# A Compact CPW Fed 2 Element MIMO Antenna for C - Band and X- Band Applications

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**Abstract** This article presents a two-element MIMO antenna design for C and X - band applications. The proposed design radiates at 7.1 GHz and has an overall size of (0.58 × 0.29 × 0.04) λo. Each radiating element consists of two circular arcs connected by a simple microstrip element and is fed using a CPW feed. The proposed antenna provides a fractional bandwidth of 66.1% ranging from 5.55–11.03 GHz (|S11| <− 10 dB), thus giving wideband characteristics achieved by using a CPW feed. The proposed design is simulated by using Ansys HFSS 19.1 EM simulator. To evaluate the proposed MIMO antenna performance the isolation and envelope correlation coefficient (ECC) parameters are investigated.

**Keywords** CPW feed · Microstrip patch antenna · Wide - Band · MIMO · ECC

## 1 Introduction

The past few decades have seen exceptional growth in wireless communications, thus increasing the demand for efficient communication systems, high data rate and good channel capacity. To fulfill these requirements, antennas have become inevitable, causing a need for antennas that cover wideband, compact size, and provide large gain. Microstrip antennas fulfill these required characteristics as they are also easily integrable with passive and active microwave components. Multiple input multiple output (MIMO) technique is the remedial solution to provide high data rate and more reliable communication [1]. The C - Band is widely used for modern satellites and weather radars. As defined by IEEE standards, X- Band ranges from 8–12 GHz and is used in modern radars, weather prediction, and several military devices. Both the C - Band and the X – Band provide good resistance to attenuation in the rain and other atmospheric obstructions. A 2 × 2 microstrip array having an overall

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size of (1.04 × 1.04 × 0.02) $\lambda_o$ and bandwidth ranging from 3.45–3.57 GHz is depicted in [2]. A single element antenna with a ceramic DRA is proposed in [3], that provides multiband functions ranging from 3.8–4.5 GHz and 5.9–6.39 GHz. In [4], the authors proposed a two element MIMO antenna on tablets sized ground of frequency range from 1.71–2.69 GHz. Another configuration of the microstrip array for satellite communications is shown in [5], the article shows a 4 × 4 array provides a bandwidth ranging from 3.8–4.5 GHz. [6] shows a microstrip antenna with a T - shaped DGS radiating in the X - Band and having an overall size of (1.04 × 1.04 × 0.02) $\lambda_o$. A microstrip antenna having multiband characteristics in X – Band, provides a bandwidth of 270 and 440 MHz at 9.17 and 10.45 GHz, respectively [7]. A stacked configuration of microstrip antenna is proposed in [8] for multiband radiation covering both C and X bands. The proposed design has an overall size of (1.74 × 2.11 × 0.55) $\lambda_o$ and gives a bandwidth of 0.596 GHz resonating at 8.56 GHz. All the above-cited articles show good radiation characteristics in the C and X – Band but at the cost of antenna size.

In this article the authors proposed a compact 2-element MIMO antenna for 5.55–11.03 GHz frequency band. This article has attempted to reduce the size of the antenna while showing a negligible effect on the radiation characteristics. Section 2 contain the design concept of proposed single and 2 element MIMO antenna with design parameters. In Sect. 3, the authors explain the results of the proposed MIMO antenna. Finally Sect. 4 conclude the paper.

## 2 Proposed Antenna Design

The geometry of the proposed design is shown in Fig. 1. The overall size of the antenna is (25 × 12 × 0.535) $mm^3$ and is printed on Rogers RT Duroid 5880, which has a relative permittivity of 2.2, 0.001 as the loss tangent and thickness of $H_{sub}$. Table 1 lists all the parametric values of the antenna. Each element in the double element MIMO consists of two circular arcs with an outer radius of $R_1$ and an inner

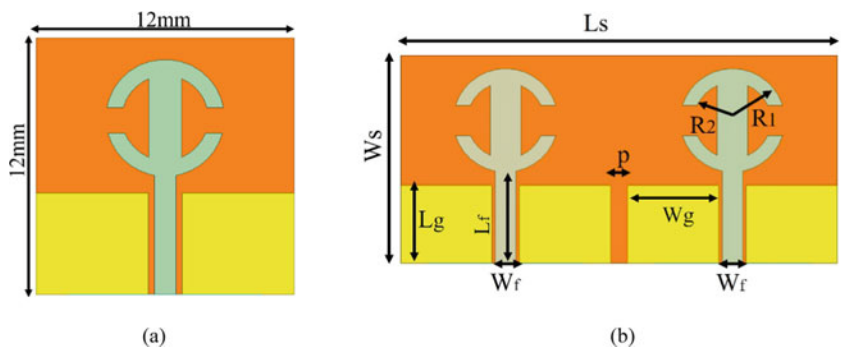


**Fig. 1** Proposed design **a** single element **b** Proposed design

**Table 1** Parametric values

| Parameter | Parameter value (mm) | Parameter | Parameter value (mm) |
|---|---|---|---|
| $L_S$ | 25 | $W_S$ | 12 |
| Lg | 5.2 | Wg | 4.5 |
| Lf | 5.25 | Wf | 1.2 |
| $R_1$ | 3 | $R_2$ | 2.2 |
| $H_{Sub}$ | 0.5 | p | 1.0 |

radius of $R_2$. In each component, the circular arcs are connected by a rectangular microstrip. These radiating elements are separately excited by a simple CPW feed that acts as the ground for the proposed antenna.

