IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

Impact Factor: 6.252

Volume 2, Issue 3, May 2022

Multiband Frequency Reconfigurable Antenna for 5G Applications

A. Shanmugam[1], S. Shyam Sankar[2], S. Sivaprasad[3], K. Sridhar[4], V. Prasanan[5]

U.G. Students, Department of Electronics and Communication Engineering[1,2,3,4]

Assistant Professor, Department of Electronics and Communication Engineering[5]

SRM Valliammai Engineering College, Kattankulathur, Tamilnadu, India

Abstract: *An MIMO system with an eight-element frequency reconfigurable rectangular slot antenna is presented, which can be tuned over a frequency band spanning 1 to 8 GHz for 5G applications. The operational frequency is 100 MHz. The ground plane has an E-shaped slot structure, and the reverse side of the substrate has a 50 microstrip line feed. The entire design is built on a FR4 substrate. The actual gain is 3.8 dBi. The simulation results show that the proposed antenna provides a good return loss response (for S11 less than 10 dB) across all three bands. Frequency Reconfigurability is achieved by using a Varactor Diode for a stable operation. The proposed antenna meets a number of commercial standards, including WiFi.*

Keywords: Slot Antenna, isolation, 8-port antenna, reconfiguration, 5G, varactor diode

I. Introduction

The next generation of Telecommunication Network 5G will reach peak market demand by the end of 2022, and it will continue to expand globally. 5G is intended to create a massive IoT (internet of things) infrastructure in which networks meet the connectivity needs and demands of billions of connected devices while maintaining the required speed, latency, and cost standards. Because frequency reconfigurable multiple-input-multiple-output (MIMO) antenna systems combine the benefits of high throughput and multiple bands/standard coverage, they are regarded as a good solution for next-generation telecommunication networks (5G). [1] describes a pentagonal slot-based miniaturized frequency reconfigurable MIMO antenna. The design includes four antenna elements etched into the ground (GND). The proposed antenna has a continuous frequency sweep over the bands 3.2 to 3.9 GHz, with a minimum operating bandwidth of 55 MHz (100 MHz when considering the 6 dB bandwidth and used for CR applications). The implementation of pattern diversity in [2] Planar inverted-F antenna (PIFA) using Symmetry is shown to be very effective in reducing mutual coupling between antenna elements, and good isolation is achieved without introducing additional decoupling structures. [3] proposed a slot-based port-reconfigurable MIMO antenna system for WLAN applications with working bands of 2.4 and 2.5 GHz as well as 4.9 and 5.72 GHz. [4] proposed a four-port MIMO frequency-reconfigurable MIMO annular slot-based antenna with a working band of 1.8 to 2.5 GHz. In [5] An E-shaped printed slot antenna is presented as a candidate to cover dualband operation over the entire wireless local area network (WLAN) frequency bands of 2.4–2.5 GHz and 4.9–5.8 GHz.

In this paper, a MIMO rectangular slotted patch antenna with increased performance is analyzed. The main objective of this paper is to operate the antenna at multiband frequencies has been proposed so far for wireless portable devices and mobile terminal. The presented design is highly compact and is confined within a board volume of 120×60×0.8 mm^3.Varactor diode are used to achieve frequency tunability. Isolation between adjacent antenna is improved by using rectangular defected ground slot (DGS).

II. Antenna Design

An Eight element MIMO system was implemented by rectangular slot antenna having dimension of 22x15.45 mm^2 and was feed with 50-ohm microstrip feedline. The slot has been constructed, in the form of E-shape, on the ground plane side of a dielectric substrate.. For achieving multi-band feature, an extra meandered type slot was added in the structure to achieve extra resonance. varactor diode was used to achieve frequency reconfigurability by loading slot with variable capacitance of varactor diode.

