A COW HEAD – INSPIRED MIMO ANTENNA FOR 5G SUB 6-GHZ BANDS N77/N78&N79

[1] Dr. D. Tilak Raju, [2]Bollula Bindu Madhavi, [3] Appikonda Lalitha Bhavani, [4] Domada Swathi Lakshmi, [5]Anaparthi Swetha,

[1]Assistant Professor, [2,3,4,5]B.Tech, [1,2,3,4,5]Department of Electronics and Communication Engineering, Vignan's Institute of Engineering for Women, Visakhapatnam, Andhra Pradesh, India

ABSTRACT

An Antenna is an electrical device that converts electric power into electromagnetic waves (or simply radio waves) and vice versa. There are many types of antennas like Wire Antennas, Log Periodic Antennas, Reflector Antennas, Array Antennas etc. Multiple Input Multiple Output (MIMO) technology is a novel wireless communication technique that reduces multipath fading problems in free space environments. MIMO technology also offers improved channel capacity, increased data rates, reliable transmission, and high-quality transmission. Because there are many elements arranged in a small area with MIMO technology, there is a high coupling between the elements. A significant part of modern wireless cellular communication is played by the combination of MIMO and 5G cellular systems. The present work proposes a novel cow-head shaped multiple input multiple output (MIMO) antenna for 5G sub:6 GHz applications, which include N77/N78 (3.3–4.2 GHz/3.3–3.8 GHz) and N79 (4.4–5.0 GHz) bands. The proposed work is designed and developed on a 30×66 mm2 size FR4 substrate with a dielectric constant of 4.4 and loss of tangent of 0.002. The parametric analysis and surface current distribution are studied for the optimization of parameters, and the coupling between elements is analysed respectively. The performance of the design will be studied in terms of efficiency, peak gain, and radiation patterns (E & H fields).

Key words:

Cow-Head Shaped MIMO Antenna, FR-4 Substrate, N77, N78&N79 Bands.

INTRODUCTION

Antennas are devices used to transmit or receive electromagnetic waves, typically for communication purposes. They come in various shapes and sizes, each designed to optimize the transmission or reception of specific frequencies. Antennas play a crucial role in modern technology, enabling wireless communication across vast distances.

Functionality: Antennas work by converting electrical signals into electromagnetic waves for transmission or vice versa for reception. They operate based on the principles of electromagnetism, with factors like length, shape, and material affecting their performance.

The novel cow head-shaped antenna designed specifically for the Sub 6 GHz N77, N78, and N79 bands applications. This cutting-edge antenna promises enhanced performance and coverage, catering to the growing demand for high-speed connectivity in urban and rural areas alike. With its unique design and optimized functionality, it represents a significant advancement in telecommunications, paving the way for a 5G experience for users worldwide.

In this project MIMO Technique is used, which is playing a vital role in today's Wireless communications because of it's features like high data rate, channel capacity and good quality service. This Technique is also used because it avoids multipath fading problems, which are caused by atmospheric conditions. But this MIMO technology is having one of the limitation that is mutual coupling, this main caused because of

antenna elements connected very close to each other. So that radiations and surface currents of one element may collide and flow to another antenna element. Generally, we are aware of networks like 1G, 2G ,3G, 4G. But we still search for 5G because it is having higher data rate with more channel capacity and effective

transmission. This 2G,3G,4G are not capable of providing higher data rate and better channel capacity

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 6, June : 2024

due to the limited band width.

LITERATURE SURVEY

[1] Niamat Hussain, Member, IEEE, and Nam Kim. The complete coverage of the operating frequency bands from microwave bands to millimeter (mm-wave) is required for the realization of the fifth-generation (5G) Internet of Thing (IoT) systems. Here, we present a multiband antenna operating at the microwave (2.5/3.5/5.5/7.5 GHz) and mm-wave bands (23–31 GHz and its 12-port MIMO configuration with pattern diversity affording 360◦ coverage for 5G IoT applications. The multiband characteristics are obtained by adding well designed quarter-wavelength stubs. The antenna operates at the important frequency bands from 2.37–2.65, 3.25–3.85, 5.0–6.1, and 7.15-8.5 GHz (|S11| <-10dB), while it resonates from 23-31 GHz at the mm-wave band with the desired radiation characteristics.

