Dual-Band Dual-Polarized MIMO Antenna Design for GSM Application

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Abstract

In this study, a dual band compact antenna that can provide dual polarization for each band is proposed and its design is presented. Proposed structure operates at 0.96 GHz and 1.81 GHz frequencies. Thus the antenna can be used for GSM (Global System for Mobile Communications) applications. It consists of two symmetrical antennas that placed closely to obtain compact size. The distance (edge to edge) between these antennas is 10 mm ~ 0.032 λ_l, as the λ_l is the wavelength at the lower band of the operation. Isolation between the feeding ports in the structure has been succeeded with a slot on the ground plane, the length and width of the slot adjusts the isolation. In the two operation frequencies the isolation is below -10dB. The proposed MIMO (Multiple-Input Multiple-Output) antenna is simulated and then fabricated prototype is measured. The results of simulation and measurements are presented and the results are consistent with each other.

Key words: Dual-Band,Dual-Polarized,MIMO

Özet

Bu çalışmada, her bir bant için çift polarizasyon sağlayabilir bir çift bant kompakt anten önerilmiştir ve antene ait tasarım sunulmuştur. Önerilen yapı 0.96 GHz and 1.8 GHz frekanslarında çalışmaktadır. Böylelikle söz konusu anten GSM uygulamaları için kullanılabilmektedir. Tasarım, kompakt boyut elde etmek amacıyla yakın bir şeklilde konumlandırılmış iki simetrik, antenden oluşmaktadır. λ_l alt çalışma bandındaki dalgaboyu olmak üzere, bu antenlerin kenardan kenara uzunluğu 10 mm ~ 0.032 λ_l' dir. Önerilen yapıdaki besleme portları arasında yüksek izolasyon toprak tabakasındaki oyuk ile başarılmıştır ki oyuğun boyu ve uzunluğu izolasyonu ayarlamaktadır. Her iki çalışma frekansında izolasyon -10dB' nin altındadır. Önerilen Çoklu Giriş Çoklu Çıkış (MIMO) antenin benzetimi yapılmıştır ve sonrasında üretilen prototipin ölçümü gerçekleştirilmiştir. Elde edilen benzetim ve ölçüm sonuçları sunulmuştur ve sonuçlar birbirleri ile uyumludur.

Anahtar kelimeler: Dual-Band,Dual-Polarized,MIMO

1. Introduction

Data transmission rate of wireless communication systems have increased due to the need to transfer large amounts of data [1]. Recently, Multiple-Input Multiple-Output (MIMO) antenna systems have been widely researched as a solution to enhance channel capacity [2, 3, 4]. So the MIMO Technologies as both single band and multi band applications have an important place when considering future wireless standards. MIMO antenna systems are used for several multifunctional applications such as GSM (Global System for Mobile Communications), UMTS

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(Universal Mobile Telecommunications System), LTE (Long Term Evolution) and WLAN (Wireless Local Area Network) [5]. For example, in [6] the dual-band dual- polarized MIMO antenna is investigated for LTE band at f_{01}= 826 MHz and f_{02}= 2.59 GHz. Reducing mutual coupling of closely spaced microstrip antennas for WLAN application is presented in [7]. Presented structure consists of two microstrip antennas operating at 5.8 GHz.

It is difficult to obtain high isolation between antennas [8] due to good isolation effects correlation coefficient and diversity of the system [9]. In consideration of the correlation, mutual coupling changes the performance of the system. The coupling between antenna elements increases, if the antennas are closed to each other. Therefore, both the smaller size and enhanced isolation is difficult.

