Simulation and Measurement of Narrow-Band Antennas for Small Terminals

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***Abstract*—In this paper both normal-band and narrow-band PIFA antennas for small terminals are compared through numerical simulations and measurements for different UMTS bandwidths. It is found that using different antennas for the transmitting and receiving regions of the frequency duplex it is possible to achieve a significant improvement in terms of isolation. Measurement results show also that ohmic losses lower the total efficiency in the narrow-band case especially at low frequencies.**

Keywords; narrow-band antennas; small antennas; antenna isolation;

I. Introduction

The growing demand for smaller and thinner handsets is threatened by the fundamental limitations of small antennas operating in a given volume [1]. The mutual coupling between different antenna elements is detrimental to the antenna efficiency especially at low frequencies, where the ground plane acts as the main radiator [2]. As the tradeoff between antenna size, efficiency and bandwidth cannot be avoided [3], novel approaches focusing on narrow-band antennas might be a candidate solution [4]. In fact if the antennas are narrow-band, their mutual coupling is expected to be inherently lower, leading to higher efficiency and smaller size [5]. The Transceiver Separation Mode (TSM) [6] considers two separate receiving and transmitting antennas exhibiting high isolation. In this paper we are comparing 4 handsets based on the aforementioned paradigm, both numerically and experimentally. Each handset consists of a pair of PIFA antennas on a 40mm x 100mm ground-plane.

TABLE I

Description of the manufactured and simulated handsets 1-4 with total efficiency. The total efficiency is simulated in FDTD and measured in anechoic chamber in correspondence of the best impedance match of each receiving antenna (RX). h is the height of the PIFA over the ground plane.

Handset	UMTS Frequency Band	Antenna Impedance Bandwidth	h [mm]	Sub-strate ε_r	η_{Tot} (RX) [dB]	
					Sim.	Meas.
1	I	NOB	5	none	-0.3	-0.6
2	I	NAB	1	none	-0.1	-0.9
3	V	NAB	2	2.3	-0.8	-4.9
4	V	NOB	10	2.3	-2.7	-3.8

Both normal-band (NOB) and narrow-band (NAB) operation is investigated for two UMTS bands (I, V). The geometrical features of the handsets are illustrated in figure 1 and summarized in table I that also shows results.

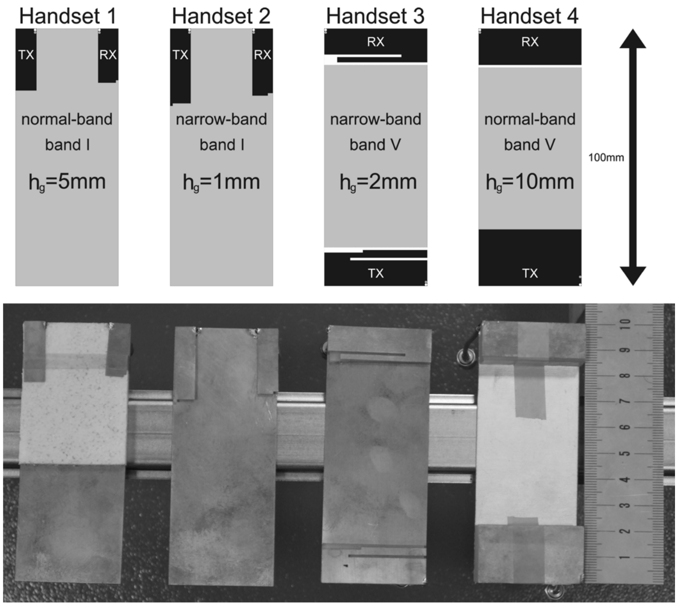

Fig. 1. Simulated and manufactured handsets 1-4. Handset 1 had a white Styrofoam brick only used as support (ε_r=1.03).

II. Simulation and Measurement Results

Figures 2, 3 show a comparison between the simulated and measured scattering parameters S_{11}, S_{22}, and S_{21} for all 4 handsets. Except a frequency shift due to cable influence in the low band and imperfections in the manufacturing process, it is found a fair agreement between measurements and simulations. In figure 2 handsets 1 and 2 in the high UMTS band (I) are compared, showing that a -25dB isolation level is achievable when narrow-band antennas are used. The low band (V) handsets 3 and 4 exhibit an impressive isolation level of -20dB despite the very high coupling of their normal-band counterparts. In table V the simulated and measured total efficiencies for handsets 1-4 are shown.

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For band I the total efficiencies are very good in both normal-band and narrow-band cases. Concerning band V handsets, the measured loss is significantly higher than the simulated one. This could be explained by the underlying phenomena taking place in real-life narrow-band antennas. It is well known that ohmic losses tend naturally to increase as the bandwidth shrinks, but other side-effects such as imperfect soldering, non-ideal dielectric substrate and contact loss might concur in lowering the total efficiency. Moreover, the strong currents flowing in narrow-band antennas might be deviating around the discontinuities of the antenna metal edges. All this happens while keeping the mutual coupling very low, which is instead the dominant loss factor in the normal-band antennas.

III. Conclusion

In this paper we investigated through measurement and simulation the novel concept of transceiver separation mode. Both low and high UMTS frequency bands were studied comparing normal-band and narrow-band antennas in 4 different handsets. Despite narrow-band antennas exhibit very attractive features in terms of isolation improvement with respect to their normal-band counterparts, more research effort is needed in order to properly understand the loss mechanism, especially in the low frequency band.

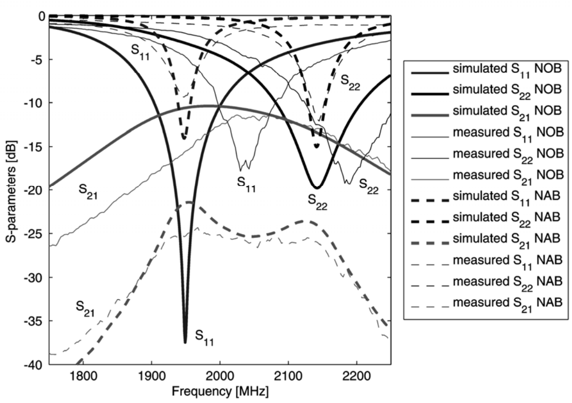

Fig. 2. Comparison of the simulated and measured scattering parameters for handsets 1, 2 (band I).

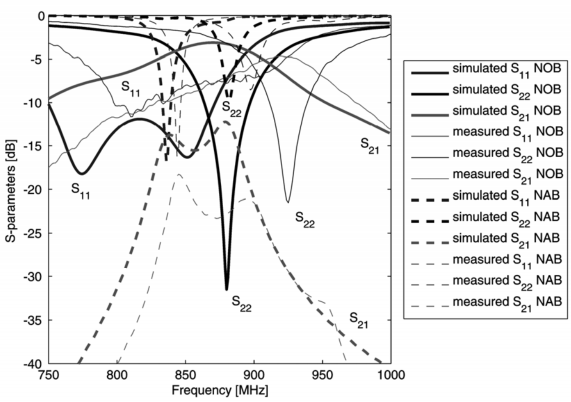

Fig. 3. Comparison of the simulated and measured scattering parameters for handsets 3, 4 (band V).

Future Work

Tunability capabilities are currently under investigation for the practical implementation of the aforementioned design concepts. The loss phenomenon is also being studied in order to generalize it to different antenna topologies.

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