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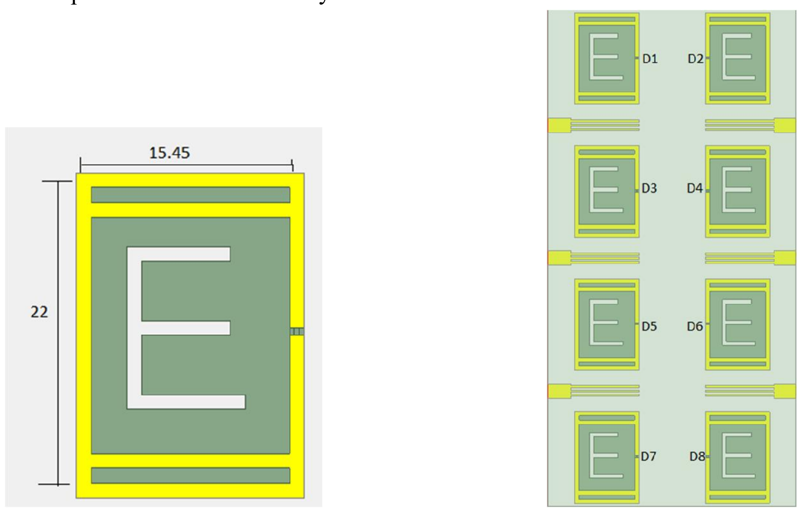
The varactor diode was reverse biased with a voltage ranging from 0 to 15 volts. The varactor diode is on the ground (GND) plane, and diode terminals were soldered across the slot to connect it to the GND plane and the bias circuit via two vias on the other side of the substrate. Figure 1 depicts the proposed multi-band eight-element MIMO slot antenna system, as well as varactor diode biasing circuitry. Figure 1a depicts the single slot antenna, Figures 1b depicts ground plane for triband operation and 2 contained microstrip feed line and biasing circuitry for varactor diodes . The antenna is printed on a FR-4 substrate (tan =0.02 and r =4.4). The entire antenna system is printed on a 120x60x0.8 mm^3 substrate, making it suitable for handheld wireless devices. The substrate board is made up of eight antennas, each with a E Shaped meandered slot for extra resonance, allowing for tri-band operation. For frequency reconfigurability, eight varactor diodes labelled D1–D8 were used, one in the middle of each antenna. Capacitive loading with varactors was used to achieve frequency reconfigurability. The GND plane is on the bottom layer.



(a) (b)

Figure 1: (a) Single element for multiband operation (b)GND plane for multi-band operation

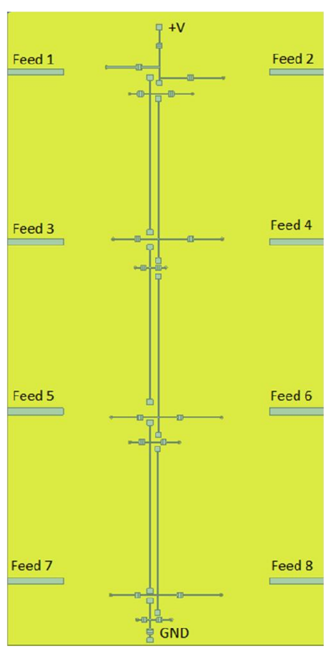


Figure 2: Top view and Biasing circuit

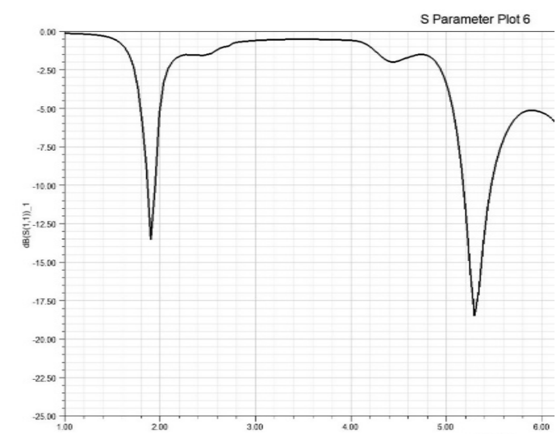
III. Simulation and Result

The proposed slot reconfigurable MIMO antenna was modeled and simulated using HFSS. The antenna dimensions were optimized to maximize the number of covered bands for the given realizable capacitance values. To improve MIMO performance metrics and isolation, multiple parametric sweeps were performed to optimally place the antenna elements and select the positions of the varactor diodes.