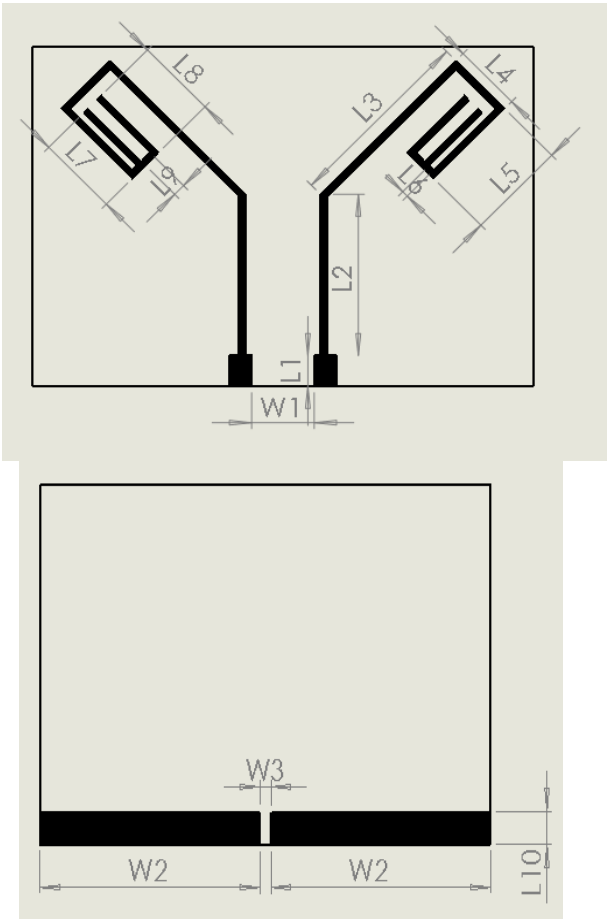
In the literature, several techniques have been applied to obtain a high isolation. In [9], there are two slots etched in the ground plane; vertical and horizontal slots are used for a better isolation at lower band and at upper band, respectively. Aperture-coupled feeds provide high-isolation antenna in [10]. With the purpose of obtain higher isolation; a T shaped parasitic element was used in [11]. [12] has proposed two solutions to achieve a good isolation at desired frequencies by connecting transmission lines and radiators.

In this paper, a dual-band dual-polarized MIMO antenna for GSM applications is proposed. The antenna consists of symmetrically positioned monopoles. It operates at 0.96 GHz and 1.81 GHz frequencies. Isolation between ports achieved by a slot on the ground. The rest of paper is organized as follows: Next section presents the geometrical design of the MIMO antenna system, whereas Section III shows the simulation and experimental results. In the final section, the results are summarized and concluded.

2. Antenna Design

In this section, there are details about proposed antenna herewith the dimensions of the geometry. The antennas are symmetrically placed in the middle of the top portion of the layer. The geometrical design of the proposed dual band dual polarized MIMO antenna is illustrated in Figure. 1. The antenna design, is used for 960 MHz and 1800 MHz frequencies have realized with AD 300 A which have h=1.524 mm thickness and permittivity of ε_r=4.4. The dimensions of the antenna represented in Figure 1(a) are (in mm) detailed as follows: For the top of the layer; $L1$ = 5, $L2$= 26.10, $L3$= 30.5858, $L4$ = 11, $L5$ = 16, $L6$ = 1, $L7$ = 13, $L8$ = 13, $L9$ = 2, $W1$ = 10; for the bottom of the layer; $L10$ = 5, $W2$ = 39, $W3$ = 2. The overall dimension of the antenna is 55 mm x 80 mm.

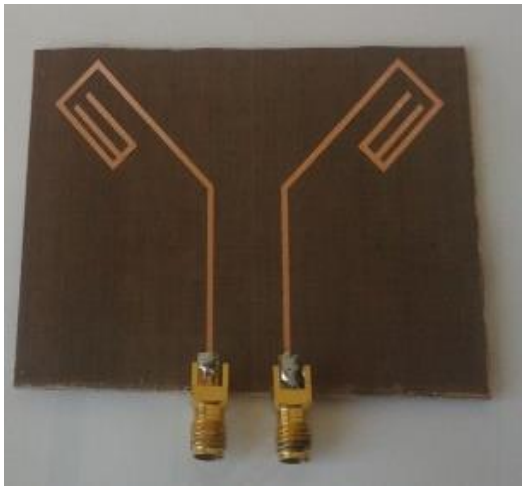
The structure of the length L8 changes significantly the frequency of upper band, but changes little the one of lower band. The length of *L10* in the bottom of the layer effects both lower frequency band and upper frequency band. In order to have a compact size, MIMO antenna is constructed from the meandering strips. There is a slot in the bottom of the layer and this slot plane provides the isolation between antennas. In the interested frequencies, the isolation is below -10 dB for upper band and lower band.