[2]Jeong, H.; Park, J.; Song, S.C.; Jung, S.-O. A new compact and modified hexagonal-shaped circular MIMO antenna that operates in the band of 2.95–6.3 GHz is presented in this paper. This antenna covers the complete range of 5G sub: 6 GHZ (N77/N78 & N79) and WLAN bands. The design consists of two element MIMO antenna fabricated on low-cost FR-4 substrate. In order to improve the isolation a vertical stub is placed between two elements. Isolation greater than 15 dB is achieved over the entire operating band. The suggested MIMO antenna is excited using an asymmetric feeding approach. Simulated and measured results from fabricated prototypes are in good agreement. Results confirm the diversity and radiation performance of the proposed MIMO antenna are good. The diversity metric parameters ECC, DG, TARC, CCL, and MEG values strongly agree. The construction is created on a FR4 substrate with dimensions of 20 × 34 mm2,6 mm in height, and 4.4 as the constant. The structure has efficiency and gain values of above 83% and 0.2–3 dBI, respectively.

EXISTING METHOD

The proposed cow-head shaped antenna is developed on a low-cost FR4 substrate having a height of 1.6 mm and a dielectric constant of 4.4. The proposed single antenna works in the band from 3.0 to 5.2 GHz, and the two- element antenna operates in 3.3 to 5.0 GHz band region. The proposed cow-head-shaped single antenna with dimensional parameters is presented in figure and parameter values are presented in Table 1. The proposed cow-head-shaped single antenna with dimensional parameters is presented in Figure.

Step1: The proposed design evolution process is depicted in Fig. 2. Initially, with two united small circular patches of radii 4 mm are attached to the microstrip line feed, and it was named Antenna 1. And the output waveform of the Antenna 1 is shown below.

Step 2: Due to the impedance mismatching, Antenna 1 did not work in the 5G sub:6GHz region. Later, one more circular patch is united on the top layer, and the rectangular strip is subtracted from the ground layer to form Antenna 2.

Step 3: However, Antenna 2 covers only the N79 band, which is from 4.2 to 5.2 GHz, but impedance matching at this region is very poor. To get better impedance matching at this region, optimized dimensional values of the moon-shaped patch are added to Antenna 2.

Finally, Antenna 3 is also formed with the inverted C-shaped strip added to the ground layer, and two small circular slots are removed. Now, Antenna 3 looks like a cow-head shaped antenna, and it works from 3.0 to 5.2 GHz.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 6, June : 2024

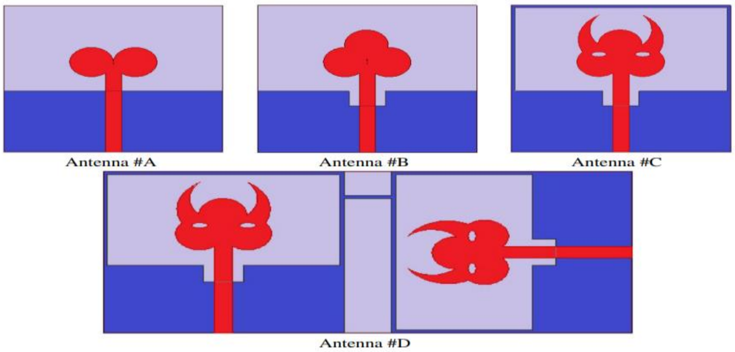

Figure.1. Schematic diagram for proposed antenna

PROPOSED METHOD

The proposed single antenna covers all 5G sub:6 GHz bands. To extend the single antenna MIMO structure, another same antenna is placed orthogonally with a separation of 6 mm. A small strip of size 6 × 0.5 mm2 is used to connect the two antennas. Then Antenna #D is formed, and it is a MIMO antenna with connected
ground. The proposed two-element cow-head shaped MIMO antenna works in the band from 3.3 to 5.0 GHz,

