# Design Of Printed MIMO Antenna With Metamaterial Matching Network For LTE Mobile Handset Application

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## Abstract

A printed MIMO antenna with an embedded metamaterial matching network to increase the bandwidth is proposed for a LTE mobile handset application. The proposed antenna has an isolation of 30 dB at 0.77 GHz (LTE band 13) and the -6dB bandwidth increased from 19MHz to 65MHz.

**Keywords :** MIMO antennas, Metamaterial, Matching network, LTE.

## 1. Introduction

Recently, the long-term evolution (LTE) system is considered as one of the most promising 4th generation (4G) mobile standards to increase the capacity and speed of mobile telephone networks [1]. In order to realize the LTE wireless communication system, the multi-antenna systems such as diversity and multiple-input multiple-output (MIMO) systems have been introduced [2]. In a MIMO mobile user terminal such as handset or USB dongle, at least two uncorrelated antennas should be located in an extremely restricted space. It is usually a big challenge to design a printed MIMO antenna at 0.77 GHz for mobile handset. Due to the limited space available for antenna elements, the printed antennas are strongly coupled with each other and have narrow bandwidth.

The matching networks had been studied to increase the bandwidth of a frequency dependant load, such as an antenna [3-5]. Either a single-tuned matching network or a double-tuned matching network was investigated to match an antenna over wideband in [6-7]. The recent development of metamaterial opens a new way to realize the antenna matching network. A complementary split ring resonator (CSRR) microstrip matching network was applied to a monopole antenna in [8].

In this paper, we present a compact planar MIMO antenna with an metamaterial matching network for LTE mobile handset application. The proposed MIMO antenna consists of two simple curly radiating strips and the embedded matching networks based on split ring resonator (SRR). In order to improve the isolation between MIMO antennas elements, a resonator consisting of three stubs is placed between the two radiating strips.

## 2. Antenna Design

The geometry of the proposed printed MIMO antenna is shown in Fig. 1 (a), Fig. 1 (b), and Fig. 1 (c). The proposed MIMO antenna consists of two radiating elements, embedded matching networks, and resonator. All the antenna elements are placed on either the front or the back surface of a FR-4 ($\varepsilon_r$=4.4) substrate. The overall dimension of the substrate (including both antenna and ground) is 40mm×68mm×1mm, which makes the designed MIMO antenna suitable for a thin mobile handset. The front view of the suggested MIMO antenna is shown in Fig. 1 (b). Two antenna radiating elements are placed at the two corners of the top edge of the substrate within a total area of 40mm×15mm. Each radiating element is curly shaped strip having the width of 0.5mm and total length of 80mm, which is about 0.2λ at 0.77GHz. An additional resonator is inserted between the two radiating elements and consists of three stubs with the width of 0.5mm. The back view of the MIMO antenna is shown in Fig. 1 (c). Two spiral-type SRRs placed on the back surface of the substrate and beneath the microstrip feeding line. The width of each SR is 0.5mm and the total length is 84.5mm, which is about 0.2λ at 0.77GHz.

