NOVEL TRIPLE-BAND ANTENNAS FOR PERSONAL COMMUNICATIONS HANDSETS

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ABSTRACT

The rapid evolution of the mobile phone market requires the development of terminals, which can operate within different nets, and implement different standards. In most cases, these terminals feature multiband antennas. In this paper, some investigations on the influence of plastic carriers on the performance of a novel internal, triple-band patch antenna are presented.

INTRODUCTION

The increasing demand of multi-standard personal communications handsets fosters the development of small-size integrated multiband antennas. The preferred solution are are usually metallic patches with multiple resonances. These patches allow a great flexibility in the antenna design, as they are cost-effective and straightforward to produce, as well as easy to adapt to the shape of the handset. On the other hand, due to their lack of mechanical stability, they require some kind of fixation. In many cases, this is achieved by attaching the patch to a plastic carrier, which is clipped to the PCB of the mobile device. Yet, the use of such carriers affects the performance of the radiating element, as it changes the effective permittivity under the antenna, and introduces new losses. In this papers, some results concerning this topic are presented, in relation with the behavior of a triple-band integrated antenna.

DESIGN CONSIDERATIONS

In order to optimize the use of the limited space available for integrated antennas, most of the designs are based on a quarter wavelength concept. Among them, the Planar Inverted-F Antenna (PIFA) enjoys the largest acceptation [1]. This PIFA concept, which consists of a probe-fed metal plate with a shorting pin, was chosen as the basis for a dual-band antenna. A shorted parasitic plate capacitively coupled to the main radiator adds a third resonance. Thus, the frequency bands of three different standards can be covered. This antenna is based on previous dual-band developments [2],[3].

The novel triple-band 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. As the patch antenna consists of a metallic plate, it may need a plastic carrier to assure the mechanical stability of the structure. The performance of the antenna alone, and with carriers made of different plastic materials, was investigated with the FDTD-based field solver Empire [4].

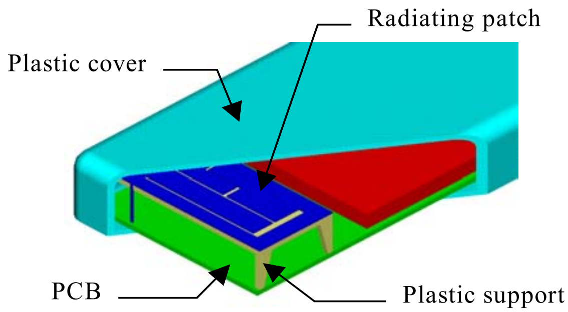

Fig. 1: Integrated patch antenna with a plastic carrier.

SIMULATED AND MEASURED RESULTS

A prototype of this antenna was built, and the input return loss measured using a HP8719D network analyzer. In a first step, no plastic carrier was considered. A comparison between the simulated and measured input return loss is presented in Fig. 2, and shows a good agreement between them. In both cases, the triple resonance of the structure is clearly visible. Although the performance is encouraging, the resonant frequencies have to be further tuned to comply with the desired standards.

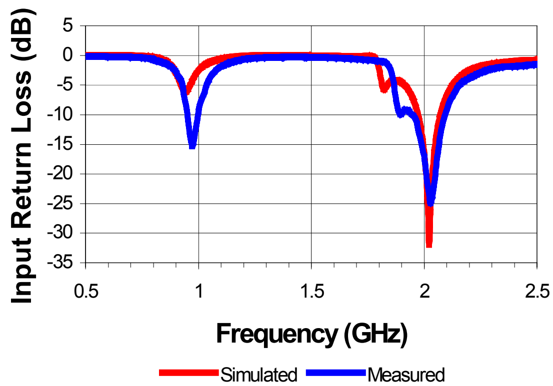

Fig. 2: Simulated and measured input return loss of the triple-band antenna

The Wheeler-cap method [5], [6] was used to characterize the radiation efficiency of the antenna. Fig. 3 illustrates the difference between the radiation efficiency, determined by the losses in the antenna itself, and the total efficiency, which includes also the matching losses. If the matching was perfect, both curves would be superposed. In this case, we get a high total efficiency (above 80%) in the frequency bands considered. The shift in the operating frequencies, previously mentioned, can also be observed.