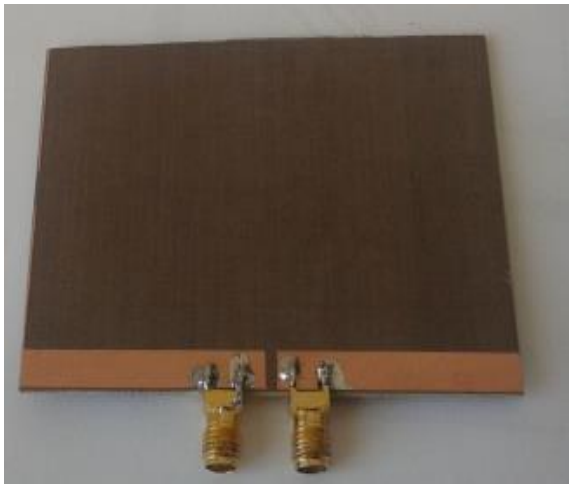


(a)

(b)

Figure 1. Simulated model of the MIMO antenna for GSM application.
(a) top view; (b) bottom view





(a) (b)

Figure 2. Fabricated prototype of the MIMO antenna for GSM application
(a) top view; (b) bottom view

Figure 2 shows the fabricated dual band dual polarized MIMO antenna, on an AD 300A substrate with the thickness of 1.524 mm and dielectric constant of 3.

3. Simulation and Measurement Results

The simulation and measurement results of the proposed MIMO antenna are given in this section. The simulated and measured S_{11} results of the MIMO antenna are indicated in Figure 3.

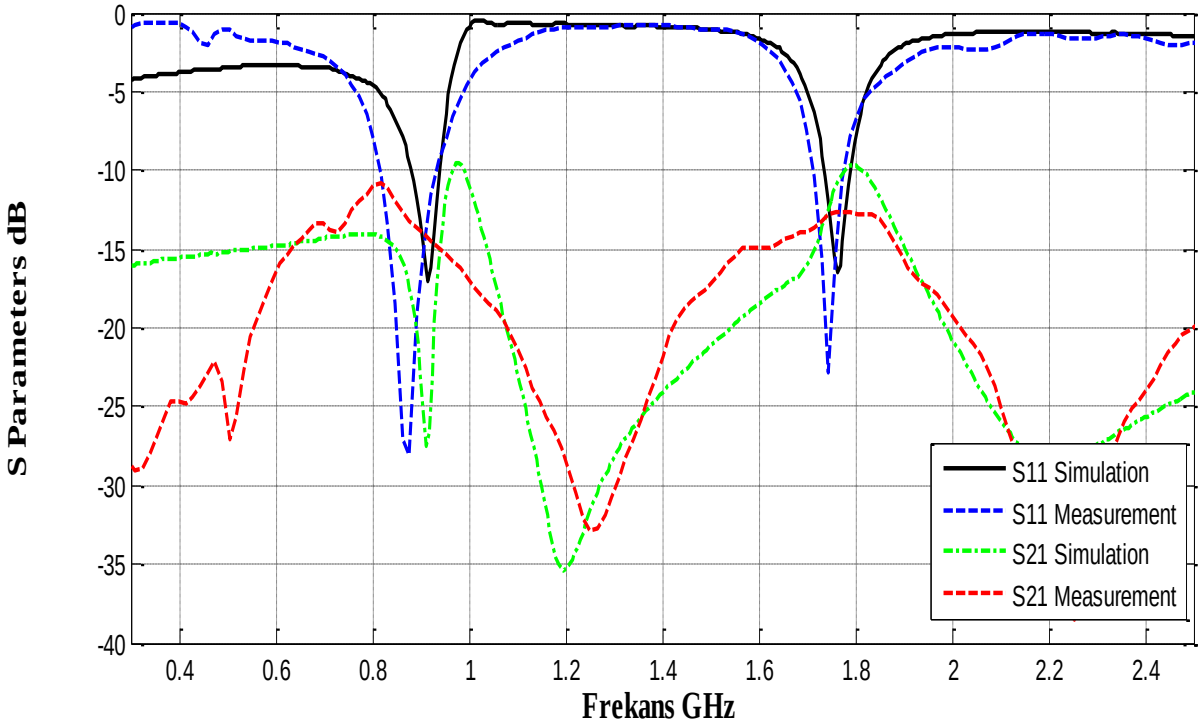


Figure 3. Simulation and measurement belong to S Parameters of the proposed MIMO antenna

In Figure 3, the simulation and measurement results belong to both S11 and S21 parameters are given in comparison. According to the results (S11< - 10dB), both the simulated and fabricated antennas have resonated in dual-band approximately at 0.96 GHz and 1.8 GHz frequencies. So this designed MIMO antenna is useful for GSM bands. The isolation is seen as below – 10 dB at both operating frequencies. As shown in Figure 3, the simulation results are agree with the measured results. The measured S-parameters of the fabricated MIMO antenna are shown and the isolation between ports is observed in Figure 4.

