Design of a quadband antenna system for PCMCIA

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Abstract

The advent of new standards and mobile communications devices a real challenge for antenna designers, as they have to implement integrated multiband operation within very different kinds of terminals, using sometimes more than an input port. In this paper, some investigations concerning the input return loss, isolation and efficiency of a novel internal, quadband patch antenna integrated into a PCMCIA are presented..

1 Introduction

The increasing demand for access to mobile communications through portable equipment such as laptops or PDAs fosters the development of small-size, multiband antennas integrated into PCMCIA cards, as shown in [1]. This allows to provide the desired connectivity almost everywhere, through the access to cellular or private networks. Therefore, both mobile standards, such as GSM, and unlicensed solution, i.e. WLAN, should be implemented.

Regarding the antenna technology, wire antennas such as monopoles or helix have been widely employed. Nevertheless, nowadays the preferred solution tends to the integrated patch antennas, as shown in **Fig 1**.. Again, as multiple standards have to be covered, metallic patches with multiple resonances are frequently used. 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 allocated volume.

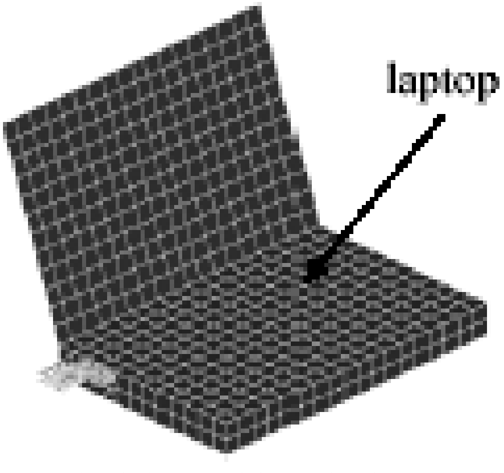

Fig. 1 Simulation model of the laptop with the PCMCIA

Furthermore, this PCMCIA must be compatible with different mobile and wireless standards, such as de GSM family and WLAN. Thus more frequency bands must be covered by antennas that are contained in a volume that shrinks rapidly, requiring high efficiency small antennas.

2 Description of the structure

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. Its structure allows obtaining two resonances: one to cover the GSM bands, the second for DCS and PCS operation. Indeed, though usually multiple resonances are preferred to cover these two overlapping bands, a single mode with enough bandwidth can also be used.

Additionally, an Inverted-F Antenna (IFA) was added, to ensure the access to WLAN. It consists on a flat structure printed onto a non-metallised area of the PCB board. The WLAN radiator is fed through a different port as the GSM patch, to comply with the current requirements of hardware manufacturers, who can thus use cost-performant circuitry. This in turn arouses some problems concerning the isolation between the ports, which have to be addressed in order to obtain a good performance. The final structure is presented **Fig 2**.

The GSM/PCS/DCS antenna occupies a volume of 50mm x 18mm x 8mm, whereas a surface of 29mm x 6mm was reserved for the WLAN IFA. The overall sice of the PCMCIA board is 54mm x 110mm.

Fig. 2 Simulation model of the multiband antenna on a PCMCIA.

3 Matching characteristics

The antenna structure was simulated using the FDTD-based *em*-solver EMPIRE [3]. The obtained results are displayed in **Fig 3** and **Fig 4**.

Fig 3 shows how two resonant modes are excited in the main patch, to cover the mobile frequency bands (GSM/DCS/PCS), whereas the IFA connected to the second port accounts for the WLAN operation.

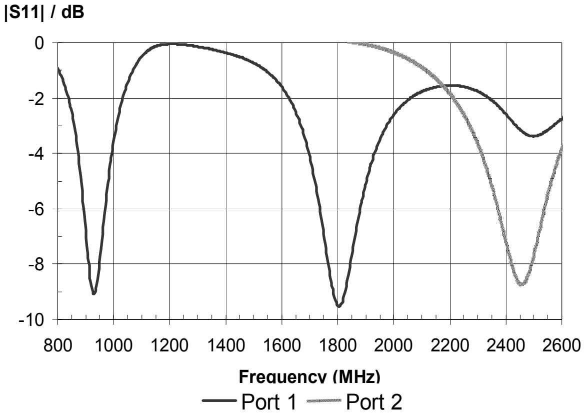

Fig. 3 Simulated input return loss for GSM/DCS/PCS (Port 1) and WLAN (Port 2).

In **Fig 4** the isolation between both ports is represented. This isolation is better than –7 dB for all the frequencies of interest, which should guarantee the correct performance of the system.

