Design of Quad ACS-fed MIMO Antenna for 6G Wireless Applications

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Abstract: An asymmetric coplanar strip (ACS) fed 4 x 4 multiple-input multiple-output (MIMO) antenna is designed and outlined in this paper. To meet the progressively increasing demand for high data rates, a MIMO antenna is developed. The data is divided and transmitted by multiple similar antennas in a particular operating band. In this work, four ACS-fed similar antennas are designed to operate in the sub-6 GHz band. The four antennas' ground structures are connected. The radiator structure is designed using rectangular strips. The feed line is connected to U-shaped and S-shaped radiators. The designed structure covers the band 4.32 GHz to 4.63 GHz. The isolation between the antenna elements should be less than -15 dB. In the proposed design, the isolation is less than -10 dB between antenna elements 1, 3 and 4. Whereas between antenna elements 1 and 2, the isolation is greater than -10 dB in the operating band. This gap in the design can be mitigated by incorporating parasitic elements between the radiators and will be considered in future work.

Keywords: MIMO; ACS-fed; Wireless Applications; 6G; Connected ground.

Introduction

To meet the recent requirements of high data rates in wireless communication, multiple-input multiple-output (MIMO) technology is introduced. In the MIMO system, multiple antennas are used to transmit and receive data. The MIMO antenna system consists of multiple similar antenna structures that operate in the same frequency band. The antenna elements are arranged in such a way that the interference between the elements is less, so that the radiation efficiency of each antenna will be high [1]. Different shapes of radiators and ground structures are proposed by authors in the literature for MIMO antenna design. The authors in [2] suggested a hook-shaped radiator design to achieve dual-band performance for WLAN applications. A ladder-shaped radiator fed by an ACS feed is proposed for sub-6 GHz applications [3]. A small slit is introduced in the radiator to achieve WLAN operation [4]. This radiator is fed using an ACS feed to achieve compactness in the antenna structure. In the literature, shapes such as the 5-shape, C-shape, inverted U-shape, trophy shape, meander line, F-shape, L-shape and many more are used [5], [6], [7], [8], [9], [10]. As per the literature, it may be concluded that most of the radiator structures used are rectangular or circular strips, and those strips are arranged in different shapes. The length and width of the strips are adjusted to obtain the operating band for various applications. In this work, a 4 x 4 MIMO antenna is structured and discussed.

Key Contribution

A 4 x 4 MIMO antenna is structured and discussed in this paper. To integrate the antenna with the existing printed circuit board (PCB), a one-sided antenna design is carried out. The antenna radiator and ground structure are placed on one side of the substrate. This arrangement occupies compact space in the PCB. The feed used for this type of antenna structure is called an asymmetric coplanar-strip (ACS) feed. This design is also helpful for integrating the antenna with monolithic microwave integrated circuits (MMICs). Figure. 1 depicts the structured MIMO design. The design is carried out on an FR4 substrate of 0.8 mm thickness. This is a substrate commonly used for any electronic circuit design, and it is also easily available at low cost. The MIMO antenna design occupies a length and width of 50 mm. The designed structure has a rectangular-shaped ground, and all four antenna elements' ground structures are connected with each other. The connected ground provides a uniform and stable potential across antenna elements. Since the antenna elements are placed so close to each other, the surface current interruption between the ports is reduced by having a connected ground arrangement. The radiator is composed of a U-shaped and S-shaped structure. These two structures are connected through a feedline. The results obtained from the design is discussed in the next section.

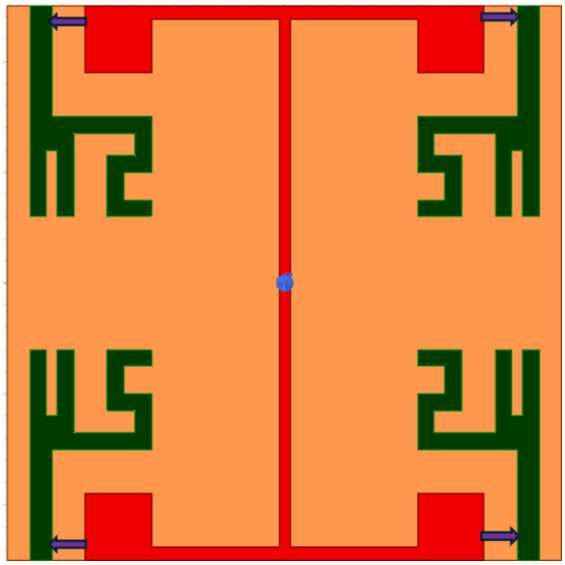

Figure 1. ACS-fed connected Ground 4 x 4 MIMO Antenna.

