# Two-Port Compact Wideband Planar MIMO Antenna

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***Abstract*—A wideband dual feed antenna is designed and manufactured for multi-input, multi-output (MIMO) application. The antenna is optimized to match the ports to 50 ohm, and adjust the isolation between the ports for more than 15 dB in 2-6 GHz frequency band. The disk is fed using the microstrip transmission lines with 90° angular spacing to reduce the cross polarization and hence coupling between the ports. Due to the disk radiator, the antenna can be utilized as a two ports omnidirectional antenna. The antenna is measured for S-parameters and gain that comply well with the simulations. Antenna measured gain varies between 2.3 dBi and 6.3 dBi for 2-6 GHz. The antenna can be employed as a two port compact antenna, for multiband communication in 2-6 GHz and for WLAN applications.**

***Index Terms*—MIMO, wideband antenna, wireless communication.**

## I. Introduction

Nowadays, with the development of technology, sound, image and video are sent and received with high resolution and quality. This high data rate that is transferred between two interfacing devices requires a multiband/wideband transceiver to deliver the raw data to the signal processing section.

To design an antenna (for a multiband RF front-end module) that is wideband and also has multiple ports is a challenging task. Such antenna can operate with a transmitter/receiver (TX/RX) in a single frequency band either with a duplexer or with two separate ports of the antenna for TX and RX connection. To have an antenna that can be used in both TX/RX part of the transceiver or can receive and transmit data at the same band and simultaneously, there is a need for high isolation between its ports, as well as lower cross polarization to prevent the signal correlation.

In literature, there are studies which show how to locate and optimize two or multiple separate antennas near each other to achieve better isolation between antennas [1-3]. However, having a compact and single antenna that supports multiple input/output ports can be of great interest to the device designers to minimize the system package and get rid of the multiple antenna arrangement and ease the design process.

This paper presents a wideband two-port antenna with 15 dB isolation between the ports, which can be used for various applications due to its wide bandwidth.

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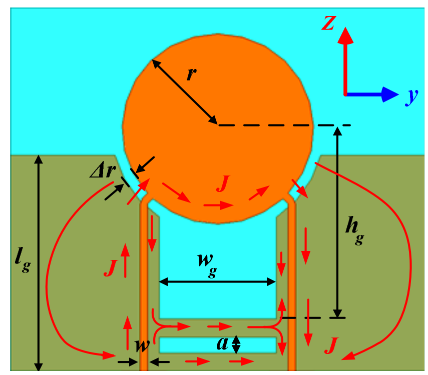



Fig. 1. Schematic of the dual feed wideband disk antenna.

## II. Antenna Design

The wideband disk antenna is designed for fabrication on Rogers RT/duroid 5880 laminate with dielectric constant and thickness of $\varepsilon_r = 2.2$ and $h = 0.787$ mm, respectively. The used PCB board has low dielectric tangent loss of 0.0009 and thin 35 µm copper cladding at both sides. The geometry of the designed two ports disk antenna and the top/bottom layers, indicated with different colors are shown in Fig. 1. The antenna is optimized to operate in the 2 to 6 GHz band with isolation between ports that can exceed 15 dB for frequencies greater than 2.4 GHz. The disk is fed by two microstrip lines with 90° angular spacing at the edge of the disk. In this manner, the effect of co-polarization reaching to the other port is reduced significantly. To minimize the dimension of antenna, the feed lines are bent toward each other to be paralleled as seen in Fig. 1. To fulfill the design criterion the antenna parameters $r$ (disk radius), $\Delta r$ (gap between the disk and ground plane), $w_g$ (gap width between the ports), $h_g$ (gap height), $a$ (slot width), $l_g$ (ground plane length) and $w$ (microstrip trace width) are optimized. In the shown structure, the antenna matching is mainly controlled by $r$, $\Delta r$, $w$ and $l_g$, while the isolation between the ports is improved by changing the length ($h_g$) and width ($w_g$) of etched ground between the ports. The height of rectangle gap, $h_g$, manages the phase difference between two currents that flow from two different paths to second port. As the first port is fed, the current that is reflected towards the second port, over the disk, is canceled by the current originating directly from port 1 to the second port by passing

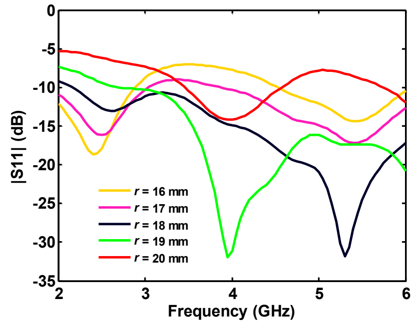



Fig. 2. Antenna reflection coefficient for various radii.

