PCMCIA MULTI-STANDARD ANTENNA FOR LAPTOPS

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ABSTRACT

In this paper, a multi-standard PCMCIA antenna system is presented. This system can be used to connect laptop computers to GSM nets within three different frequency bands, as well as WLAN. To implement both standards, a dual-port configuration was used. Some results concerning the simulation and measurement of the antenna system are discussed, including input return loss, isolation, radiation patterns and efficiency.

INTRODUCTION

The need for mobility when using portable devices such as laptop computers has fostered the development of efficient small antennas, which can be integrated into PCMCIA devices [1], and thus replace protruding elements such as monopoles or helix antennas.
To provide the desired connectivity, access to cellular, unlicensed and private networks must be possible. Therefore, mobile cellular standards, such as the GSM family or third generation standards such as UMTS should be supported, along with other ISM standards, like WLAN.
To implement a multi-standard PCMCIA antenna system that covers simultaneously the frequency bands of the GSM family GSM (namely, GSM 900, GSM 1800 and GSM 1900) and WLAN, a system consisting in a shorted patch in combination with a printed inverted-F antenna will be used. Two feeding ports will necessary, in order to comply with the current requirements of hardware manufacturers, who can thus use cost-effective 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.

DESCRIPTION OF THE STRUCTURE

The simulation model of the structure of the PCMCIA with the antenna system is presented in Fig. 1, whereas in Fig. 2 the simulation model includes the effect of the laptop. The overall size of the PCMCIA board is 54mm x 110mm, whereas the size of the laptop body is 280mm x 300mm x 30.

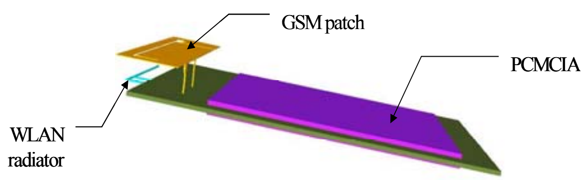

Fig. 1: Simulation model of the multiband antenna on a PCMCIA.

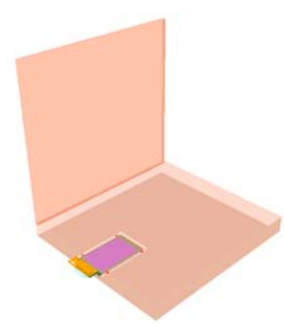

Fig. 2: Simulation model of the PCMCIA within the laptop.

A PIFA [2] concept was chosen to cover the GSM bands. It consists of a probe-fed metal plate with a shorting pin. Two resonant modes are thus excited: the first one for the GSM 900 band, the second one has enough bandwidth to cover both the GSM 1800 and GSM 1900 bands. The GSM 900/1900/ 1800 antenna occupies a volume of 50mm x 18mm x 8mm.
Additionally, a separate Inverted-F Antenna (IFA) was used to implement WLAN operation. It consists of a shorted wire printed onto a non-metallised area of the PCB board. For this antenna, a surface of 29mm x 6mm is used.
Fig. 3 displays the actual implementation of the structure. A semi-rigid cable was connected to each of the antenna feeding points, for measurement purposes.

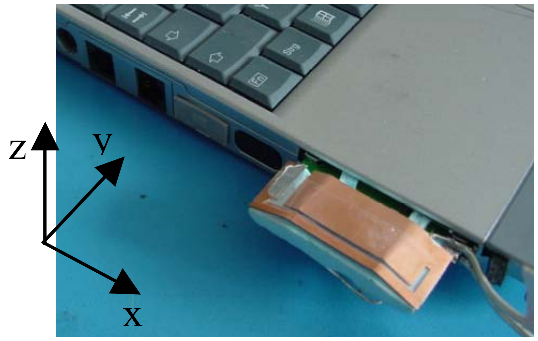

Fig. 3: PCMCIA antenna: implementation and measurement setup.

