ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)

Vol 10, Issue 2, February 2023

Design of 4x4 MIMO Antenna for 5G Applications

[1] Kalpita B Velip, [2] Asst. Prof. Sangam Borkar

[1] [2] Department of Electronics and Telecommunication Engineering, Goa Engineering College, Goa, India.
Corresponding Author Email: [1]1kalpitav@gmail.com, [2] sangam@gec.ac.in

***Abstract*— The design presented in the paper for the 5G application (5G NR N78 Band) at the operating frequency 3.5GHz of a patch antenna with U shaped slot was investigated to realize a structured 4x4 MIMO antenna. To widen the bandwidth U-shaped slot was cut out on the microstrip patch antenna that was coaxially fed. FR4 material was used as the dielectric substrate in designing with relative permittivity 4.4 with a height of 1.6mm and loss tangent 0.02. The antenna model was designed and analyzed using HFSS software to obtain a bandwidth of 250 MHz with good performance parameters like VSWR, Gain, Reflection coefficient and Impedance. The parameters and analysis have been added in this paper.**

***Index Terms*— 5G NR N78 band, HFSS, Microstrip, MIMO, U-slot.**

I. INTRODUCTION

This technology of MIMO (Multiple-input multiple-output), one of the key components playing substantial role in the 5G system of communication can greatly boost spectral efficiency without using additional power.

3GPP (3rd Generation Partnership Project) recognized many licensed and also unlicensed bands which form a wide bandwidth from 3.3GHz to 5GHz as the combination of 5G NR bands N77 (3.3–4.2 GHz), N78 (3.3–3.8 GHz) and N79 (4.4–5 GHz) [1]. The 5G sub-6 GHz spectrum has NR bands N77/N78/N79 its key constituents.

3GPP (3rd Generation Partnership Project) recognized many licensed and also unlicensed bands which form a wide bandwidth from 3.3GHz to 5GHz as the combination of 5G NR bands N77 (3.3–4.2 GHz), N78 (3.3–3.8 GHz) and N79 (4.4–5 GHz) [1]. The 5G sub-6 GHz spectrum has NR bands N77/N78/N79 its key constituents.

The main method for improving all facets of wireless communications is MIMO. It has a significant impact on 5G technology and is changing how everyday people engage with these technologies. By implementing 5G New Radio (NR), data can reach more users and be accessed by more people at the same frequency and time rates.

A light-weight and smaller sized antenna is probably recommended to enable the high mobility required for a wireless equipment to communicate. Microstrip antennas that compact enough are among the best tools for this job. Due to their low cost and planar form, microstrip antennas have been extensively well used in modern systems.

Cutting a U-shaped slot in the patch of the rectangular patch antenna that is coaxially fed is one way to increase the bandwidth. The finite ground plane and U-shaped slot are employed to produce excellent impedance matching and expand the bandwidth [2]. Due of its benefits, our design takes into account a U-shaped slot on the patch antenna's rectangular shape.

For our design, we took into account the coaxial probe feed approach because it is simple and adaptable because it may be positioned wherever is necessary to meet impedance.

In this paper a single basic structure of Microstrip patch antenna was considered for designing. The design of a 2x2 and finally 4x4 antenna system with multiple single element antennas were placed compactly in a MIMO configuration Fig.1.FEKO model of a U-slot Rectangular Patch Antenna.

II. DESIGN OF THE ANTENNA

In Fig. 1, Fig. 2 and Fig.3 the rectangular U-slot patch antenna's geometry which is proposed above is shown.

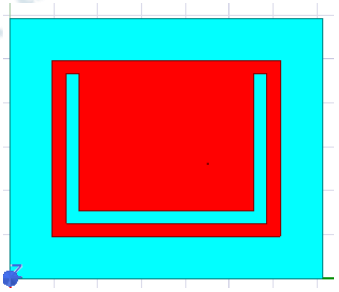

Fig. 1. HFSS model of a U-slot Rectangular Patch Antenna.

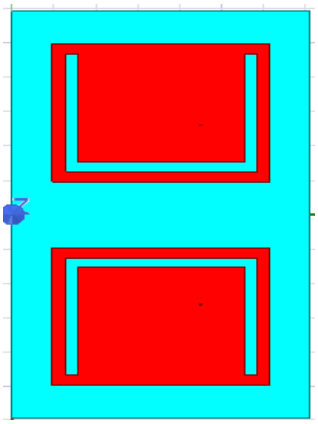

Fig. 2. HFSS model of a 2X2 MIM0 U-slot Rectangular Patch Antenna.