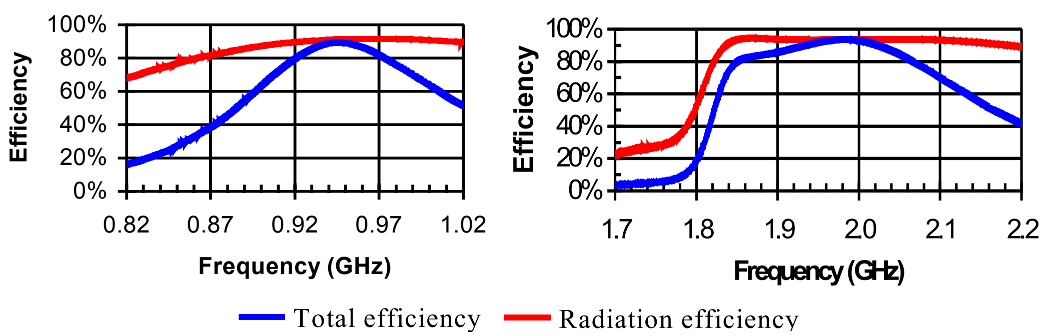

Fig. 3: Antenna efficiency for the GSM (left) and DCS/PCS (right) frequency bands

The low total efficiency at the outer boundaries of the GSM frequency band is not due to a small radiation efficiency, but to high input return losses. These could be compensated by the implementation of a matching network. On the other hand, this would not solve the lack of efficiency on the verges of the upper frequency bands. In this case, the low total efficiency is due to the losses in the patch itself.

EFFECT OF A PLASTIC CARRIER

In order to provide a better mechanical stability of the structure, the antenna was attached to a 1 mm-thick plastic carrier. The plastic support of the antenna has a strong influence on the antenna performance, as it changes the effective dielectric constant under the patch. Thus, the resonant frequencies of the patch are lowered by using plastics with a higher dielectric constant. Fig. 4 illustrates this effect for different commercial, 1mm-thick plastic supports. It can also be noted that the matching decreases with the increase of the dielectric constant, specially in the lower frequency band.

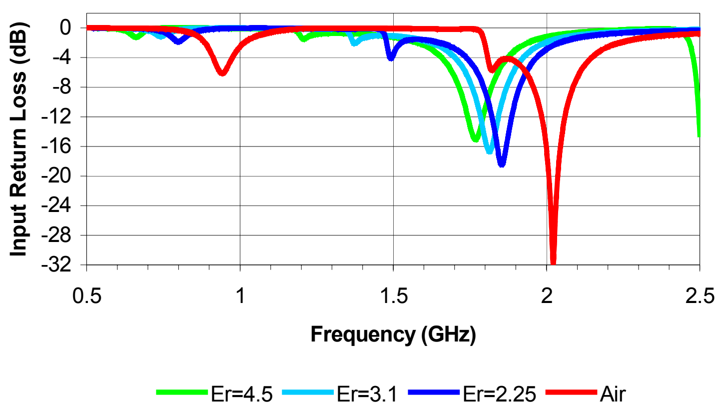

Fig. 4: Input return loss with different plastic carriers, made of different, commercial plastics.

Moreover, the capacitive effect between the different parts of the structure is enhanced by the presence of the plastic body, as the electric field is strongly concentrated in the dielectric. This effect can be observed in Fig. 5 and Fig. 6. There, the difference between the nearfield of an antenna without support, and with a 1mm-thick plastic carrier, with ε_r=4.5, is clearly illustrated. It can be observed how the capacitive effect between the different elements is enhanced by the presence of the dielectric material under the patch. The electric field is now concentrated in some specific regions, and the performance of the antenna is thus strongly modified by the formation of new hot spots.