## 3. Antenna Analysis And Performance

The S-parameter and input impedance characteristics of the reference antenna without matching network are compared to those of the proposed antenna with matching network in Fig. 2. According to the Fig. 2(a), the -6dB bandwidth of the proposed antenna is increased from about 20MHz to the around 40MHz. The insertion of SRR structure effectively improves the bandwidth of the proposed antenna. The input impedance on the Smith chart is shown in Fig. 2(b). From the Fig. 2(b), it can be observed that the enhancement of the proposed metamaterial matching network is mainly accomplished by simultaneously reducing the inductive and capacitive components of a frequency dependant load at the high and low frequency edges of the frequency band of interest [8]. In addition, the effect of the resonator on the isolation of the MIMO antenna has been investigated in Fig. 3. Due to the existence of a resonator, the isolation between different ports increases form around10 dB to 23dB. Nonetheless, the bandwidth of the proposed antenna is not hardly affected. Fig. 4 shows the measured S-parameters of the proposed antenna. The proposed printed antenna at the center frequency of 0.77 GHz and has a -6dB bandwidth of 65MHz. The envelope correlation coefficient (ECC), which is used to evaluate the diversity capability of a multi-antenna system, is calculated from the measured S-parameters, which is shown in Fig. 5. The suggested MIMO antenna has the ECC lower than 0.1 over the whole frequency band. The photograph of manufactured antenna is shown in Fig 6. Fig. 7 shows the radiation patterns of the MIMO antenna at 0.77 GHz. The co-polarization and cross-polarization radiation pattern of antenna #1and antenna #2 are both plotted in y-z plane and x-z plane. Moreover, the results shows that the proposed MIMO antenna has radiation efficiency of 28% and peak realized total gain of around -2.1 dBi.

## 4. Conclusion

In this paper, a MIMO antenna for LTE mobile handset application operating at 0.77 GHz (LTE band 13) is proposed. The MIMO antenna consists of two embedded metamaterial matching network to increase the bandwidth. An additional resonator containing three stubs is located between the two radiating elements to increase the isolation characteristic. The proposed antenna has an isolation of 30 dB and the -6dB bandwidth of 65MHz. The simulated and measured results show that the proposed multiband MIMO antenna could be a good candidate for LTE mobile systems.

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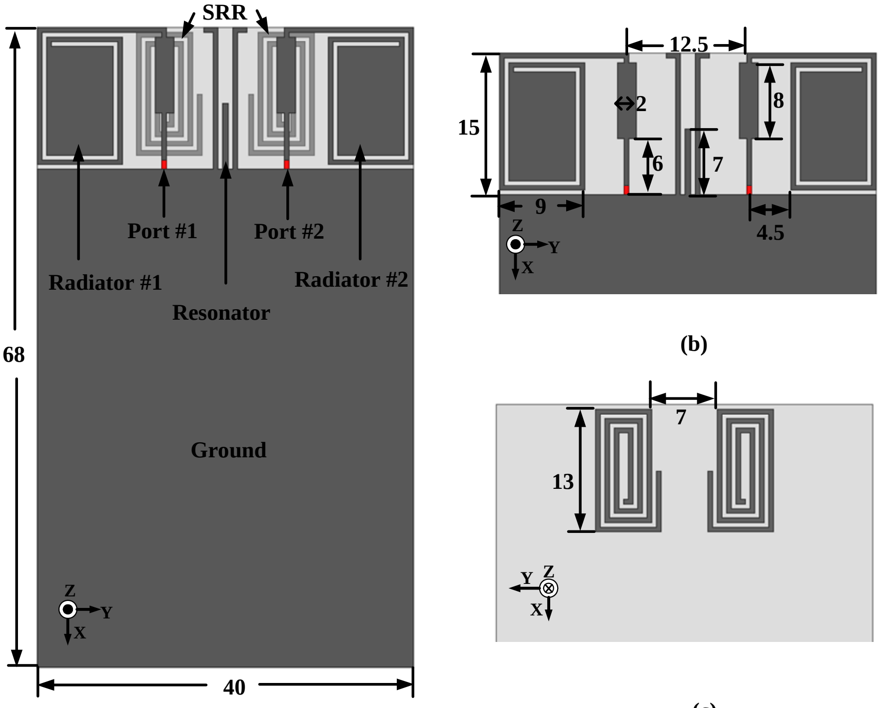
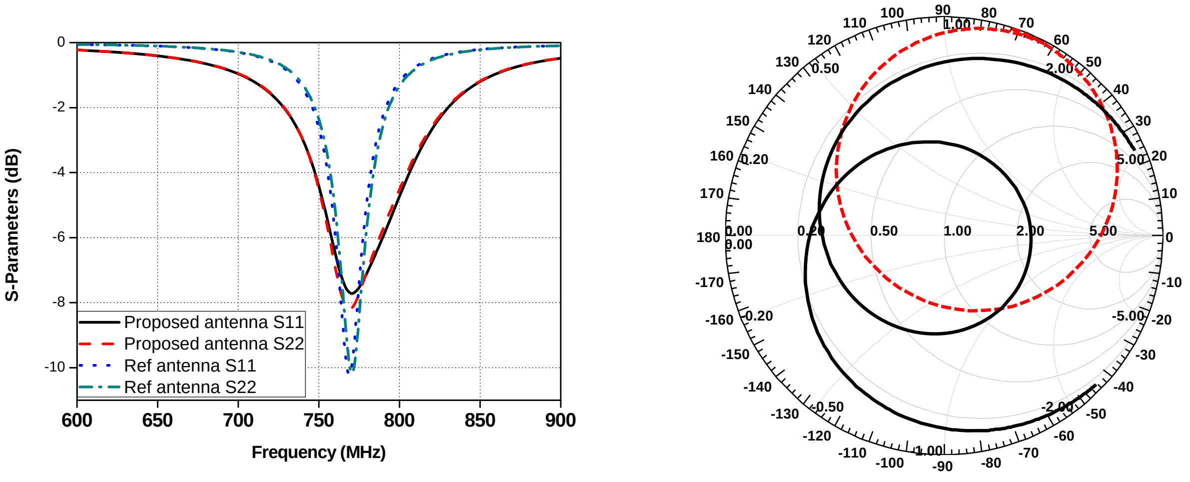


