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DESIGN AND IMPLEMENTATION OF ARRAY ANTENNA FOR 5G WIRELESS APPLICATIONS

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Abstract:
The research on wireless communication demands technology-based efficient radio frequency devices. A printed array antenna is designed and presented. The presented antenna exhibits a promising response with improved gain. The antenna radiates from 3.3 GHz to 4.1 GHz and from 5.9 GHz to 7.1 GHz frequencies with 6.553 dB and 3.739 gain, respectively. The novelty in the developed antenna is that resonating elements have been engineered adequately without the use of the additional reactive component. The cost-effective FR4 laminate is utilized as a substrate. The numerically computed results through simulations and measured results are found to be in good correlation. The aforesaid response from the antenna makes it is an appropriate candidate for wireless applications.
Keywords: array antenna; wide band antenna

1.Introduction

In the last few years, considerable growth has been observed in the utilization of mobile devices. Researchers have paid significant time to the development and exploration of conventional antennas. A low profile and stable array antenna for wireless wide area network communication. Array antenna is designed and analyzed for wireless applications. The array antenna slots were created to have a balance between radiation efficiency and bandwidth. In embedded antennas, size miniaturization is very essential and needy. A systematic approach to fix long array antenna in limited space is by the implementation of branches. These branches of a particular shape could excite the desired resonant modes. The current density of the surface determines the radiation pattern and resonances. Notably, optimizing the dimensions of these strips shall make the structure appropriate for required applications. Lump elements could be incorporated with array antenna strips to get resonance at targeted frequencies. However, lump elements may cause a decrement in antenna efficiency. Planar antennas have attractive design characteristics, such as ease of fabrication and a low profile. Due to these advantages, they are appropriate candidates for and it is the choice of researchers in handheld devices, such as laptops. A combination of metal loops and dielectric substrate exhibits a convenient alternative in array antenna design. The literature has shown that a n inverted F antenna with a C-shaped radiator and meander shorting strips could exhibit dual resonance for wireless applications. Electrically small antennas are preferable to be embedded in communication devices. However, these antennas always suffer from the issue of desired gain and efficiency at target resonance. Metamaterial- inspired antennas could be the alternative to enhance gain with size miniaturization. In this paper, it has been reported that an array antenna with adequate gain.

In the proposed antenna structure, FR4 material is utilized as a substrate, which is a dielectric material whose permittivity (εr) is 4.4. Though other materials having lesser permittivity exist in the market, FR4 is preferred because of ease of availability and cost- effectiveness. Due to the low cost, bulk production of this structure is feasible. The detailed antenna geometry is discussed in the Antenna Design section. The subsequent sections explain the comparison of simulated and measured results, parametric study analysis, fabricated antenna testing, and measurements. antenna antennas with meandered strips were discussed for wireless applications. However, the size of these antennas is a challenging task to embed for wireless applications. Many size reductions geometries have been reported for targeted applications. The researchers created a printed loop that formed a matching circuit for an antenna. Notably, a widened portion of a parasitic shorted strip, having a width of 2.4 mm, was provided to enhance the bandwidth for lower resonating frequencies. The presented structure utilized a combination of the shorted strip, a loop, and an inductive strip to get antenna response for target frequencies. Similar research has presented another RF structure for wireless applications. As discussed previously, instead of developing widened strip, T shaped strip and U-shaped strip were incorporated with a array antenna to meet the desired requirements. The combination of these strips significantly reduced the antenna size. In addition, the miniaturized structure could be easily mountable on wireless devices. A reconfigurable antenna, resonating for multiband frequencies was claimed. The RF switch was embedded with antenna geometry to alter the resonating frequencies of the lower band for four various working Several techniques have been utilized to develop an antenna structure for wireless applications. The array states. However, the designing concept is similar to having a couple of shorting strips as discussed earlier. The presented structure exhibits promising radiation efficiency and antenna gain. A couple of strips with a shorting strip were incorporated to excite the resonant modes. Additionally, the integration of metal components in the structure gave a fair rise in antenna efficiency and operating bandwidth. Furthermore, due to incorporation of resonating strips, the frequency of resonating band is shifted to the targeted frequencies without any additional reactive component. The additional reactive elements adds fabrication cumbersomeness. This is the novelty of a presented antenna.