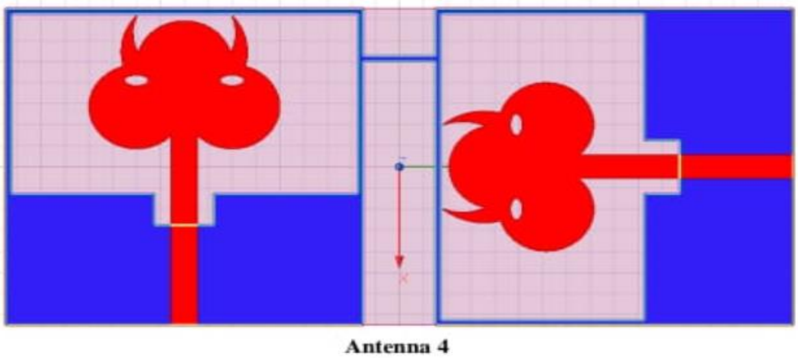

Figure.2. Two Port Network Antenna

THE DESIGN STRUCTURE OF COW HEAD- SHAPED ANTENNA

Designing a cow head-shaped MIMO (Multiple Input Multiple Output) antenna for 5G sub-6 GHz bands (N77, N78, N79) involves several steps:

Antenna Geometry: Design the antenna structure resembling a cow head while ensuring it meets the size constraints for operating in the desired frequency bands.

Material Selection: Choose appropriate materials with suitable dielectric properties to fabricate the antenna. The choice of materials affects antenna performance.

Frequency Band Coverage: Optimize the design to cover the frequency bands N77 (3300-4200 MHz), N78 (3300-3800 MHz), and N79 (4400-5000 MHz) efficiently.

MIMO Configuration: Determine the MIMO configuration (such as 2x2, 4x4, etc.) based on the desired spatial diversity and multiplexing gains.

Radiation Pattern: Ensure that the antenna exhibits desired radiation characteristics, such as omnidirectional or directional patterns, suitable for 5G applications.

Impedance Matching: Design the antenna elements and feed network for impedance matching across the frequency bands to maximize power transfer.

Isolation between Antenna Elements: Minimize mutual coupling between antenna elements to maintain MIMO performance and reduce interference.

Simulation and Testing: Simulate the antenna design using electromagnetic simulation software to validate its performance. Prototyping and testing in real-world conditions are essential to verify simulation results.

Compliance: Ensure the antenna design complies with regulatory requirements and standards for electromagnetic radiation and interference.

Integration: Integrate the antenna into the device or system architecture, considering factors like size, form factor, and compatibility with other components.

Throughout the design process, iterative optimization and testing are crucial to achieve the desired performance metrics for the cow head-shaped MIMO antenna in the specified 5G frequency bands.

RESULT ANALYSIS

The surface current distribution of an antenna refers to the distribution of electric currents flowing along the surface of the antenna structure. It's crucial in understanding how electromagnetic waves are generated and propagated by the antenna. Factors such as antenna geometry, material properties, and operating frequency influence this distribution. Engineers analyze and design antennas by modeling and manipulating these current distributions to achieve desired performance characteristics like radiation pattern and impedance matching.