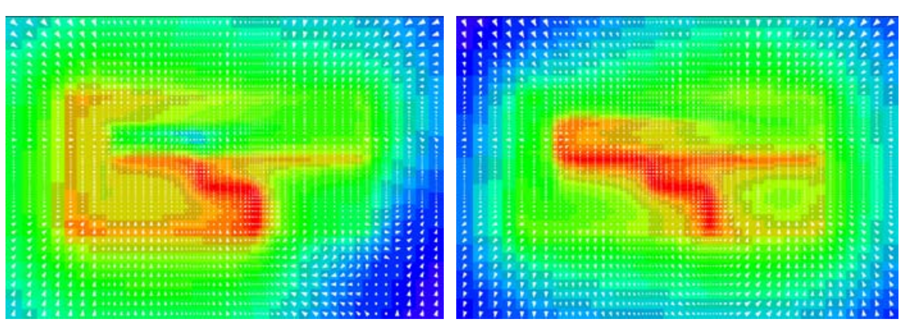

Fig. 5: Electric nearfield of the antenna normalized to its maximum, f=900 MHz. Antenna without support (left), and with a 1 mm-thick plastic carrier, ε_r=4.5 (right).

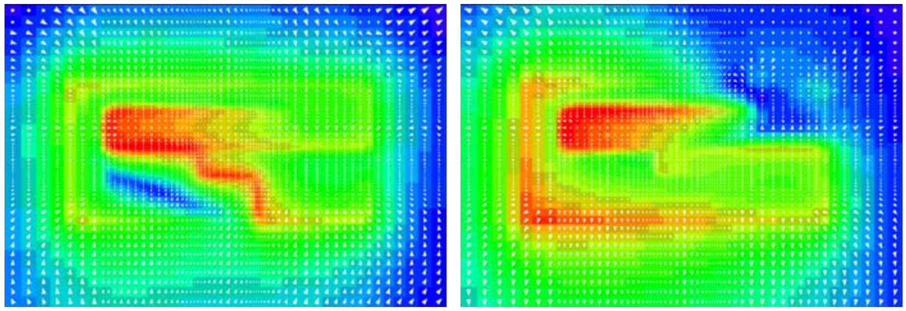

Fig. 6: Electric nearfield of the antenna normalized to its maximum, f=2 GHz. Antenna without support (left), and with a 1 mm-thick plastic carrier, ε_r=4.5 (right).

CONCLUSIONS

This work has presented some investigations concerning triple-band integrated antennas for personal communications handsets. The effect of plastic carriers has been illustrated, in terms of changes in the impedance matching and the field distribution. Further investigations will focus in more detail on the effect of plastic supports on the antenna efficiency and radiation characteristics.

REFERENCES

[1] T. Taga, Hirasawa and Haneishi, "Analysis of planar inverted-F antennas and antenna design for portable radio equipment", *Analysis, Design, and Measurement of Small and Low Profile Antennas*, Artech House, Boston/London, 1992, pp. 161-180.

[2] M. Martínez-Vázquez, M. Geissler, D. Heberling, A. Martínez-González and D. Sánchez-Hernández, "Compact dual-band antenna for mobile handsets", *Microw. and Optical Tech. Lett.*, Vol. 32, no. 2, Jan. 2002, pp. 87-88

[3] M. Martínez-Vázquez, M. Geissler and D. Heberling, "Volume considerations in the design of dual-band handset antennas", *IEEE Antennas and Propag. Society Symposium*, Vol. 1, July 2001, pp. 112-115.

[4] EMPIRE User and Reference Manual, IMST GmbH, 2000.

[5] D.M. Pozar and B. Kaufman, "Comparison of three methods for the measurement of printed antenna efficiency", *IEEE Trans. Antennas Propag.*, Vol. 36, no 1, Jan. 1988, pp.136-139.

[6] R.H. Johnson and J.G. McRory, "An improved small antenna radiation-efficiency measurement method", *IEEE Antennas Propag. Magazine*, Vol. 40, no 5, Oct. 1998, pp. 40-48.