2. Antenna Design andGeometry

Figure 1 illustrates the systematic design flow of the proposed antenna. The flow describes the steps that have been performed in a sequence to identify and rectify errors, if any. The array antenna is demonstrated with metallic strips developed at the top of the structure as shown in Figure 2a which depicts the top view of an antenna. The close observation of the top view exhibits two stubs are provided at the end of strips to get resonance at desired frequencies. The microstrip line feed technique is used to energize the design. Figure 2b, and 2c show the back view and trigonometric view of the model, and 2d shows the structure of the array antenna with a single strip respectively. By keeping the basic concepts of antenna radiation in mind, geometry has been proposed. Many corners and branches in the conducting strips are provided toincrease the current distribution. The response from an antenna due to the variation in dimensionsof the ground plane and the addition of various metallic strips is analyzed in the parametric studysection. In the isometric view, all layers are visible. The standard height of 1.6 mm is fixed for the substrate.

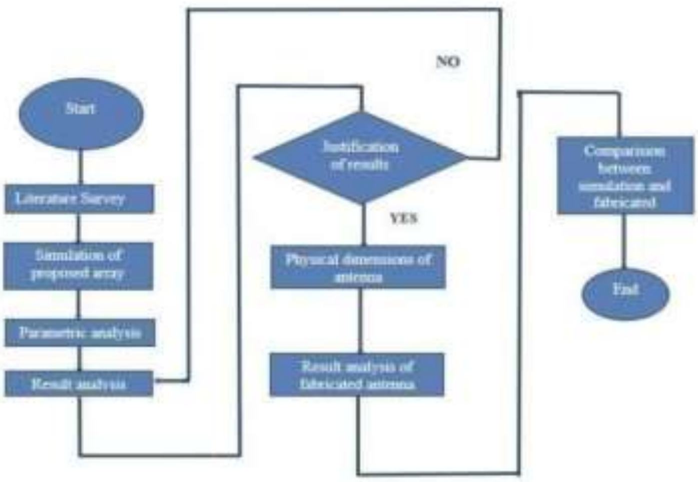


Figure 1. Development flow of proposed antenna.

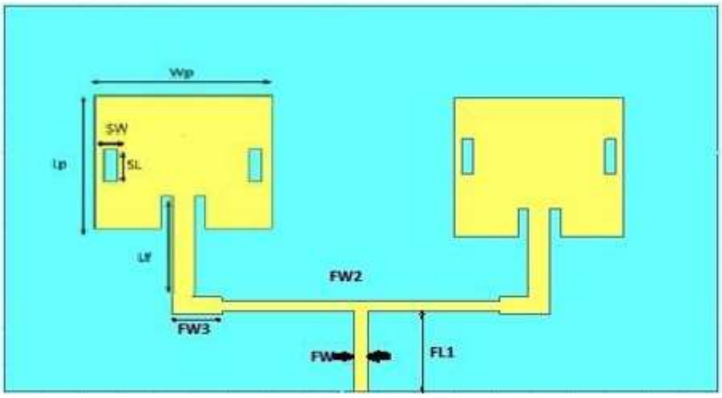


Figure.2. Proposed array antenna with slots

Table 1 illustrates the dimensions of the proposed antenna. The dimensions are optimized to have acceptable impedance matching. By developing many stubs, the discontinuity over the entire structure was increased to receive optimal radiation.

Table 1. Antenna dimensions.

Notations	Dimensions (mm)	Notations	Dimensions (mm)
WG	36	WF	2.85
LG	35	LF	15
WP	22.5	FW	2
LP	20	FL1	12
SW	1.5	FW2	37
SL	5	FW3	4

