns are shown in Figure 4.

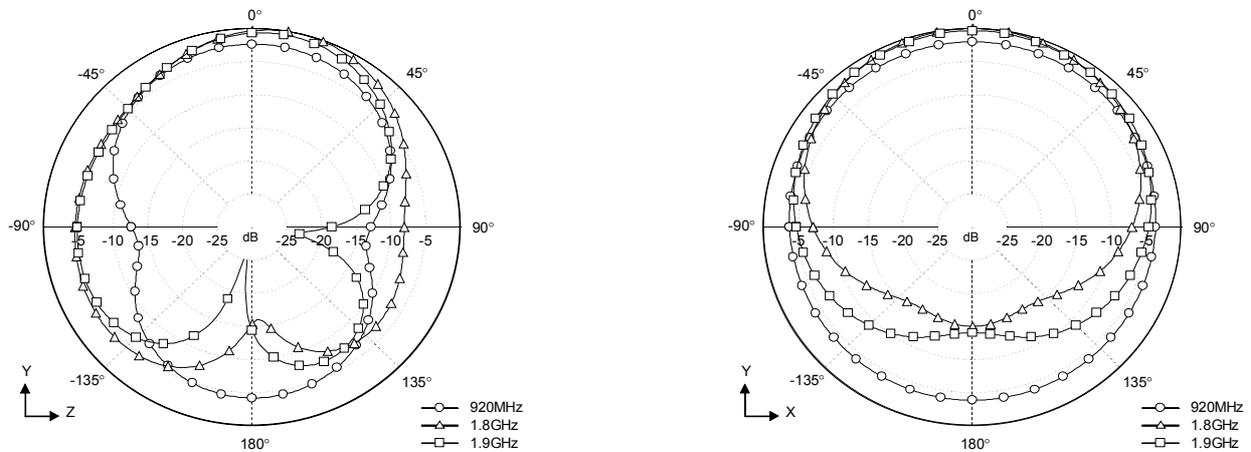


Figure 4 – Radiation patterns for Antenna configuration multi-band handset antenna

The radiation patterns possess pattern nulls at 1800 and 1900 MHz toward the head and as before indicate potential for low SAR. The 920MHz pattern is dipole-like with no distinct null.

CONCLUSIONS and FUTURE WORK

Continued simulation of the low SAR multi-band ferrite coated monopole configuration has revealed alternative metallization geometries to control the excitation process and the band structure. One such design with reduced metallisation and manufacturing requirements is presented, which results in high efficiency values and further reduced SAR. Additional research is required to identify the optimum geometry while the material mix and monopole offset remain key factors that influence the performance. These techniques have been applied to the Antenna balanced configuration, with very promising results. Initial studies show an increase in multi-band capability along with potential for very low SAR operation in all but the lowest frequency band. Further research is underway to refine and consolidate the adaptation.

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The authors acknowledge the support of Flomerics in providing their Micro-stripes TLM tool. This work is funded by the UK EPSRC, Grant number GR/R94596101