MATCHING CHARACTERISTICS

The antenna performance, both with the PCMCIA only and with the laptop, was simulated using the FDTD-based em-solver EMPIRE [3]. Then, a prototype of the antenna for the PCMCIA was built and mounted onto a test device. Its performance was measured using a HP8719D network analyser. During the measurements, the PCMCIA card was inserted into the corresponding slot of the test laptop. When measuring at one port, the second port was terminated with a 50Ω load.
Fig. 4 shows how two resonant modes are excited on the main patch, to cover the cellular frequency bands (GSM 900/1800/1900), when port 1 is excited. The measurements represented in show a good agreement with those predicted by the simulation. The antenna displays good matching performances, and thus the frequency bands defined by the three standards of the GSM family can be covered with only two resonant modes. A matching better than –6 dB is achieved even in the band limits for GSM 1800, GSM 1900. As for GSM 900, the –6 dB matching level for the lower limit of the GSM 900 band should be easily achieved through a slight tuning of the resonant frequency.
The matching properties at the WLAN port are displayed in Fig. 5. Again, a good agreement is found between the simulated and measured results. In the simulation of the antenna with the laptop a second resonance appears, which is due to the imperfect modelling of the connexion between the PCMCIA and the laptop. operation, regarding. Nevertheless, in the WLAN frequency band the influence of the laptop is less significant than in the case of the GSM frequency bands, so the measured results are very close to those of the simulation of the PCMCIA only.
Again, the antenna displays good matching characteristics, that satisfy the requirements of the WLAN standard.

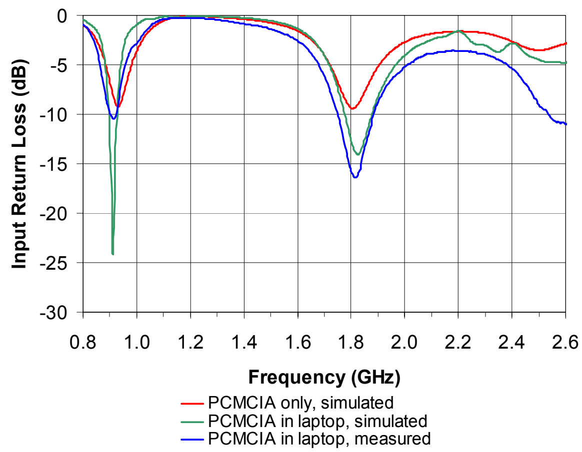

Fig. 4: Input return loss. Port 1: GSM standards.

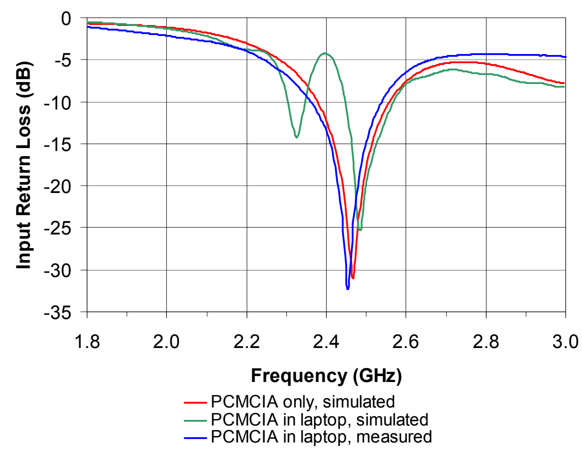

Fig. 5: Input return loss. Port 2: WLAN

In Fig. 6, the simulated and measured transmission coefficient S_{21} between the two ports of the antenna is represented. Again, a good correspondence is achieved between simulation and measurements for the PCMCIA inserted into the laptop for the GSM standards. For WLAN, a better agreement is reached when the simulation of the PCMCIA alone are considered. As expected, the measured isolation values are better than –8 dB throughout the whole frequency band. Therefore, no coupling problems are expected during the intended normal operation of the device.

