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Published in:
Progress In Electromagnetics Research Symposium PIERS 2011 in Marrakesh, Morocco, 20-23 March, 2011

Publication date:
2011

Document Version
Early version, also known as pre-print

Thin Wires Structure for Decoupling of Multiple-antenna Terminals

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Abstract— In this paper, a thin wires (TW) structure has been used in order to reduce the coupling between two very close antennas on a common ground plane. Two dual-band planar inverted F antennas (PIFA) have been considered as the edge to edge distance at low band between both elements is $0.016\lambda_0$. After optimization of the location and the size of the TW structure, at low band, for the proposed two elements antenna we have achieved an isolation of 8.1 dB compared to the 3.1 dB for the initial antenna structure.

1. INTRODUCTION

When implementing Multiple Input Multiple Output (MIMO), the integration of several antennas operating in a diversity scheme at the base station side of the link is today a well-known and well-used solution. However, gathering together several antennas in a small device is much more complicated task due to the small allocated space for them and the highly complex fields within the antenna volume. Moreover, with the deployment of the Long Term Evolution (LTE) technology, the need to find efficient solution for isolating the antennas especially at low frequencies becomes extremely important. Consequently the academic research on multiple antennas operating at the same frequency, in a small communicating device is still of a great interest.

Identical planar inverted F antennas (PIFA) or monopoles-like antennas have been moved along the mobile phone printed circuit board (PCB) and different orientations have been investigated as well in [1, 2]. As could be expected, the best isolation values between the antennas were found for having the antennas spaced by the largest available distance, i.e., one at the top of the PCB and the other at the bottom. Several techniques to reduce the coupling between the antennas have been proposed [3–17]. Today future challenges concentrate on multi-antenna structures for the GSM 850/900 MHz [18, 19] and the long term evolution (LTE) 700 MHz bands [20]. At those low frequencies, indeed there is a huge challenge to isolate the ports of the antennas as the PCB is the unique radiator and the antennas only coupling elements. In this paper, we have proposed a thin wire (TW) structure to be placed in between two radiating elements of a PIFA type in order to reduce coupling between the antennas. An optimization of the best location of the TW structure and number of the elements within the TW structure has been performed using the finite-difference time-domain (FDTD) method [21]. The latter has been proved to be an efficient technique for solving complex electromagnetic problems [22].

2. ANTENNA CONFIGURATION

The investigated model with two PIFA antennas and the TW structure within the volume corresponding to a typical mobile phone handset are shown in Fig. 1.

The TW structure consists of periodically arranged wires with 1 mm distance between. In our study, the lateral number of the wires (M) has been fixed to 3, while the longitudinal number of wires (N) has been varied. The wires are 9 mm long and are connected to the ground plane at their bottom. An optical unit with size $40 \times 40 \times 10$ mm modeled by perfect electric conductor is attached to the ground plane. The aim of the optical unit is to avoid using conducting cables and, consequently, spoiling the antenna characteristics in measurement campaigns. An optical unit with that size has been designed and used during several measurement campaigns in Aalborg, Denmark as some more information and results can be found in [23]. In a real mobile phone, the place of the optical unit would be usually occupied by a battery of similar size, and the model would also be similar. The antennas resonate at 786 MHz and at 2.02 GHz which are very close to the LTE low and high bands. The edge to edge distance between both elements is $0.016\lambda_0$, where λ_0 is the wavelength in free space.