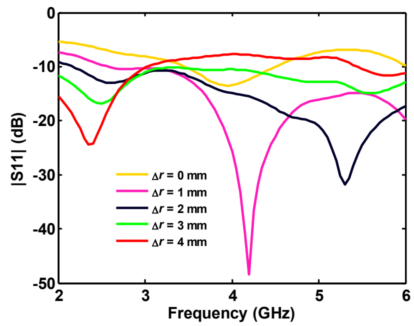
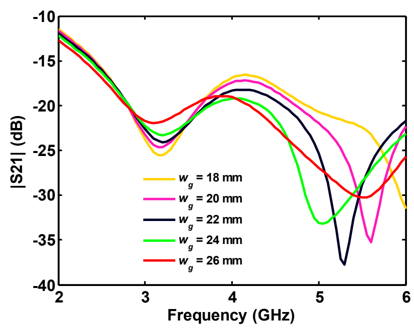
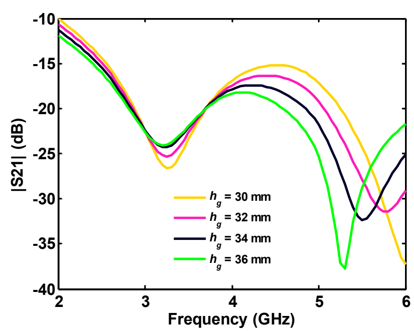



Fig. 3. Antenna reflection coefficient for different spacings between disk and ground plane.



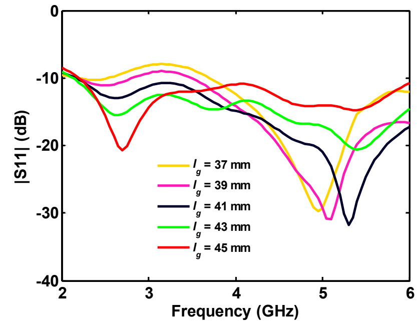

(a)



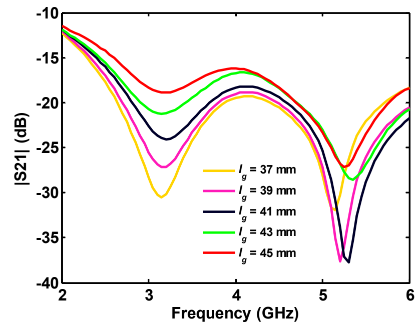

(b)

Fig. 4. Magnitude of $S_{21}$ for different (a) width and (b) height of the rectangle etched area.

around the slot. Thus, two currents are canceled due to the 180° electrical phase difference between the different trajectories of the current flow. Therefore, a part of the injected power from first port, which is not radiated, is canceled at the second port and isolation between the ports is improved, significantly.




(a)




(b)

Fig. 5. The effect of ground plane length on magnitude of (a) $S_{11}$ and (b) $S_{21}$.

TABLE I
MANUFACTURED ANTENNA PARAMETERS DIMENSION

| $r$ | $\Delta r$ | $h_g$ | $w_g$ | $l_g$ | $w$ | $a$ |
|---|---|---|---|---|---|---|
| 18 | 2 | 36 | 22 | 41 | 1.4 | 3 |

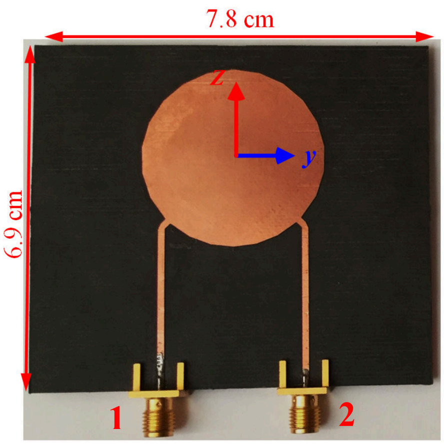
Values are in mm.