(a) (b) (c)

Fig. 1. Geometry of the proposed MIMO antenna. (unit: mm)
(a) General view of the proposed antenna (b) Front view of the proposed antenna
(c) Back view of the proposed antenna



(a) (b)

Fig. 2. The simulated S-parameters and input impedance characteristics of the reference antenna without matching network compared to the proposed antenna with matching network.
(a) The S-parameters (both the S11 and S22) (b) Input impedance on the Smith chart (The solid black curve is the proposed and the dashed red curve is the reference).

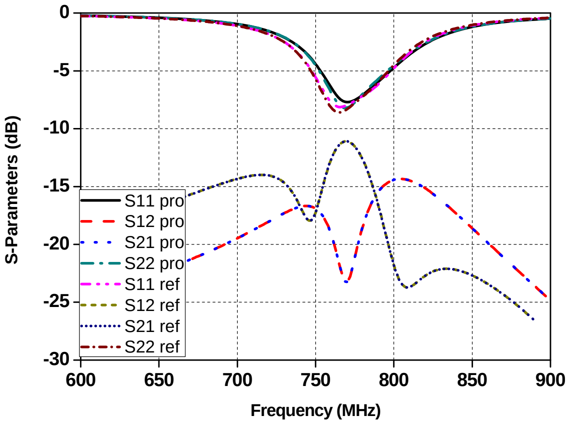


Fig. 3. The Simulated S-parameters of the MIMO antenna with and without resonator

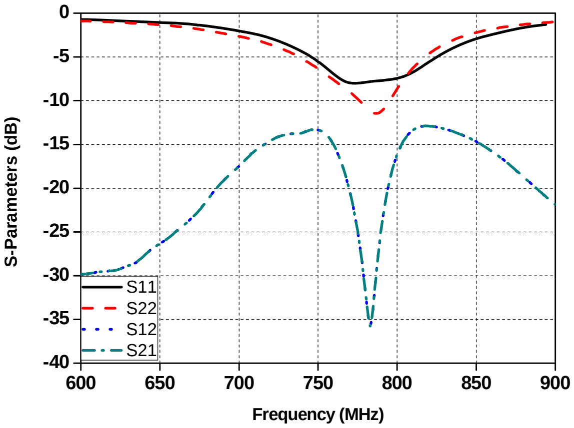


Fig. 4. The measured S-parameters of the proposed antenna.