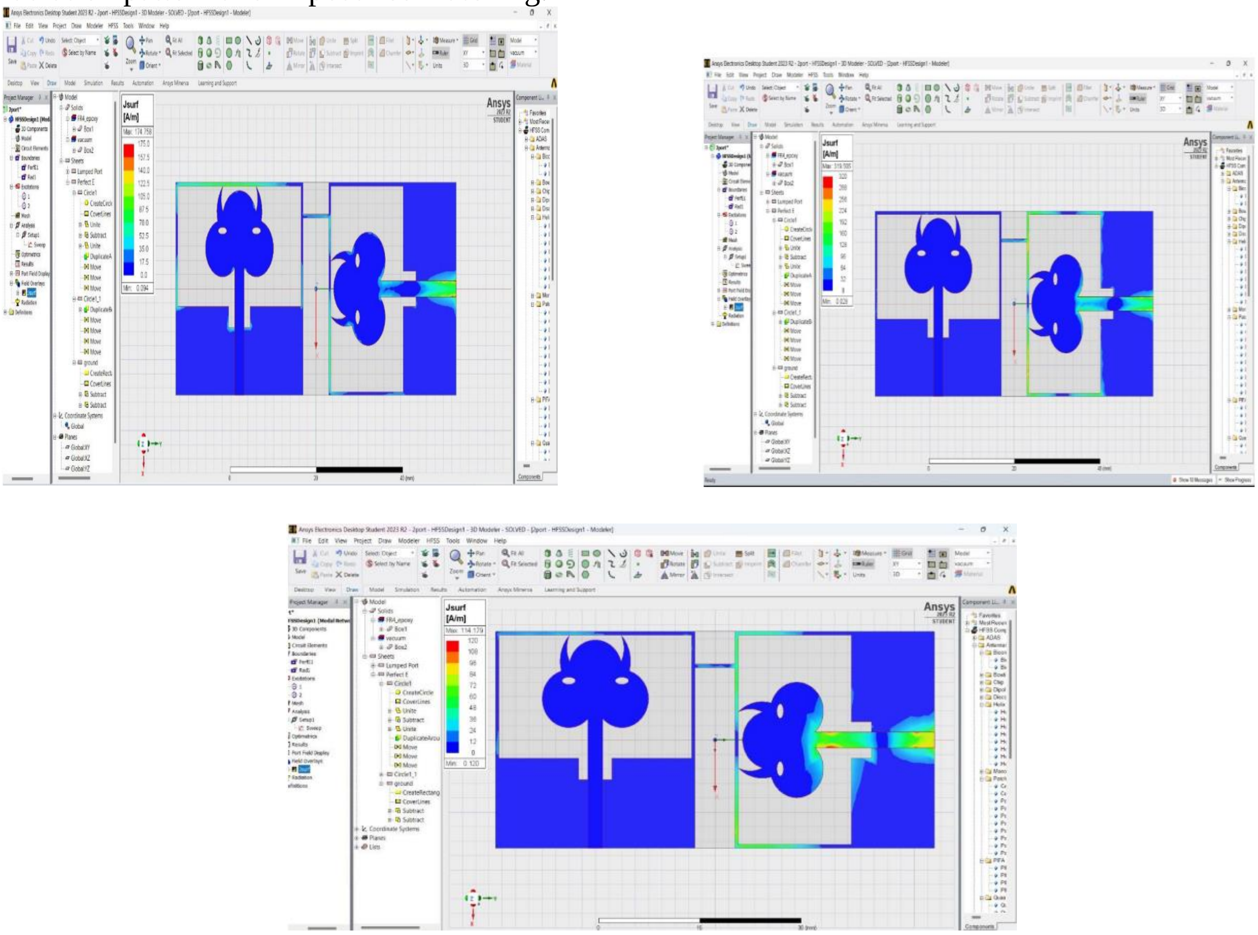

Fig 3: Surface Current Distribution at different frequencies

Radiation Efficiency: The radiation efficiency of an antenna refers to the ratio of the power radiated by the antenna to the total input power supplied to the antenna. It indicates how effectively the antenna converts input power into radiated electromagnetic waves.

