Validation of a Decoupling Technique by Using Two Types of Antennas

Lamia Sadaoui, Georges Kossiavas, RobertStaraj
Université Côte d'Azur, CNRS, LEAT, 930 Route des Colles, 06410 Biot, Sophia Antipolis, France
Lamia.SADAOUI@unice.fr, Georges.KOSSIAVAS@unice.fr, Robert.STARAJ@unice.fr

***Abstract*—This paper presents a decoupling technique for two close radiating elements, designed for the low LTE band [0.7-0.9] GHz. This method can be applied to a coupled antenna structure with an axis of symmetry. It consists in using a power splitter and a phase shifter between the two ports of the symmetrical antenna structure, in order to feed them simultaneously with equal amplitudes and opposite phases. Thus, the currents coupled to the center element cancel one another, which results in very low coupling. Two different types of radiating elements are mentioned in this paper for the central antenna. The first one is a standing classical monopole, the second one is an improved and printed T shaped element on the substrate to reduce the dimension of the system. Thanks to this method, strong isolation can be obtained which can reach 70 dB around the center frequency. The two corresponding prototypes are realized and tested. Measurement results correspond well to those of the simulation for the two different cases.**

Keywords—T printed monopole antenna; mutual coupling; antenna isolation.

I. INTRODUCTION

For multi-antenna radiating systems, several studies have focused on improving antenna isolation, particularly in the case of miniature antennas with reduced spacing. The degradation of antenna isolation affects the performance of multiple-input multiple-output (MIMO) systems.

Many solutions are currently being used to enhance antenna isolation in the RF domain. In [1], a cancellation technique based on tunable connectorized phase shifter has been proposed to increase the isolation between two patch antennas at 2.6 GHz. An additional isolation greater than 20 dB is obtained over 10 MHz bandwidth. In [2], lumped elements between the antenna feeds have been used to improve the isolation between antennas at 2.45 GHz by using a decoupling and a matching networks. Other more practical methods have been proposed to reduce mutual coupling and to maximize isolation as the use of the neutralization line that has been applied in [3] - [4] to two antennas (PIFAs) between their power supplies and / or between their short-circuit points to cancel the mutual coupling. By tuning the length and the width of the line, the isolation can become more than 40 dB.

The latest version of LTE requires efficient MIMO systems covering the band [0.7-0.9] GHz. The design of such MIMO systems is very challenging considering the large bandwidth and the reduced available size. In this paper, we propose a decoupling technique to reduce the mutual coupling between two close radiating elements designed for this band.

II. TWO HIGHLY COUPLED ANTENNAS

To evaluate the proposed decoupling technique, we designed a simple MIMO antenna solution based on two printed monopoles located at both corners of the common ground plane (Fig. 1). Each monopole has been optimized to cover the [0.7-0.9] GHz band. The two monopoles are printed on a rectangular FR-4 substrate of 220 × 95 mm^2 (0.51λ × 0.22λ) with ε_r = 4.3, a loss tangent of 0.025 and a thickness of 1.6 mm.

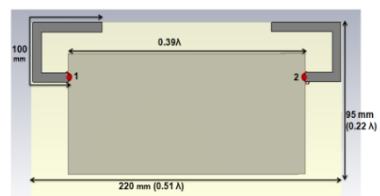


Fig. 1. Geometry of the antenna system.

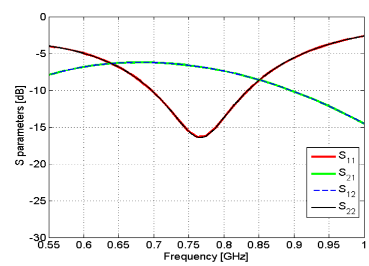


Fig. 2. Simulated S parameters.

The results of the simulated S parameters (Fig. 2) show a strong coupling between the two ports. The |S21| which is about 6 dB between 0.7 and 0.9 GHz indicates very low isolation. Thus, the following section describes a decoupling technique applicable to a coupled antenna structure presenting an axis of symmetry.

