QUADBAND ANTENNA FOR HANDHELD PERSONAL COMMUNICATIONS DEVICES.

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ABSTRACT

The advent of new, multi-standard mobile phone devices is a real challenge for antenna designers, as they have to implement integrated multiband within a volume which is rapidly shrinking. In this paper, some investigations concerning the input return loss, field distribution and efficiency of a novel internal, quadband patch antenna are presented.

INTRODUCTION

To be competitive on the market, the latest personal communications handsets must face challenging demands. They have to operate within different networks with different standards (GSM900, GSM1800, PCS, UMTS), still fulfill design constraints such as small size, weight, and user acceptance, and must be low cost with respect to material and mounting.. The preferred solution nowadays are metallic patch structures with multiple resonance (different bands) which are easily adapted to the shape of the handset and can therefore be integrated within the back cover. This solution has different advantages: fashion designers do not anymore have to take into account the antenna, the phone becomes more robust as there are no external radiating elements that could break of, and the antenna can be produced in a more cost-effective way. Because more frequency bands must be covered by antennas that are contained in a volume that becomes ever smaller, miniaturisation is the keyword for the antenna designer.

In this paper, some of the experimental results obtained for a quadband (GSM 900/GSM 1800/PCS/UMTS) integrated antenna for mobile phones are presented.

DESIGN CONSIDERATIONS

As the volume available inside the handset is utterly reduced, a quarter wavelength concept was used, based on the Planar Inverted-F Antenna (PIFA) [1]. This concept consists of a probe-fed metal plate with a shorting pin, which provides a double resonance. A shorted parasitic plate, capacitively coupled to the main radiator adds a third resonance. To generate a fourth resonance, a slot was etched within the perimeter of the main patch. Thus, the frequency bands of four different standards can be covered, namely GSM900, GSM1800, PCS and UMTS. This antenna is based on previous dual-band and triple-band concepts [2][3].

The quadband antenna was developed within the limits of a 16x36x8 mm^3 rectangular area, with a height of 8 mm over a 36x95 mm^2 ground plane of FR-4 material, as depicted in Fig. 1. To assure the mechanical stability of the structure, the antenna was attached to an 8 mm-thick foam block, without any significant change of its performance. To simulate the effect of the plastic casing, a 1 mm thick plastic cover was also considered. The plastic material has a permittivity of ε_r=2.9, and was located 0.5 mm over the surface of antenna. The performance of the antenna was investigated with the FDTD-based field solver Empire [4]. Fig. 1 displays the simplified model used in the simulations.

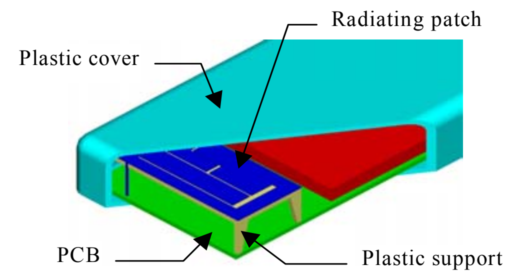


Fig. 1: Integrated quadband patch antenna with a plastic cover.

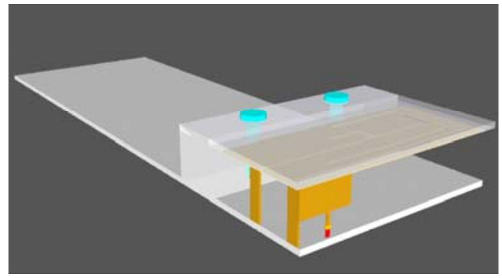


Fig. 2: Simulation model of the structure.

INPUT RETURN LOSS

A prototype of this antenna was built, and its input return loss measured using a HP8719D network analyzer. Fig. 3 shows how there is a good agreement between both between simulation with the FDTD-solver and the measured values. In both cases, the four resonance's of the structure are clearly visible, although a frequency shift appears, due to the discretisation of the structure prior to the simulation.

To provide mechanical stability of the structure, the antenna could be etched on a thin dielectric substrate. This support would have a strong influence on the antenna performance, as it changes the effective dielectric constant under the patch.

Fig. 4 illustrates this effect when RT/duroid substrates of different thickness are considered. This material features a dielectric constant of ε_r=2.2, and a dissipation factor of tan δ=0.004. It can be seen how the resonant frequencies are lowered by the use of the substrate. This decrease is higher with the thicker substrate, as the effective permittivity increases, and thus also the electrical length of the structure.