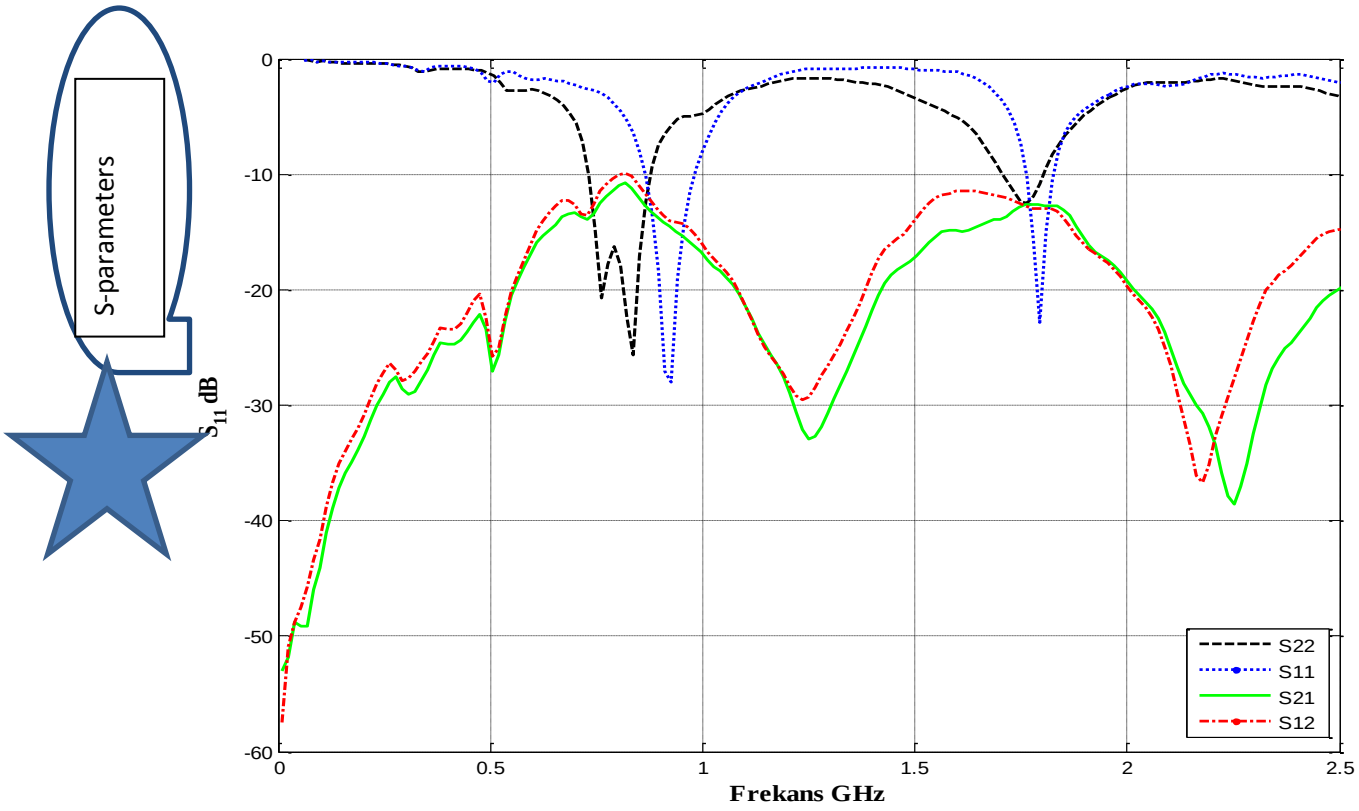
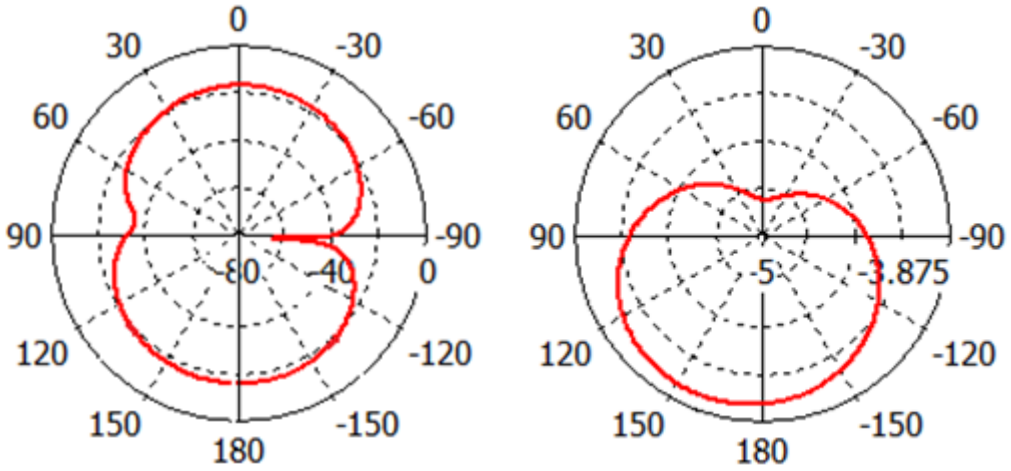