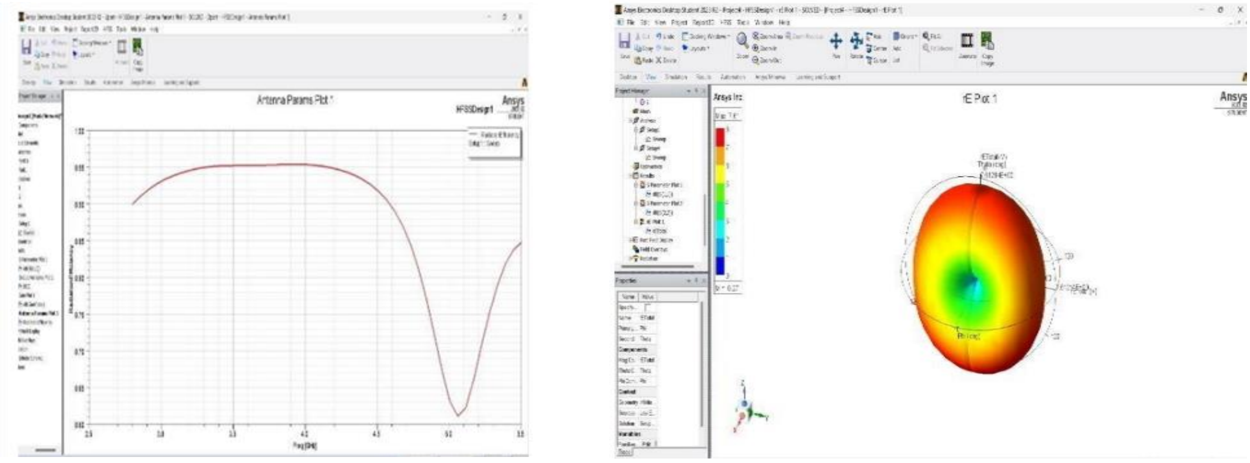

Fig 4: Graphical representation for Radiation Efficiency

Peak Gain: The peak gain of an antenna refers to the maximum gain observed in a specific direction compared to an isotropic radiator (an ideal point source that radiates energy uniformly in all directions). It represents the antenna's ability to concentrate radiated power in a particular direction.