III. DECOUPLING TEHCNIQUE

This concept of decoupling is based on the insertion of a third element placed on the axis of symmetry of the antenna system. The principle is described in Fig. 3 (a) and 3 (b). The two symmetric antennas are fed simultaneously with equal amplitudes and opposite phases. Thus, the currents coupled to the element at the center cancel one another, which results in very low coupling. The new inserted element can thus be used as a second radiator, thus again obtaining a two-element antenna system.

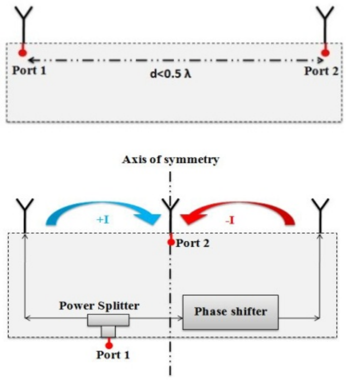
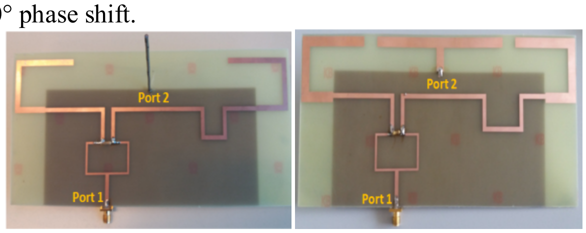


Fig. 3. Decoupling concept (a) initial case without decoupling (b) final case with a decoupling technique.

IV. Realization and Measurment

The proposed approach has been validated experimentally on the antenna system shown in Fig. 1. We began by grouping the two monopoles and feeding them with a single port. In order to obtain an equal distribution of the power between the two elements, we used a 3dB power splitter, printed on the substrate. As shown in Fig. 4 and for the two prototypes, the right output of the splitter has been connected to a transmission line used to add the desired 180° phase shift.



(a) (b)

Fig. 4. Realized prototype showing the new geometry of the structure. with the new third central element (a) standing monopole (b) T monopole.

The two monopoles initially folded (those starting from Fig. 1) being powered by a single port, a third new element is inserted in the middle of the structure and fed by a second port . This new element is also optimized to radiate into the same band. This radiating element is a standing monopole case (a) or a T-shaped monopole printed for case (b) which allows both to reduce the vertical size of the monopole and to maintain the axial symmetry. The introduction of the central element has the purpose of forming an antenna system with two ports again.

The new simulated and measured S parameters correspond well to each other, but in this paper only the measurements are shown in Fig. 5 and 6, corresponding to cases (a) and (b) respectively.

The results show that we have reached a very good level of isolation around 50 dB for the first case and 70 dB for the second case near the central frequency, and we can conclude both in simulation and in measurement that the two new ports, and therefore the two antennas, are now highly decoupled for the two different structures (a) and (b).

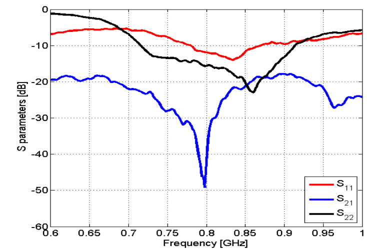


Fig. 5. Measured S parameters of structure (a).

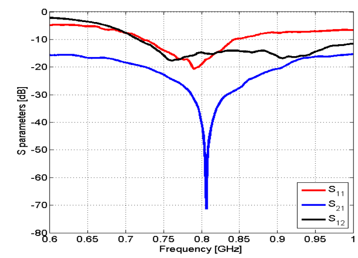


Fig. 6. Measured S parameters of structure (b).

V. Conclusion

In this paper, a technique for decoupling closely spaced antennas has been proposed and applied to two folded printed monopoles, covering the LTE band [0.7-0.9] GHz.

Two different antenna types were inserted in the center of the structure as a third element. The first one was a standing monopole which provides a 50 dB of isolation. The second one was a printed T shape element which provided 70 dB of isolation between the two ports, at the central frequency 0.81 GHz. Compared to the original antenna system, an isolation improvement of more than 64 dB (for case b) was obtained, allowing us to validate this concept of decoupling.

The other performances such as the radiation pattern and efficiency have already been studied and will be presented and analyzed in more detail during the conference.

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