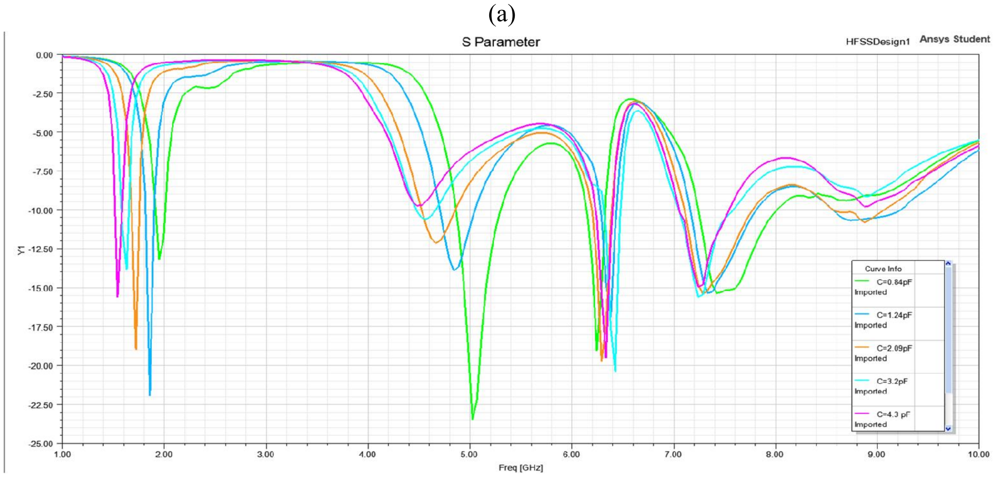
3.1 MIMO Antenna Scattering Parameters

The simulated curves for reflection coefficients (S11) of the proposed MIMO system for multi-band operation are shown in Figure 2a. We obtained similar results from all ports due to the symmetrical structure of all antennas. As a result, S11 results are sufficient to provide a complete picture of resonant frequencies. The varactor diode was modeled as a variable capacitance with values ranging between 0.84pF to 5.08pF. The capacitance values used were C1=0.84pF, C2=1.24pF, C3=2.09pF, C4=3.20pF and C5=4.30pF and the S11 parameters are shown in 2b.

The presented design was tested for isolation values between various antennas. The proposed 8-element MIMO frequency-reconfigurable antenna system's simulation and measurement isolation curves were examined. Closely placed antennas did not perform well in the absence of DGS, but DGS significantly improved isolation. The simulated isolation curves between Ant 1 and Ant 2 for triple-band operation for different values of capacitance are shown in Figure 3. Because of the symmetrical placement of all antenna elements, we obtained similar curves for S23, S24, and so on, so they are not included.



(a)



(b)

Figure 3: (a) Simulated S_{11} for single slot structure (b) Simulated S_{11} for multiband operation

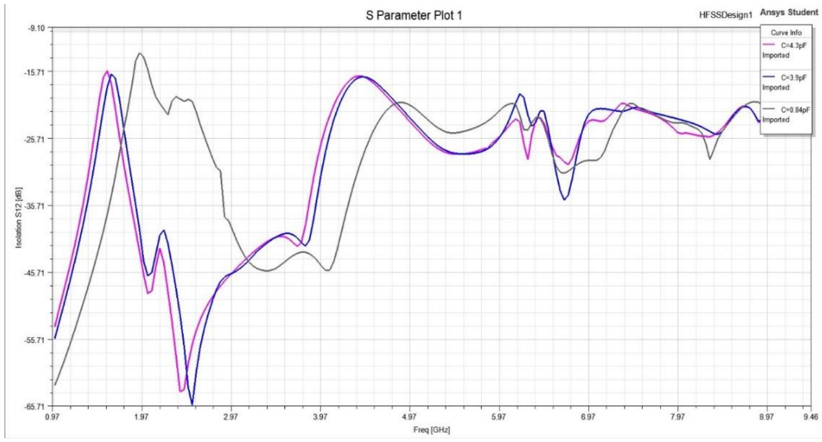
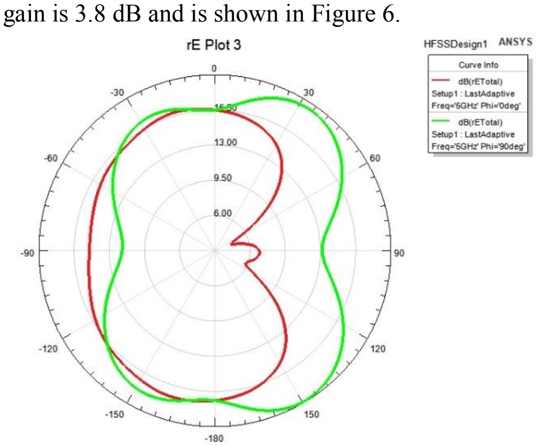