Method, Experiments and Results

The MIMO antenna design is carried out in ANSYS HFSS software. The four antenna elements are structured similarly. The antenna element-1 reflection characteristics is shown in Figure 2. It has -10 dB characteristics in the operating band 4.32 GHz to 4.63 GHz, which is within the sub-6 GHz application.

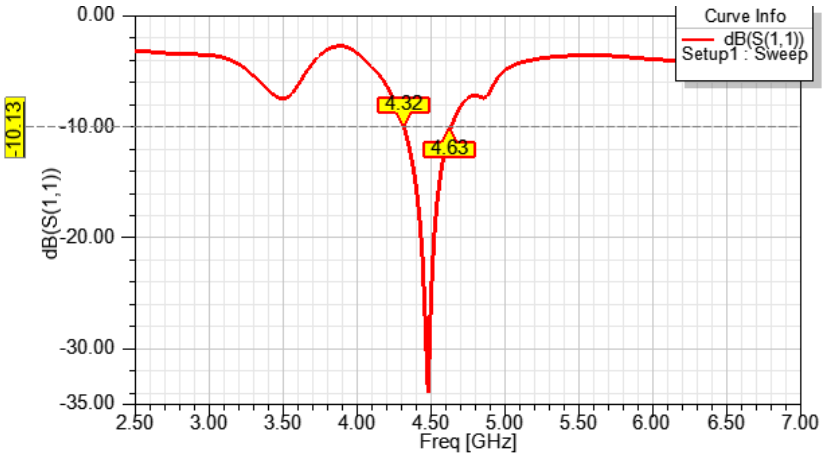

Figure 2. ACS-fed connected Ground 4 x 4 MIMO Antenna – S_{11} Characteristics.

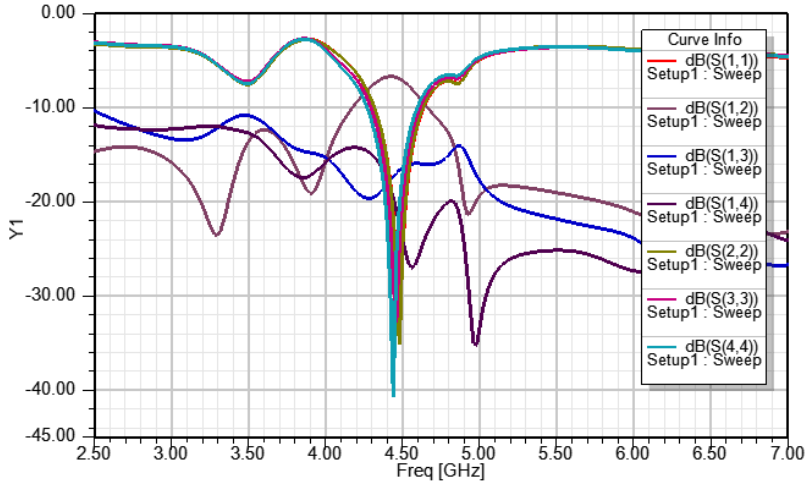

Figure 3. ACS-fed connected Ground 4 x 4 MIMO Antenna – Reflection & Isolation Characteristics

Figure. 3 details the isolation characteristics of antenna element-1 with the other antenna elements 2, 3 and 4. It also shows the reflection characteristics of antenna elements 1, 2, 3 and 4. The reflection characteristics of all four elements are similar, covering the band from 4.32 GHz to 4.63 GHz. The isolation between antenna elements 1 & 3 and 1 & 4 is better having less than – 15 dB for the operating band. But the isolation between antenna elements 1 & 2 is not the expected level. This needs to be improved by incorporating parasitic elements or by modifying the connected ground structure.

Discussions

A 4 x 4 MIMO antenna is designed and discussed in this paper. The designed MIMO works in the band from 4.32 GHz to 4.63 GHz. The isolation between the antenna elements is not at the expected level (i.e < -20 dB). This needs to be improved in the next work.

Conclusions

In this work, a compact ACS-fed 4 x 4 MIMO antenna is presented, and the simulated reflection and isolation characteristics are presented. The antenna element radiator is structured using a combination of U-shaped and S-shaped strips. The four antenna elements' ground structure is connected to have stable

potential with less surface current interference. The design structure needs to be further improved to have better isolation and wideband operation in sub-6 GHz applications.

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