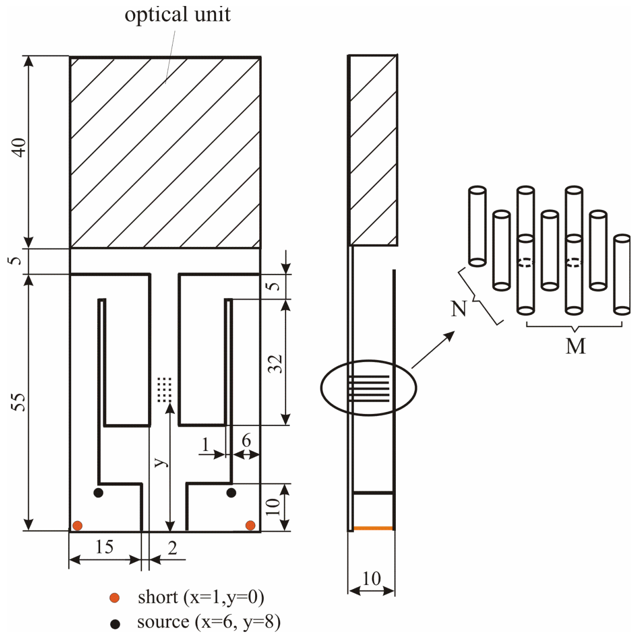

Figure 1: The handset model with two PIFA antennas and the decoupling TW structure.

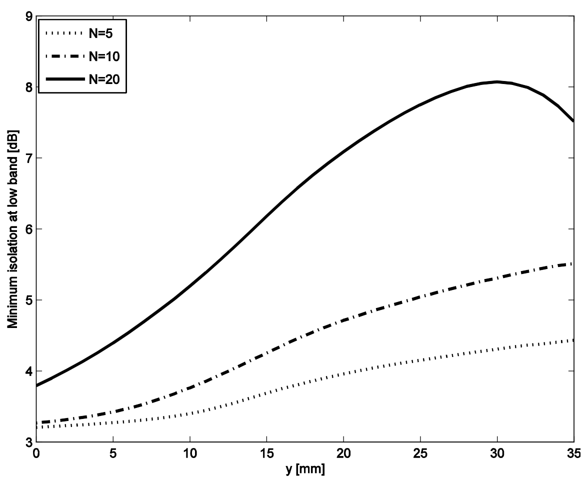

Figure 2: Minimum isolation of the proposed antenna at the low LTE band.

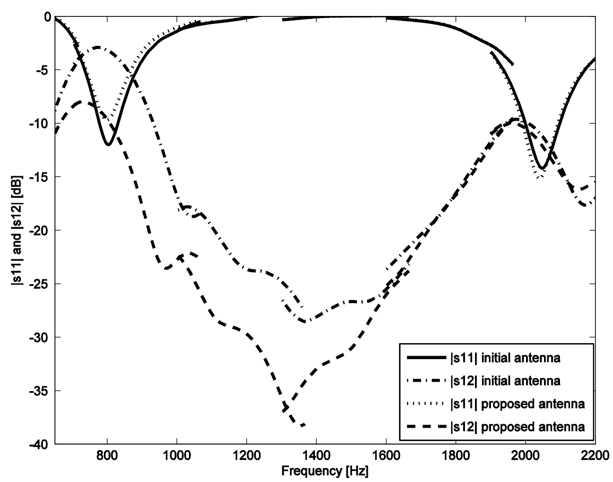

Figure 3: Simulated $|s_{11}|$ and $|s_{12}|$ of the initial and the proposed antenna (with the TW structure, y and N optimized).

Table 1: Minimum isolation of the initial antenna.

Low band	High band
3.1 dB	10.4 dB

3. NUMERICAL SIMULATIONS

In order to explain better the behavior of the $|s_{12}|$ we have defined a parameter called minimum isolation which is the maximum of the $|s_{12}|$ curve in the given frequency range. The minimum isolation of the initial antenna for both bands is shown in Table 1.

The results from the simulations for different distances y and sizes N of the TW structure are shown in Fig. 2.

The number of the wire elements N occurs to be an important parameter. The slope of the curves increases with increasing of y. Comparison of the simulated $|s_{11}|$ and $|s_{12}|$ between the initial antenna and the optimized one with the reduced coupling is shown in Fig. 3.

4. CONCLUSIONS

A thin wire structure for decoupling two PIFA antennas with edge to edge distance of $0.016\lambda_0$ at low LTE band has been proposed. The isolation has been improved from 3.1 dB to 8.1 dB. The future work includes investigation of this technique in the presence of a user's head and hand. Further, a planar version of the TW structure, supposed to be more easily manufactured, is under investigation. More optimizations of the TW structure dimensions will also be performed.

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