## 3 Result and Discussion

Figure 2 depicts the simulated results of $S_{11}$, peak gain, peak directivity, and smith chart. These results were simulated on Ansys HFSS 19.1 EM simulator. Figure 2(a) depicts the $S_{11}$ plot, which shows the proposed antenna radiates at 7.1 GHz and has a −10 dB bandwidth of 5.52 GHz ranging from 5.55–11.03 GHz with isolation more than 15 dB. Figure 2(a) depicts the impedance variation in the form of a smith chart, and it can be noticed we get perfect impedance matching at a single point, i.e., resonant frequency. The smith chart also shows that the loop lies within the VSWR = 2 circle, thus proving the obtained bandwidth (i.e., 5.55–11.03 GHz).

The envelope correlation coefficient (ECC) is the important parameter for MIMO diversity performance. ECC between two elements is calculated using scattering parameters using Eq. 1 [9]. Figure 3(a) shows the ECC of proposed MIMO antenna which is less than 0.02 over the operating frequency band. The peak gain of proposed

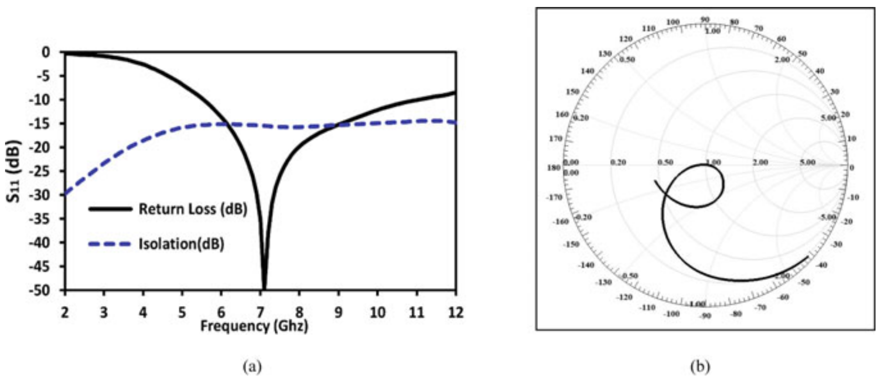


**Fig. 2** Simulate **a** S – Parameter **b** Impedance variation plot (smith chart)

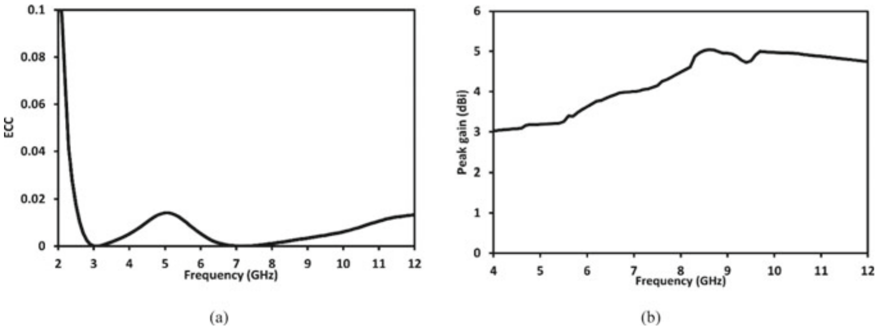


**Fig. 3** **a** Envelope correlation coefficient (ECC) vs frequency **b** Peak gain (dBi)

**Table 2** Comparison of proposed MIMO antenna with published work

| Ref. no. | Size (mm$^2$) | Frequency (GHz) | Peak gain (dBi) | No. of elements | Isolation (dB) |
|---|---|---|---|---|---|
| [4] | 75 × 75 | 4.96–5.50, | 4 | 2 | – - |
| [10] | 20 × 30 | 2.60–11.20 | 4 | 4 | > 20 |
| [11] | 22 × 36 | 3.0–11.0 | 5 | 2 | > 15 |
| [12] | 25 × 40 | 3.39- 9.10 | 2.5 | 2 | – - |
| **This work** | **25 x 12** | **5.55–11.03** | **5.1** | **2** | **> 15** |

MIMO antenna is 5.1 as shown in Fig. 3(b).

$$\rho_e = \frac{|s_{11} * s_{12} + s_{21} * s_{22}|^2}{\left(1 - |s_{11}|^2 - |s_{21}|^2\right)\left(1 - |s_{22}|^2 - |s_{12}|^2\right)} \quad (1)$$

The comparison of the proposed antenna with the reported work is listed in Table 2. The comparison is made based on the overall size, gain, and bandwidth. The proposed MIMO antenna has compact size and better gain as compared to previously published paper.

## 4 Conclusion

The design of a two-element MIMO antenna for C and X - Band applications is proposed in this article. The design consists of circular arcs connected by simple microstrip elements that have been excited using a simple CPW feeding. This feeding technique and the unique design helped us achieve wideband characteristics and suitable impedance matching at the resonant frequency of 7.1 GHz with frequency band from 5.55–11.03 GHz. The antenna is compact and provide an isolation of more than 15 dB overall the operating frequency band.

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