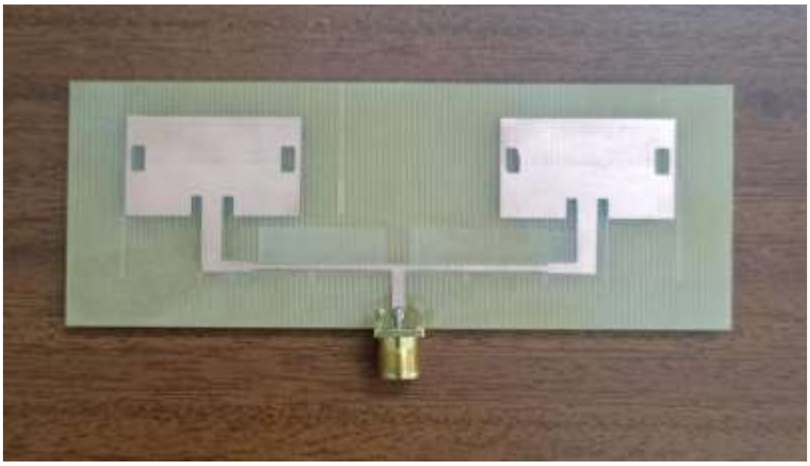
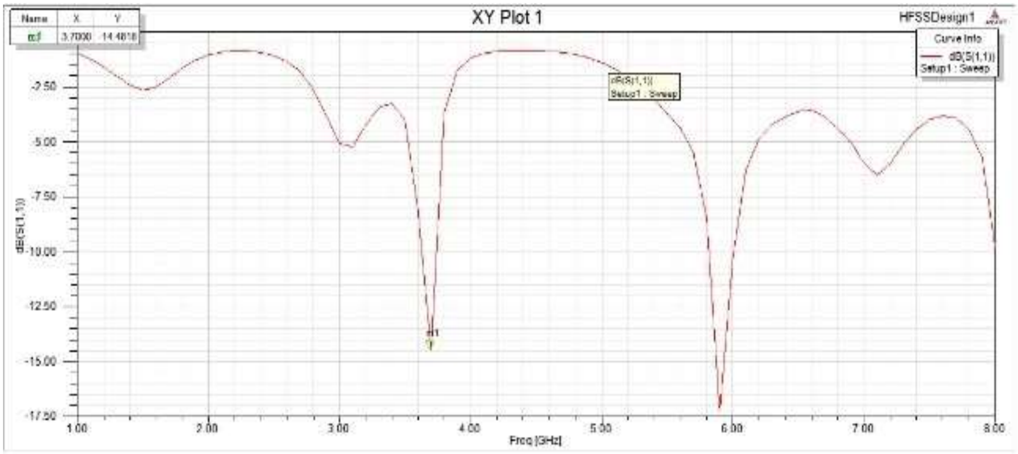


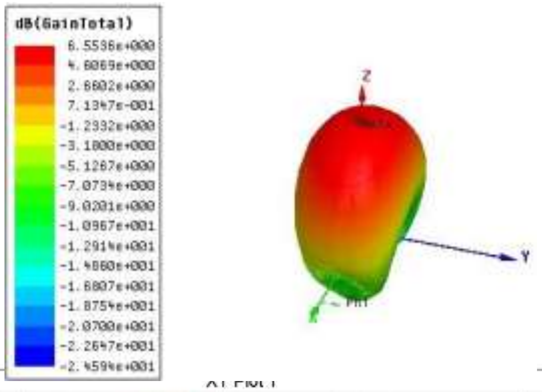
Figure 3. Fabricated array antenna with single strip

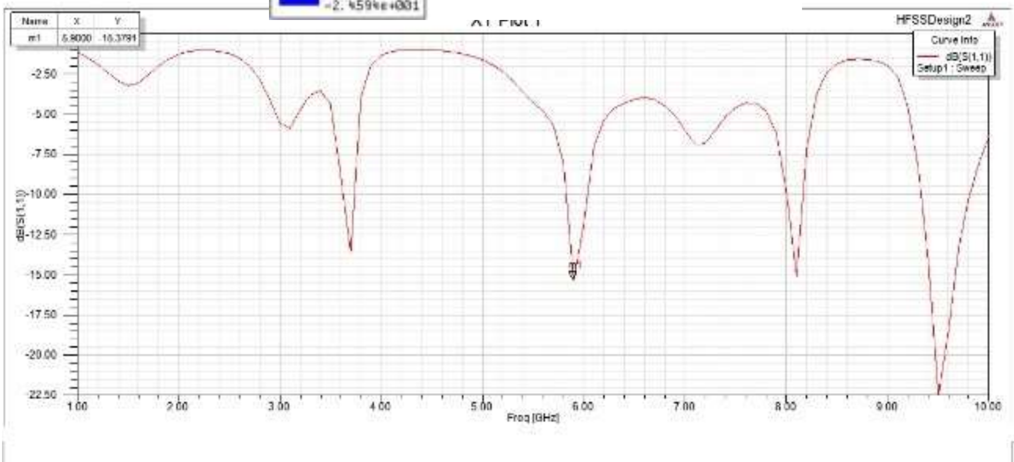
4.Results and Discussion

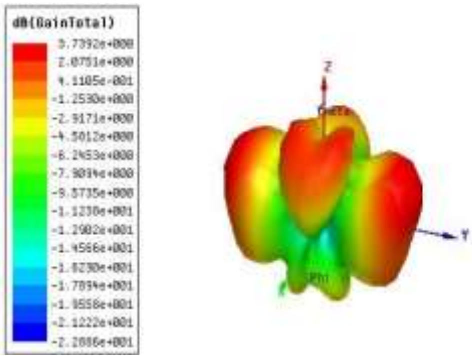
The below figures shows about results of array antenna with single strip. Figure 4a shows about return loss of array antenna with single strip and its value is -14.4818 dB at 3.45 GHz and -15.3791 dB 5.9GHz.