The optimum values for $S_{11}$ and $S_{21}$ between 2 and 6 GHz are achieved by setting the antenna geometrical parameters with values presented in Table. I. To show the effect of each parameter on the antenna performance, they are swept around the optimum value. Due to symmetry, the reflection coefficient of the both ports is the same.

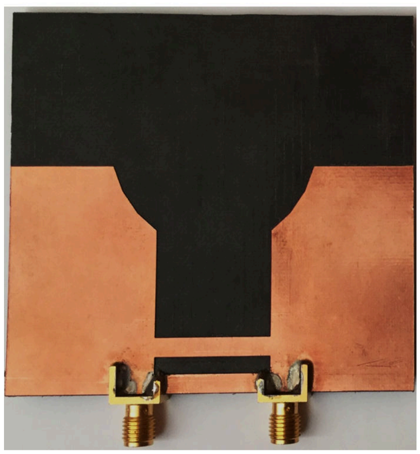
As shown in Fig. 2, the antenna matching can be adjusted over the desired frequency band of 2 to 6 GHz by some variation that is made in the disk radii. As the radius is altered, matching is improved for some frequencies, while the antenna is detuned for other frequencies in the 2-6 GHz. In addition to the influence of disk radius on the antenna reflection coefficient, the gap spacing between the disk and ground plane has an important role in antenna matching. As shown in Fig. 3, as the $\Delta r$ is changed from its optimum value of 2 mm, the antenna matching is deteriorated over the frequency band.

Although, $r$ and $\Delta r$ have significant effect on tuning the antenna reflection coefficient, they can change the $|S_{21}|$ between the ports as well. However, they are used for improving the antenna matching, since their effect on antenna reflection coefficient is critical.

As explained, the magnitude of $S_{21}$ between the ports is managed by changing the dimension of rectangle gap between




(a)



(b)

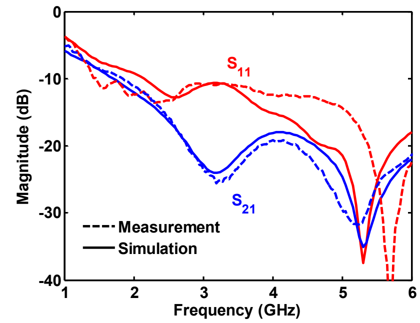
Fig. 6. The (a) top and (b) bottom view of the fabricated antenna.

the ports. The influence of width and height of this rectangle etched ground is displayed in Fig. 4. Increasing the width and height of gap changes the two trajectories length and corresponding electrical phase difference between the ports; and shifts the $|S_{21}|$ to lower frequencies. Increasing the dimensions of rectangle etch improves the isolation between ports for higher frequencies while isolation worsen a few dB for lower frequencies. The slot with the width of $a$ in Fig. 1 is also used to improve the antenna reflection coefficient for some frequencies.

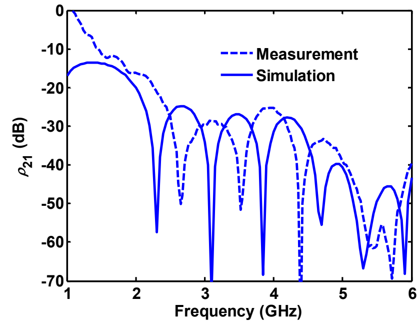
As shown in Fig. 5, the length of ground plane affects on both antenna reflection coefficient and isolation between ports by changing the mutual coupling between the disk and ground plane. Increasing $l_g$, increases the mutual coupling between the disk and ground plane, which changes the radiated power by the disk and also the part of power that reflects back to the ports, and therefore varies the isolation between the ports.

## III. Fabricated Antenna and S-Parameters

The fabricated antenna with the dimensions of 6.9 cm × 7.8 cm is presented in Fig. 6. The antenna's measurement and simulation results for S-parameters, and with




(a)




(b)

Fig. 7. The measured and simulated (a) S-parameter, and (b) envelope correlation coefficient between the ports.

the geometrical parameters of Table I, are shown in Fig. 7 (a). Fig. 7 (b) presents the correlation coefficient between the ports which is calculated using the measured and simulated S-parameters [4]. Results show that the antenna is matched for the 2-6 GHz frequency band and isolation between the ports is better than 15 dB for frequencies higher than 2.4 GHz. The proper isolation between the ports causes the envelope correlation coefficient below -20 dB which makes antenna to be employed as a compact antenna in MIMO application.