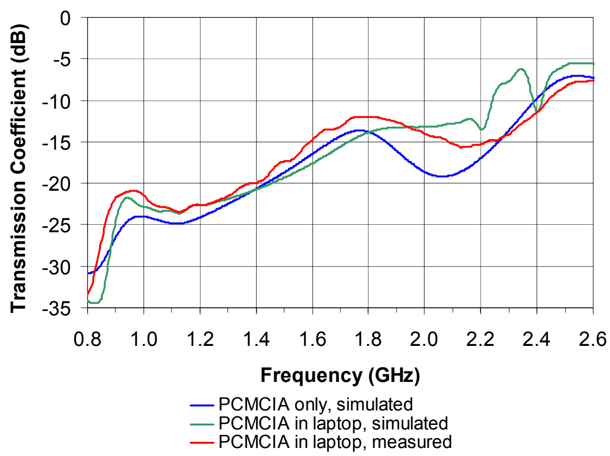

Fig. 6:Simulated and measured transmission coefficient.

RADIATION PATTERNS

The simulated radiation patterns of the PCMCIA antenna in the laptop slot for the different frequency bands are displayed in ***Fig.*** *7*. It can be observed how a distortion of the patterns appears, due to the presence of the notebook. The obtained results are similar to those normally obtained when considering integrated PCMCIA antennas.

The measurement results concerning the antenna gain are summarised in ***Table 1***. To reproduce typical operation conditions, the measurements were carried out with the notebook open, and the PCMCIA inserted in the proper slot. Then, the total electric field was considered. The obtained values are again compatible with the usual specifications for this kind of mobile communications devices.

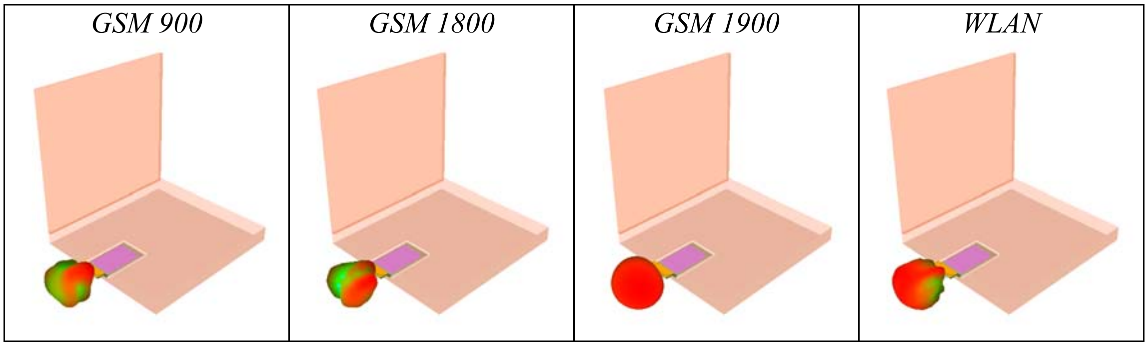

Fig. 7: Simulated radiation patterns of the PCMCIA antenna in the laptop.

Table 1: Measured antenna gain.

Standard	Centre frequency (MHz)	Maximum gain (dBi)	Average gain (dBi)
GSM 900	920	1.9	-3.7
GSM 1800	1795	3.9	-1.2
GSM 1900	1920	2.2	-1.9
WLAN	2450	2.8	-2.5

In Fig. 8, the measured radiation patterns in the azimuth plane are presented. Like in the simulations, it can be noted that the patterns are distorted, due to the shadowing effect of the notebook. Nevertheless, good azimuth coverage is achieved for all the standards considered here, thus this antenna configuration is suitable for cellular and wireless applications.

EFFICIENCY

The antenna efficiency was also measured, in order to further characterise the performance of the system. This was achieved using a Wheeler-Cap measurement setup adapted to the measurement of small mobile communications devices [4]-[5]. Due to size limitations for the objects under test, only the PCMCIA card, and not the whole notebook, was considered. The efficiency values attained for the different frequency bands are shown in Fig. 9. These efficiency results are congruent with the measured gain in each frequency band. GSM efficiency is slightly higher than the corresponding average gain. This is due to the fact that, in the measurement of the radiation patterns, the effect of the laptop was included, and that ferrites were used to attenuate the distortion introduced by the cables in the measurements. The total efficiency of the antenna remains over 60% over the different bands of interest. Therefore, the use of this configuration would be possible in a realistic mobile communications scenario. If some improvement of the total efficiency or the bandwidth should be required, the use of a passive matching network could also be considered.