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)

Vol 10, Issue 2 February 2023

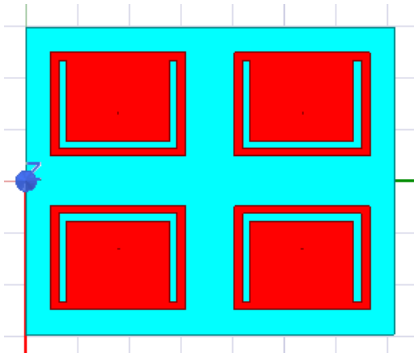

Fig. 3. HFSS model of a 4x4 MIM0 U-slot Rectangular Patch Antenna.

Fig.4. shows the detailed dimensions of the single patch antenna where Lg is the ground plane length and Wg as the width and the patch length and width are L and W respectively. The patch consists of a U-slot with the following dimensions: D for the slot width, C for the slot height, H for the slot height from the patch base, and E and F for the slot width between the upper and lower layers of the U-slot.

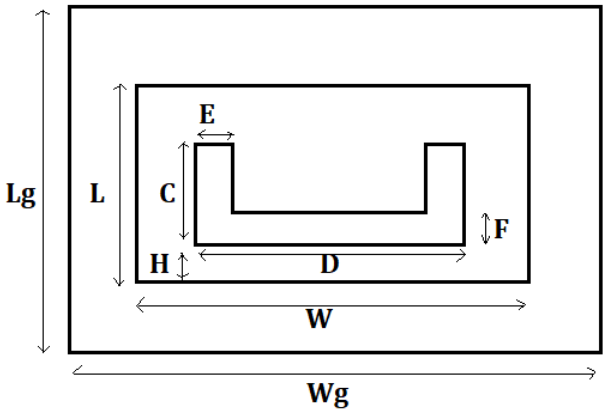

Fig. 4. U-slot microstrip Patch Antenna's dimensions.

III. DESIGN CONSIDERATIONS

The center frequency (fo) is taken as 3.5 GHz with lower bound frequency (flow) as 3.3 GHz and upper bound frequency (fhigh) as 3.8 GHz. The antenna was designed for the application of 5G for the 5G NR N78 band. Dielectric material FR4 with dielectric constant 4.4 and loss tangent 0.02 was used. Substrate height was taken as 1.6 mm.

The most popular method of feeding Microstrip patch antennas is employed i.e. coaxial-probe feeding. This type of feeding technique has the key benefit that the feed can be placed anywhere it is needed inside the patch to match the input impedance [3]. After several iterations, its position on the patch determined the impedance match that were estimated to meet a 50Ω impedance.

The various design parameters that were calculated for the single element of the MIMO antenna configuration are provided below in Table 1.

TABLE I. Design Parameters

Normal Patch Readings (mm)	
width(W)	26.08
length(L)	20
ground width (Wg)	35.68
ground length (Lg)	29.6
feed point location	(13.04, 17.84)
U Slot Patch Readings (mm)	
slot width (D)	22.76
slot Height (C)	17.07
height of from base (H)	1.465
slot thickness (E=F)	1.43

IV. SIMULATIONS AND RESULTS

HFSS software was used to create and simulate this antenna model. The feed point location (13.04, 17.84) yielded the best impedance matching, with a measured impedance of 50.5. The VSWR and Reflection coefficient were also determined to be minimal at this feed point. The performance characteristics of the antenna are shown in Table II.

TABLE II. Performance Parameters

Parameters	Values
resonance frequency (GHz)	3.42
impedance (Ω)	50.5
reflection coefficient (dB)	-19.2
gain (dBi)	13.8
VSWR (absolute value)	1.25
-3 dB bandwidth (MHz)	250

The following graphs show the plots of several performance parameters. The antenna was discovered to have a gain of 13.8 dBi and be resonating at 3.42GHz. The Reflection coefficient and VSWR values are modest and sufficiently close to optimum values. In the context of patch antennas, the bandwidth of 250 MHz from the frequency 3.35GHz to 3.6GHz is a good figure.

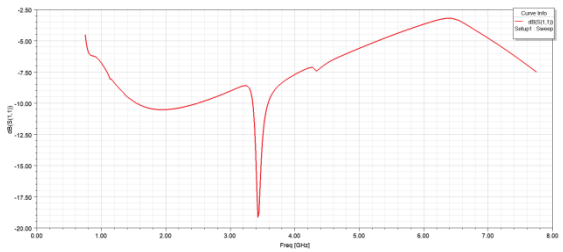

Fig. 5. Magnitude of the reflection coefficient (dB) and -3dB bandwidth.

ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)

Vol 10, Issue 2 February 2023

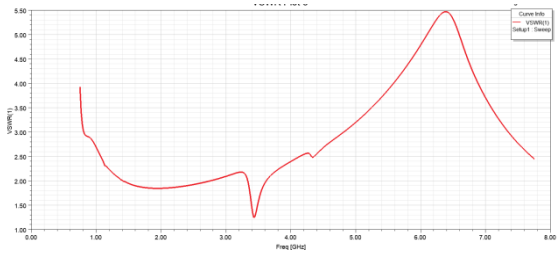

Fig. 6. Plot of VSWR.