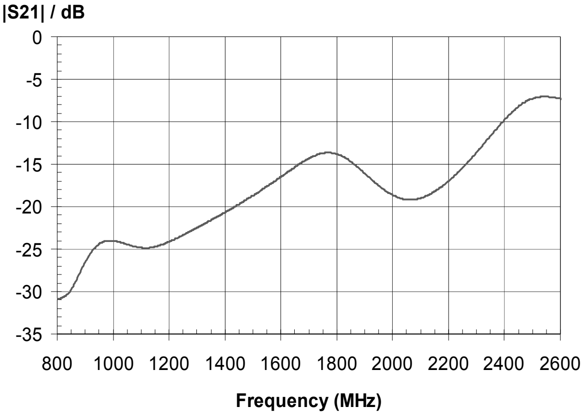

Fig. 4 Simulated isolation between the GSM/DCS/PCS port (Port 1) and the WLAN port (Port 2).

Then, a prototype of the antenna for the PCMCIA was built and mounted onto a test PCB. For the measurements, the two ports of the test antenna were connected to two semi-rigid cables. The PCMCIA card was inserted in the corresponding slot of a laptop, and the matching performance was measured using a HP8719D network analyser. When measuring at one port, the other port was terminated with a 50 Ohms load.

The measurements represented in **Fig 5** and **Fig 6** show that the antenna displays good matching performances, allowing to cover the frequency bands defined by the four standards with only three resonant modes. Thus, a matching better than –6 dB is achieved even in the band limits for the DCS, PCS and WLAN bands. As for GSM, the –6 dB matching level for the lower limit of the GSM band should be easily achieved through a slight tuning of the resonant frequency.

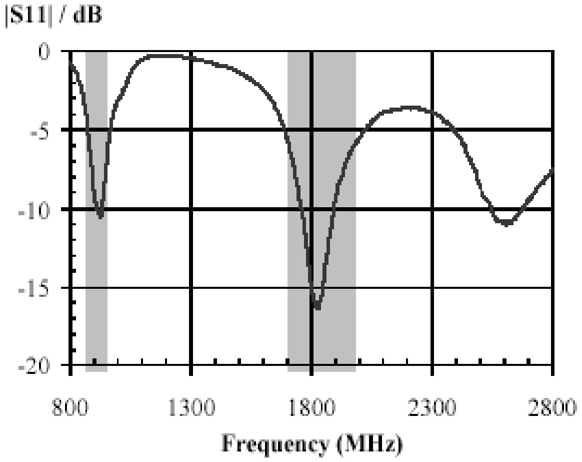

Fig. 5 Measured input return loss for GSM/DCS/PCS (Port 1).

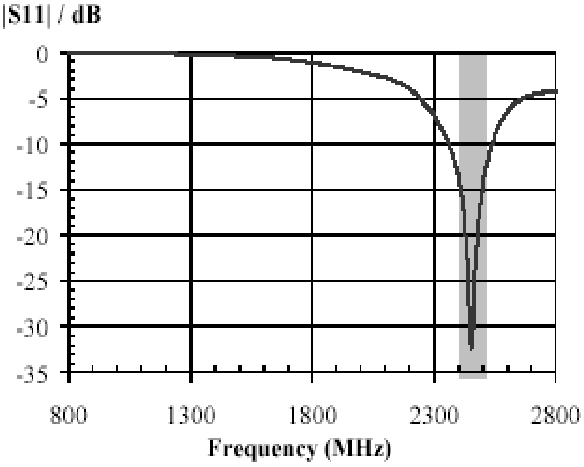

Fig. 6 Simulated input return loss for WLAN (Port 2).

The isolation between the two ports, reflected through the transmission coefficient S_{21}, was also measured using the HP8719D network analyser. The obtained results are shown in **Fig 7**.

As expected, the isolation values are better than –8 dB throughout the whole frequency band considered for the measurements, therefore no coupling problems are expected during the intended normal operation of the device, when used within a laptop.

In any case, from the results shown in **Fig. 3** to **Fig. 7** it can be inferred that the FDTD simulation is a good approach to the actual performance of the antenna, and an important tool during the design phase. Indeed, it can be observed that both matching and isolation measurements widely agree with the results obtained through simulation.