CONCLUSIONS

An integrated, multi-standard antenna system for PCMCIA has been presented. Four different standards can be covered using a combination of a dual-band PIFA and an IFA. The antenna system shows good matching and isolation performance on both input ports. The radiation properties and efficiency characteristics are also compliant with the required levels. Further investigations deal with the integration of a second WLAN radiator, to implement a diversity scheme to improve the system performance.

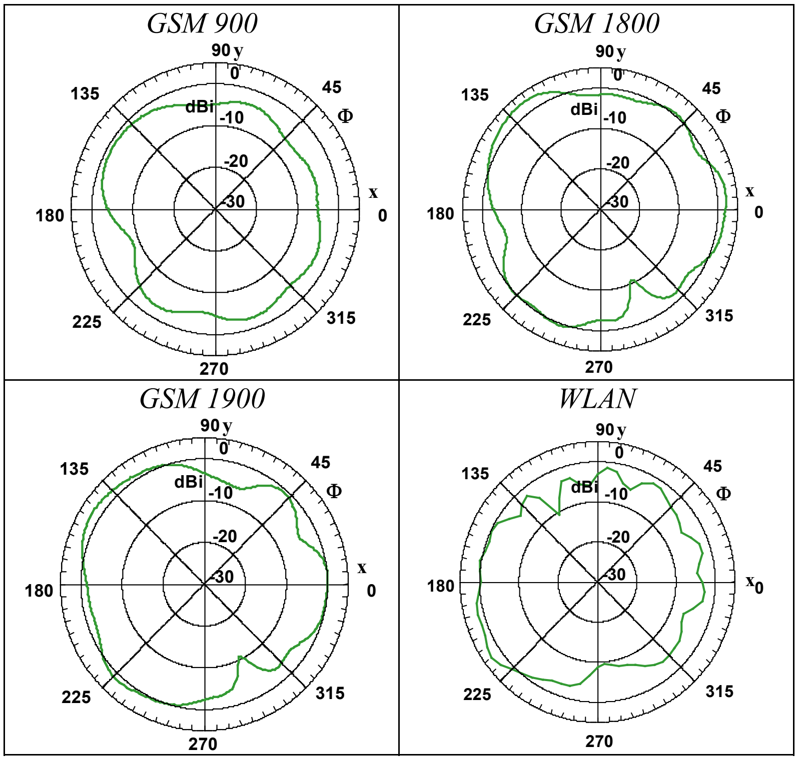

Fig. 8: Measured radiation patterns (azimuth).

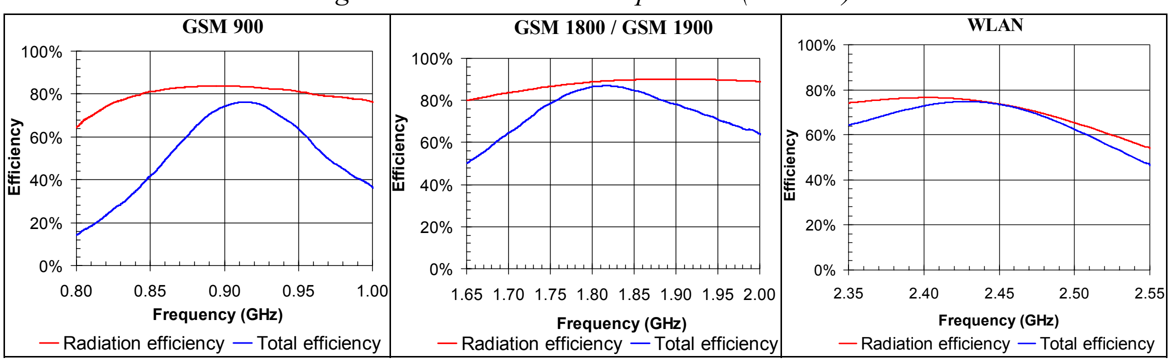

Fig. 9: Measured efficiency for GSM 900 (left), GSM 1800/1900 (centre) and WLAN (right).

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