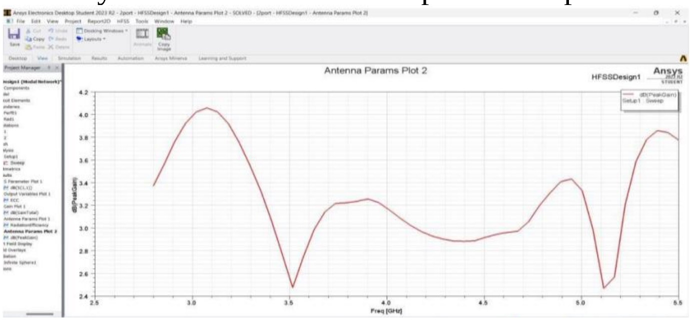

Fig 5: Graphical representation of Peak Gain

Ref. No, No of Elements	Antenna Size (mm^2)	Bandwidth (GHz)	Isolation (dB)	Peak gain (dBi)	Radiation Efficiency (%)	CCL (bits/s/Hz)	TARC (dB)
[7], 1	135 × 80	0.75, 2.7–3.5, 4.5–5.0	—	1.66, 4.72, 4.52	60, 42, 41	—	—
[8], 2	46 × 30	1.8–3.6, 5–7.9	17.2, 22.4	4.31, 4.62	71, 70	0.35	≤ −10
[9], 2	30 × 6.75	4.9–5.06	20	1.95	79.5	—	—
[10], 1	100 × 100	2.45, 3.5	—	7.64	64.5	—	—
[11], 8	192 × 76	1.3–3.8	15	13.8	83.6	—	—
[12], 2	35 × 50	4.6–4.9	15	1.8	45	0.5	≤ −10
[13], 2	59 × 55	3–7	18	5.6	85	0.4	≤ −10
[14], 2	20 × 14.75	2.38–3.0, 3.21–3.61, 5.02–6.18	—	7.93, 4.23, 7.5	23.05, 11.73, 20.71	—	≤ −10
[16], 8	22 × 22	3.3–7.1 (−6 dB)	12	4.6	48	0.3	≤ −30
[17], 4	42 × 42	3.2–12	17	5.6	80	0.4	—
[24], 8	112 × 112	3.5–4.0	17	5.0	85	0.01	≤ −10
[25], 1	28.03 × 23.45, 1	4.9–5.7	—	6.2	70	—	—
[26], 1	23.8 × 23.8, 1	3.2–5.3	—	2.7	96	—	—
[27], 2	26 × 36	3.2–6.7	26	5.3	98	0.005	≤ −10
P*, 2	**30 × 66**	**3.3–5.0**	**18**	**4.6**	**91**	**0.05**	**≤ −10**

Fig 4: Comparison of Proposed work with other literature works

CONCLUSION

In this paper, the proposed cow-head-shaped MIMO antenna is designed for 5G sub:6 GHz applications and is presented in the current work. It works in the region from 3.3 to 5.0 GHz and covers complete bands of N77/N78 & N79 bands. The element-to-element isolation of above 18 dB is attained with proper arrangement of antenna elements, and an optimized small strip is connected between the grounds. The radiation performance of the design is checked with efficiency, gain, and pattern results. The stable and bore sight patterns are attained with a properly optimized design. The diversity metrics ECC, DG, TARC, CCL, and MEG are used to estimate the MIMO performance of the proposed design in a free space environment. Low ECC, high DG, good TARC, low CCL, & acceptable MEG values are attained. These are compared with measured ones, and they are well matched.

REFERENCES

[1] Chen, X., S. Zhang, and Q. Li, "A review of mutual coupling in MIMO systems," IEEE Access, Vol. 6, 24706–24719, 2018.

[2] Addepalli, T. and V. R. Anitha, "Compact two-port MIMO antenna with high isolation using parasitic reflectors for UWB, X and Ku band applications," Progress In Electromagnetics Research C, Vol. 102, 63–77, 2020.

[3] Nadeem, I. and D.-Y. Choi, "Study on mutual coupling reduction technique for MIMO antennas," IEEE Access, Vol. 7, 563–586, 2018.

[4] Addepalli, T. and V. R. Anitha, "A very compact and closely spaced circular shaped UWB MIMO antenna with improved isolation," AEU-International Journal of Electronics and Communications, Vol. 114, 153016, 2020.

[5] Agiwal, M., A. Roy, and N. Saxena, "Next generation 5G wireless networks: A comprehensive survey," IEEE Communications Surveys & Tutorials, Vol. 18, No. 3, 1617–1655, 2016.

[6] Ikram, M., et al., "A road towards 6G communication — A review of 5G antennas, arrays, and wearable devices," Electronics, Vol. 11, No. 1, 169, 2022.

[7] An, Z. and M. He, "A simple planar antenna for sub-6 GHz applications in 5G mobile terminals," The Applied Computational Electromagnetics Society Journal (ACES), 10–15, 2020.

[8] Tiwari, R. N., et al., "Swastika shaped slot embedded two port dual frequency band MIMO antenna for wireless applications," Analog Integrated Circuits and Signal Processing, Vol. 109, No. 1, 103–113, 2021

[9] Masoodi, I. S., I. Ishteyaq, and K. Muzaffar, "Extra compact two element sub 6 GHz MIMO antenna for future 5G wireless applications," Progress In Electromagnetics Research Letters, Vol. 102, 37–45, 2022.

[10] Jin, G., et al., "A new differentially-fed frequency reconfigurable antenna for WLAN and sub-6 GHz 5G applications," IEEE Access, Vol. 7, 56539–56546, 2019.