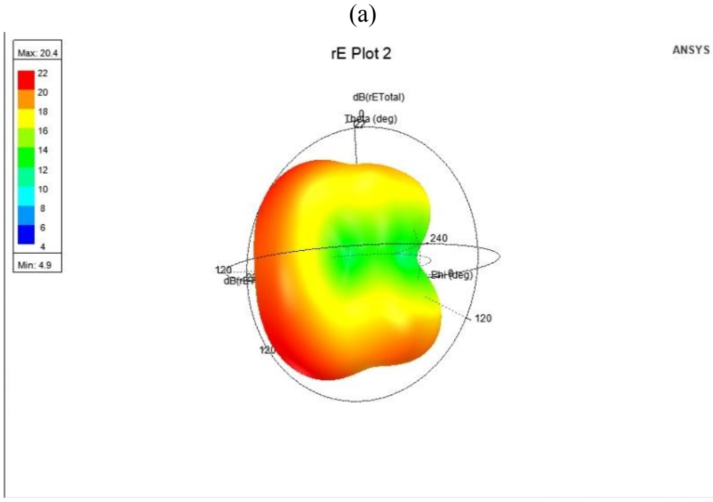
Figure 4: Simulated S_{12} for multiband operation

3.2 MIMO Antenna Gain Patterns

The Simulated 2D Radiation Pattern at 5 GHz for Phi=0deg and Phi=90deg is shown in Figure 5a and the 3D radiation pattern of the proposed antenna is shown in Figure 5b. The Total gain of the antenna is maximum when the value of Capacitance is 4.3pF and the maximum gain is 3.8 dB and is shown in Figure 6.



(a)



(b)

Figure 5: (a) Simulated 2D radiation pattern for 5GHz (b) Simulated 3D radiation pattern

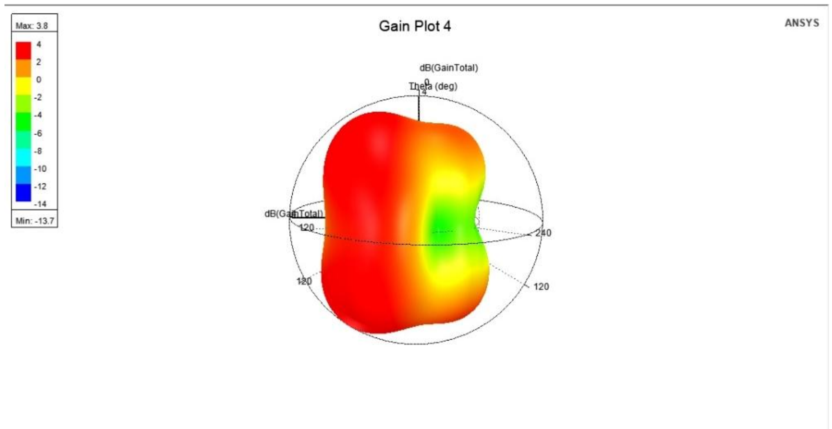


Figure 6: 3D polar Gain Plot of the proposed antenna

V. Conclusion

A Multi-band, planar, eight-port MIMO frequency reconfigurable antenna design for 5G applications has been presented in this paper. This eight-antenna element design was confined within a single substrate and employed varactor diodes for reconfigurability. Isolation was improved between antennas by utilizing DGS. The simulation and measurement results demonstrate that this rectangular slot based antenna system can work in a single band (i.e. 4.9-5.2 GHz) or triple-band mode (4.7-5, 6.2 and 4.6GHz) realizing good gain and efficiency. The compact total dimensions (120×60×0.8 mm3) and planar, low-profile structure of presented antenna system make it appropriate for Home Network Communication.

Acknowledgment

We sincerely thanking our respected principal Dr. B. Chidhambararajan. We also expressing our profound thanks to the Head of the Department Dr. Komala James and to our supervisor Mr.V. Prasanan, Assistant professor for their constant support, guidance and motivation while facing tough time in our project and making this project a successful one.

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