Figure 4. Measured S-parameters of the fabricated MIMO antenna

As shown in Figure 4, the result indicates that the magnitude of *S21* and S12 between two ports is about -10 dB in the interested frequencies.



(a) **(b)**

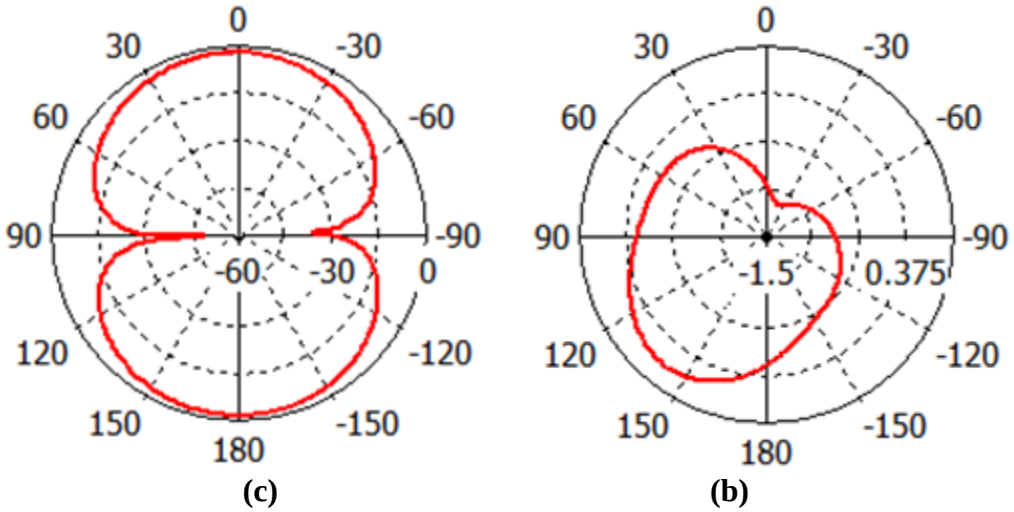


Figure 5. Simulated radiation patterns for port 1(a) in the E plane (YZ plane) at 0.9 GHz, (b) in the H plane (XZ plane) at 0.9 GHz, (c) in the E plane (YZ plane) at 1.8 GHz, (d) in the H plane (XZ plane) at 1.8 GHz

Figure 5 shows the simulated radiation patterns in the E plane (YZ plane) and H plane (XZ plane) respectively. The radiation patterns for only port 1 is given by taking into consideration the ports are symmetrical to each other.

Conclusions

The design of a dual-band dual-polarized MIMO antenna is presented in this paper for GSM application. The operation bands of the designed antenna are 0.96 GHz and 1.81 GHz frequencies. In consideration of these frequencies, the design is suitable for GSM applications. The design consists of closely placed two symmetrical antennas to obtain compact size. Isolation between feeding ports obtained with the help of a slot on the ground plane. The length and width of the slot change the isolation level. The proposed compact structure provides -10dB isolation for dual-band. The designed antenna is simulated and fabricated. The fabricated prototype is measured; the measurement results are compared with simulation results. All these results are evidences for the proposed antenna that it can be conveniently used as a GSM antenna where the dual band operation is required.

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