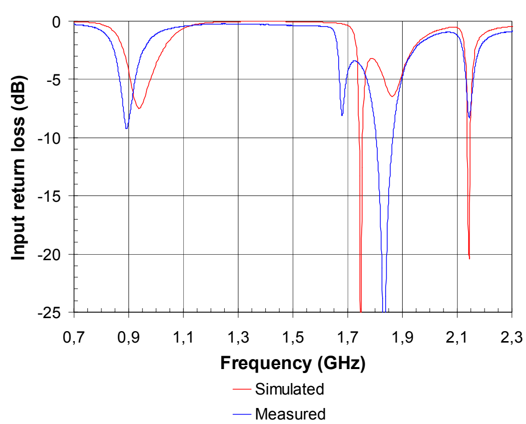


Fig. 3: Simulated and measured input return loss of the quadband antenna.

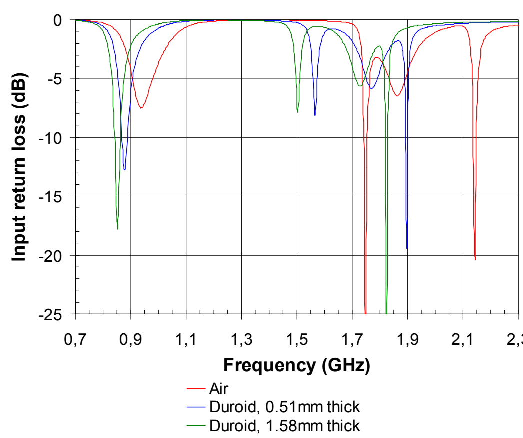


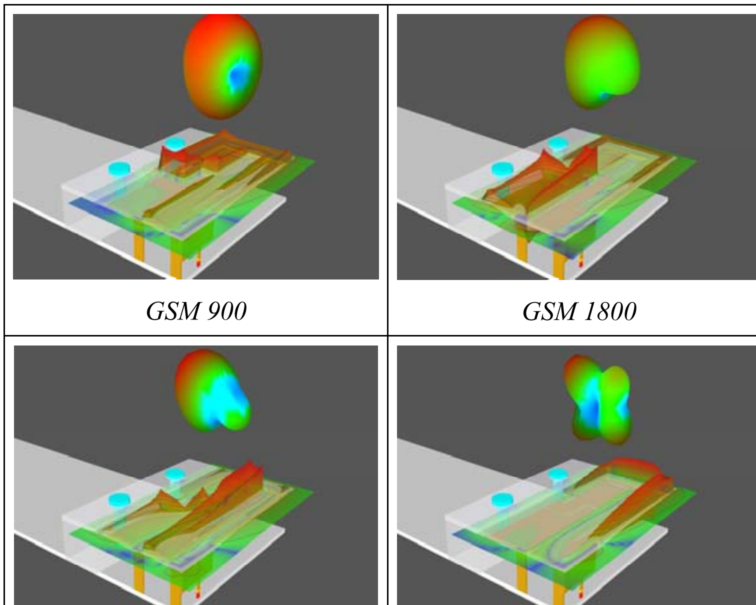
Fig. 4: Simulated input return loss of the quadband antenna on different substrates

Moreover, the coupling between the different parts of the structure is altered, thus changing the performance of the antenna. This must be compensated with a redesign of the patch, to comply with the requirements of the standards.

NEARFIELD AND FARFIELD

The simulated nearfield distributions and radiation patterns of the antenna in each frequency band are displayed in Fig. 5. The nearfield distributions show clearly how the GSM900/GSM1800/PCS bands are covered using resonant patch modes of electrical length λ/4. A fine tuning of the resonant frequencies can be achieved by adjusting the gaps between the different patches and changing their resonant length. On the other hand, the UMTS mode corresponds to the resonant slot, which has an electrical length of λ/2.

As for the radiation patterns, the antenna shows dipole-like behaviour for GSM900, whereas in GSM1800/PCS frequency bands the pattern resemble those of typical PIFA antennas, and the effect of the PCB board can be observed. UMTS features a more irregular radiation pattern, due to the shape and the orientation of the slot.