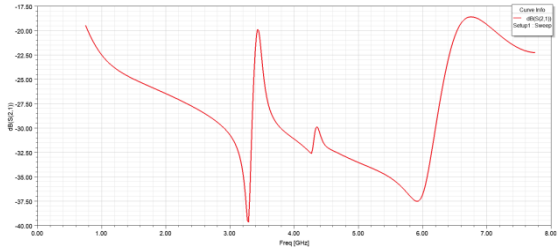

Fig. 7. S (2,1) vs frequency plot.

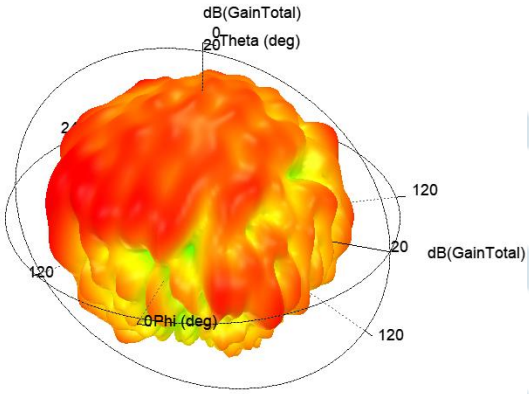

Fig. 8. 3D radiation pattern.

V. CONCLUSION

The performance criteria for the antenna created specifically for the use, 5G application (5G NR N78 Band) at the operating frequency 3.5GHz with the incorporation of U-shaped slot single antenna that was coaxially fed and designed using FR4 substrate material with the height of 1.6mm to realize a 4x4 MIMO antenna are reliable. Furthermore, a good bandwidth is achieved with the least amount of return loss and VSWR.

REFERENCES

[1] Qinyi Cai, Yixin Li, Xugang Zhang, and Wenhui Shen ‘‘Wideband MIMO antenna array covering 3.3-7.1 GHz for 5G metal-rimmed smartphone applications’’ IEEE Access, vol. 6, pp. 28041–28053, 2018.

[2] Panchatapa Bhattacharjee, Vivek Hanumante, Sahadev Roy “Design of U-slot rectangular patch antenna for wireless LAN at 2.45GHz”; 9th International Conference on Microwaves, Antenna, Propagation and Remote Sensing ICMARS-2013, Jodhpur, INDIA, 11th – 14th December, 2013.

[3] A. Sahaya Anselin Nisha, T. Jayanthy, “Design and analysis of multiband hybrid coupled octagonal microstrip antenna for wireless applications” Research Journal of Applied Sciences, Engineering and Technology 5(1): 275-279, 2013.

[4] S.-C. Chen, M.-K. Wu, C.-W. Chiang, and M.-S. Lin, “3.5-GHz four-element MIMO antenna system for 5G laptops with a large screen-to-body ratio,” Journal of Electromagnetic Waves and Applications, vol. 34, pp. 1195-1209, Nov. 2019.

[5] Y. Li, C.-Y.-D. Sim, Y. Luo, and G. Yang, “High isolation 3.5-GHz 8-antenna MIMO array using balanced open slot antenna element for 5G smartphones,” IEEE Transactions on Antennas & Propagation, vol. 67, pp. 3820-3830, June 2019.

[6] M. Bridges, M. Khalily, M. Abedian, D. Serghiou, P. Xiao and R. Tafazolli, "High isolation 8×8 MIMO antenna design for 5G Sub-6 GHz smartphone applications," 2020 International Conference on UK-China Emerging Technologies (UCET), 2020.

[7] Shing-Lung Steven, Member IEEE, Ahmed A. Kishk, Fellow IEEE and Kai-Fong Lee, Fellow IEEE “Frequency reconfigurable U-Slot microstrip patch antenna,” IEEE Antennas and Wireless Propagation Letters, Vol. 7, 2008. 9th International Conference on Microwaves, Antenna, Propagation and Remote Sensing ICMARS-2013, Jodhpur, INDIA, 11th – 14th December, 2013.

[8] H. Wang and G. Yang, "Compact and low-profile eight-element loop antenna array for the 3.6-ghz MIMO operation in the future smartphone applications," 2017 Sixth Asia-Pacific Conference on Antennas and Propagation (APCAP), 2017.

[9] H. T. Chattha, “4-Port 2-element MIMO antenna for 5G portable applications,” IEEE Access, Special Section on Antenna and Propagation for 5G and beyond, June 27, 2019.