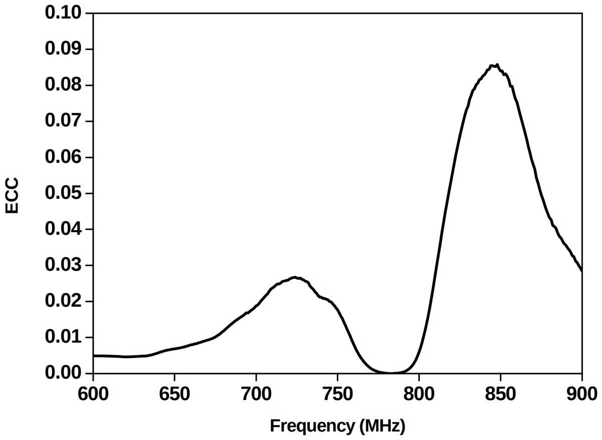


Fig. 5. The ECC characteristics computed from measured scattering parameters.

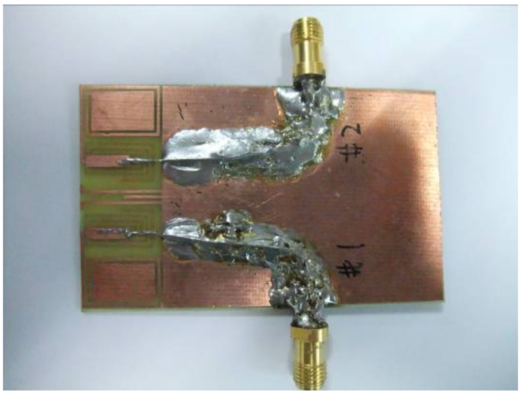
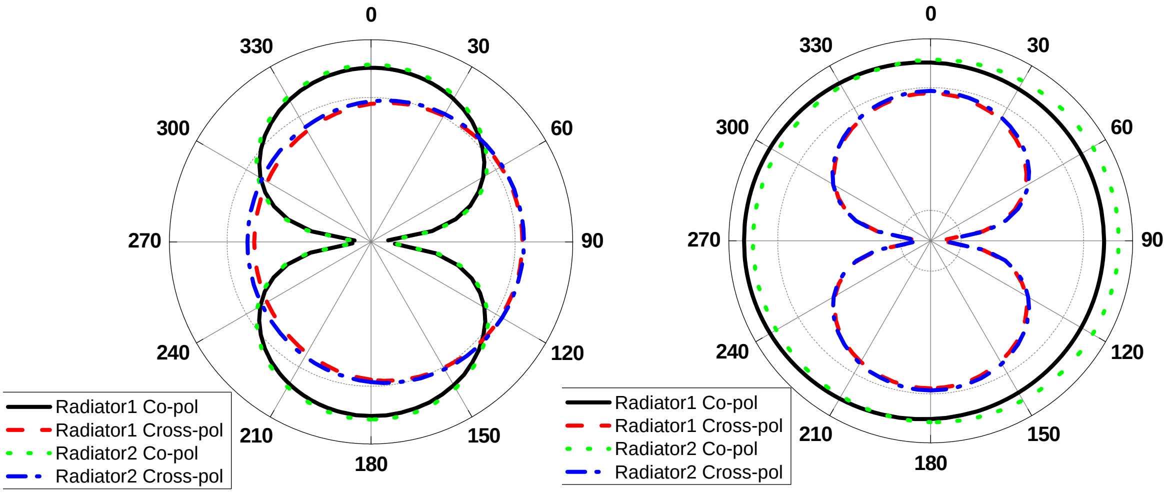


Fig. 6. The photograph of manufactured antenna.



(a) (b)

Fig. 7. The radiation patterns of the planar MIMO antenna at 0.77 GHz.
(a) The co- and cross-polarization radiation pattern of radiator #1and radiator #2 at xz plane
(b) The co- and cross-polarization radiation pattern of radiator #1and radiator #2 at yz plane