## IV. Antenna Radiation Pattern and Gain

Antenna gain pattern for frequencies 3.4 and 5.2 GHz is simulated and measured, as shown in Fig. 8. The gain patterns are shown in two $xy$- and $xz$-planes, and with respect to the coordinates in Fig. 1. Since the antenna major polarization is in (y , z) = (1 , 1) direction for the first port, the antenna co-pol can lie in both $\theta$ and $\varphi$ directions of the used coordinate system. Consequently, the co-pol and cross-pol for antenna ports can be obtained from the combination of $G_\theta$ and $G_\varphi$. The $G_\varphi$ is perpendicular to the disk edge at $\varphi = 90°$ and 270° on $xy$-plane which cause the nulls at these directions (the nulls in $G_\theta$ occur at $\theta = 0°$ and 180° on $xz$-plane).

Antenna simulated and measured peak gain and efficiency are shown in Fig. 9. The antenna efficiency is calculated using the average measured gain at specific frequencies. Results show that the antenna gain and efficiency are increased as the frequency is increased.

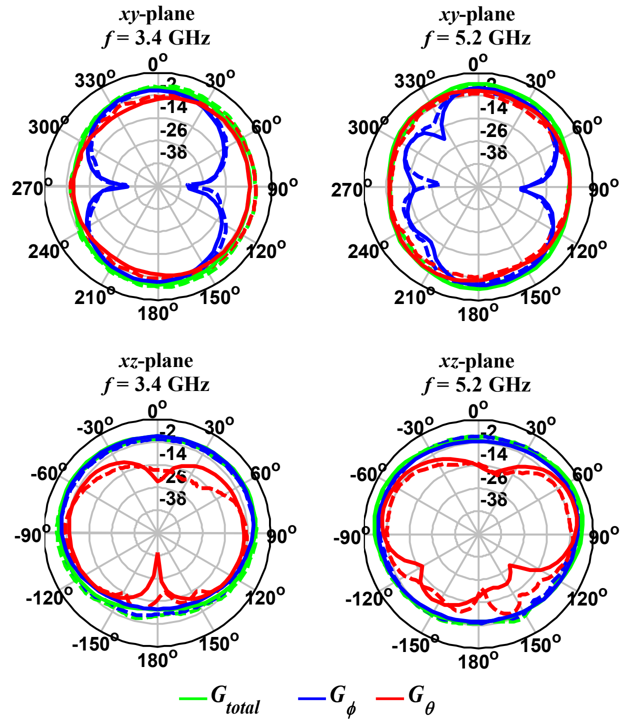



Fig. 8. The measured and simulated radiation patterns in *xy*- and *xz*-planes at 3.4 and 5.2 GHz.

## V. Conclusions

A compact two port planar antenna that can be operated in frequency band of 2 to 6 GHz is designed and manufactured. The isolation between the ports is improved using the technique that causes the out of phase currents cancel each other at the second port. The two microtrip transmission line feeds are extended in parallel manner to reduce the size of the antenna. Nevertheless, the microstrip lines are bent inward by 45° before connecting the disk, to realize the 90° angular spacing between the feeds and correspondence perpendicular linear polarizations. Due to the used disk radiator, the antenna can act as well as a wideband dipole antenna that can radiate to all directions. The antenna characteristic shows that it is well suited to MIMO application. The measurements at specific frequencies shows that the antenna minimum and maximum peak gain 2.3 dBi, and 6.3 dBi occur at 2.4 GHz and 5.2 GHz, respectively, whereas the antenna efficiency is limited between 66% and 98% over the desired frequency band.

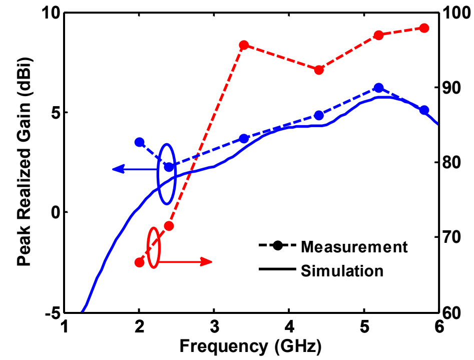



Fig. 9. Antenna efficiency and peak gain.

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