GSM 900 | *GSM 1800* | *PCS* | *UMTS*

Fig. 5: Electric nearfield and radiation patterns of the antenna.

EFFICIENCY

To point out the effect of the plastic cover on the antenna efficiency, an improved Wheeler-cap method [5][6] was used. Efficiency represents an important parameter when determining the radiation performance of a mobile handset, as it gives the ratio between the power delivered to the antenna and the power that is actually radiated.

Fig. 6 illustrates the difference between the antenna efficiency with and without plastic cover. A distinction was made between radiation efficiency, determined by the patch itself, and the total efficiency, which includes the effect of matching losses. If the matching was perfect, both curves would be superposed. As radiation efficiency is higher, and more constant over the frequency than the total efficiency, bandwidth restrictions are not caused by the antenna itself but by mismatching,. This effect is especially clear for GSM 1800, which corresponds to the first resonant mode in Fig. 6. Then, a passive matching network could be used to optimise the antenna efficiency.

The efficiency loss due to the plastic casing is about 5%. This can be attributed to dielectric losses, which remain almost constant over the considered frequency band. In any case, the performance of the antenna is rather good, as the total efficiency remains above 50%. The frequency bands are still to be further tuned, to comply with the standards.

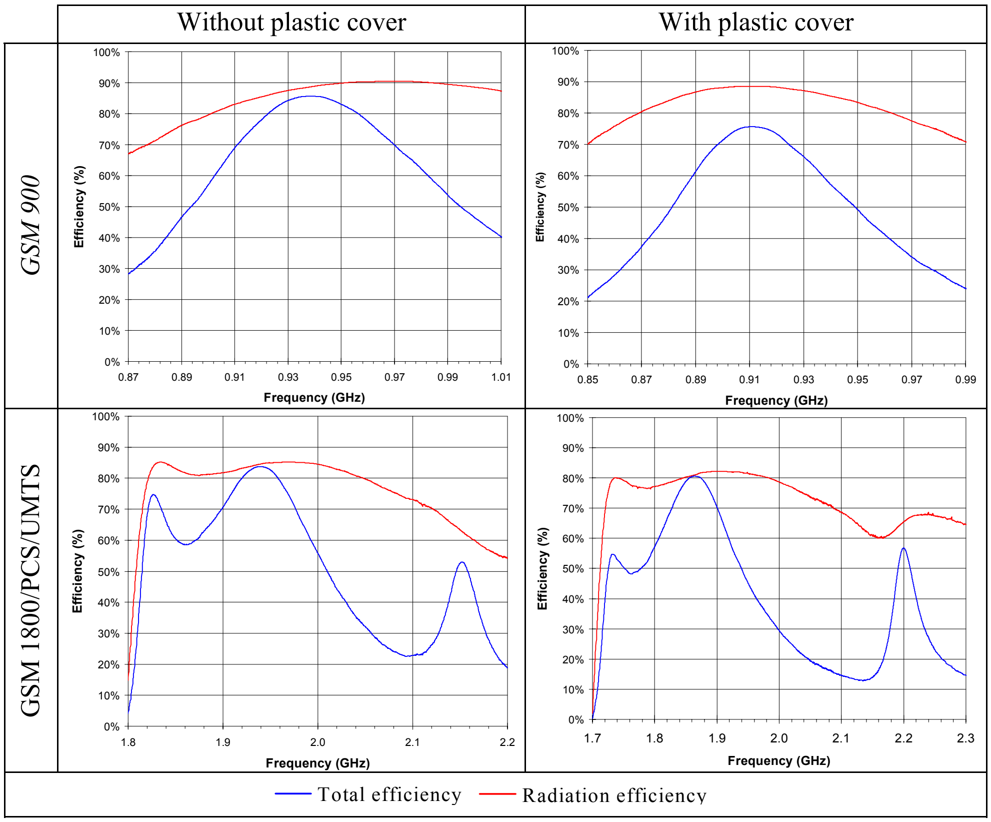


Fig. 6: Antenna efficiency, with and without plastic cover.

CONCLUSIONS

This work presents investigations concerning quadband integrated antennas for personal communications handsets. With a combination of metallic patches and slots, four different standards can be covered with one single, small antenna. Further investigations will focus on the interaction with the user, in terms of mismatching, efficiency loss and SAR.

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