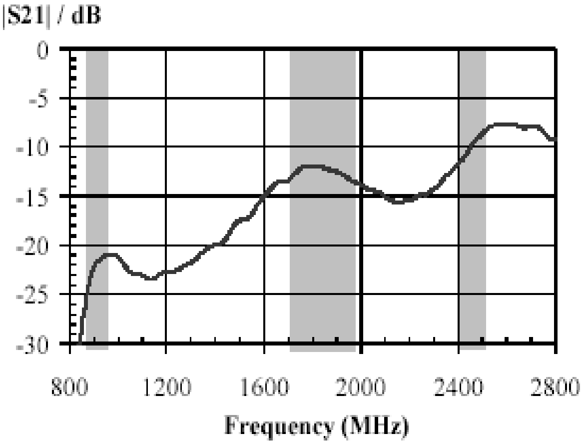

Fig. 7 Measured isolation between the GSM/DCS/PCS port (Port 1) and the WLAN port (Port 2).

3 Efficiency

To further characterise the antenna performance, its efficiency was also measured, using an improved Wheeler-Cap measurement setup [4]-[5]. 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. Only the PCMCIA card, and not the whole laptop, was considered when measuring the efficiency.

The efficiency levels attained for the different frequency bands are shown in **Fig. 8** to **Fig. 10**.

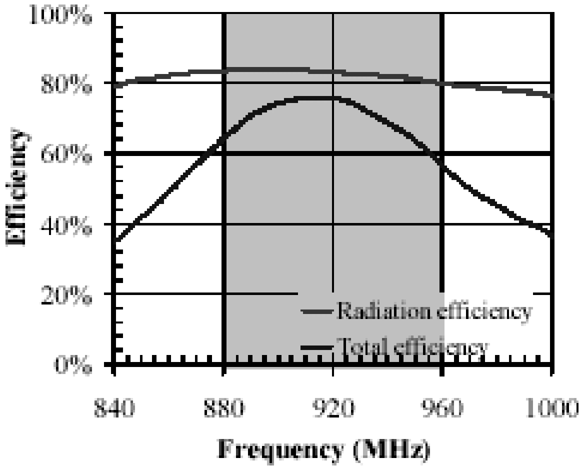

Fig. 8 Measured antenna efficiency in the GSM frequency band.

In the results a distinction was made between radiation efficiency and the total efficiency. The total efficiency is determined by the patch itself, whereas the radiation efficiency includes the effect of the losses that arouse due to mismatching. If the matching were perfect, both curves –radiation efficiency and total efficiency- 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.

For all the frequency bands considered, the total efficiency of the antenna remains over 60%, which is more than enough for the mobile and wireless applications envisaged for this device.

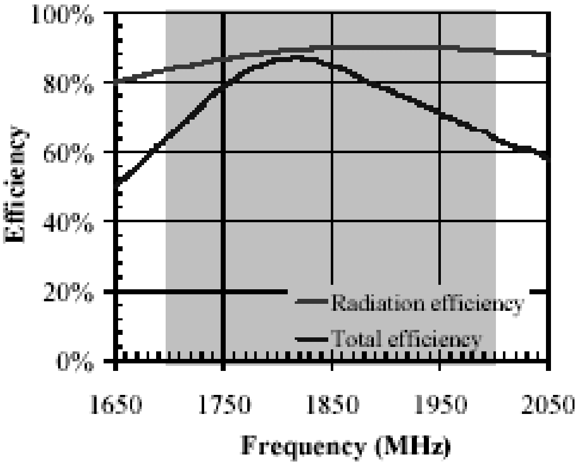

Fig. 9 Measured antenna efficiency in the DCS/PCS frequency band.

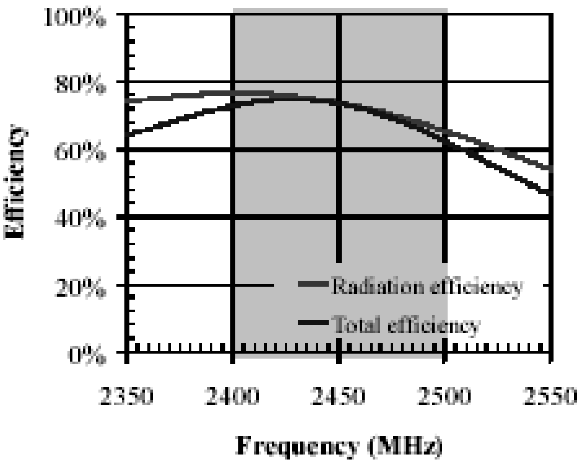

Fig. 10 Measured antenna efficiency in the WLAN frequency band.

3 Conclusions

This work presents investigations concerning multistandard integrated antennas for personal communications integrated onto a PCMCIA. With a combination of metallic a dual-band PIFA and an IFA, four different standards can be covered with a small antenna system. Though two different ports have been used, good results have been obtained concerning matching, isolation and efficiency levels. Further investigations will focus on the radiation properties of the antenna in a normal operating environment, i.e. in presence of the user.

3 Literature

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