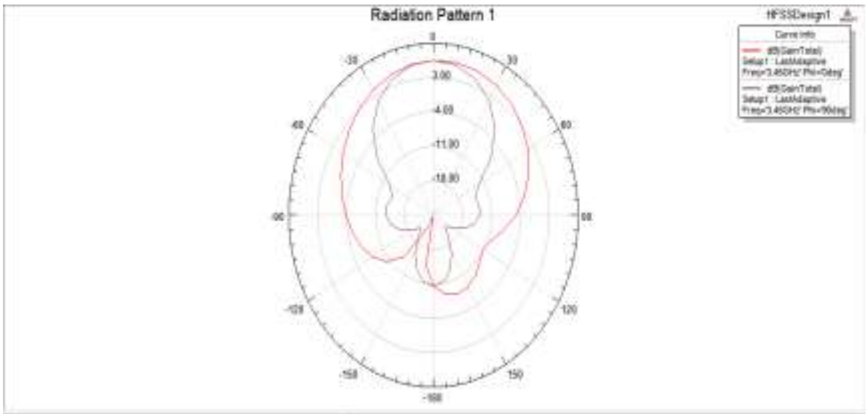
GAIN : The above graph is shows about gain of the antenna and it is obtained gain is 6.553 dB at3.45 GHz and 3.77 dB at 5.9 GHz



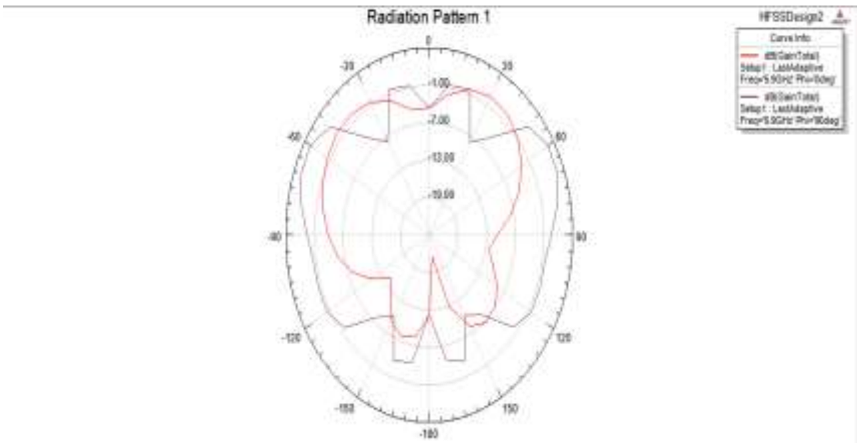




RADIATION PATTERN
A radiation pattern defines the variation of the power radiated by an antenna as a function of the direction away from the antenna. This power variation as a function of arrival angle is observed in antenna's far field. The Radiation Pattern for 2-Element Array of Microstrip patch antenna using slots in HFSS. These plots are taken for the Azimuthal angles 00 (RED) and 900 (BLUE).



The proposed work simulated results are reported in Table 2. The proposed structure is compact



concerning single element antenna structure and also exhibits high Gain.

Table 2. Comparison of proposed array antenna with single element antenna.

TYPE OF ANTENNA	RETURNLOSS(dB)	GAIN(dB)
Single element antenna	-9.96	3.313
Array antenna with slots	-14.48	6.5536

5.

Conclusion

The research on wireless communication demands technology-based efficient radio frequency devices. In the exciting method, the array antenna has low gain. To improve the Gain for the proposed structure, the array antenna comes into action. So array antenna was proposed. Finally, the project aimed to enhance the performance of a array antenna with slots and parasitic strips, operating at frequencies of 3.3 GHzto 4.2 GHz and 5.9 GHZ to 7.1GHZ, respectively. The gained improvements were significant, with the modified antennas achieve in gain of 6.55 and 3.739 dB . This transition not only resulted in increased gainperformance but also aligned the antennas with common frequency bands utilized in various wireless communication applications. The antenna is suitable for applications like wireless broadband, and satellite communications, Wi-Fi, Bluetooth, and LTE networks. These findings underscore the effectiveness of the modified antennas in enhancing signal strength and their suitability for a wide range of wireless communication applications, thus contributing to advancements in the field.

References

1) Pandya, K.V. Low Profile Meandered Printed Monopole WiMAX/WLAN Antenna for Computer Applications. Micromachines 2022, 13, 2251.https://doi.org/10.3390/mi131222
2) Chepala, A.; Fusco, V.; Naeem, U.; McKernan, A. Uniform Linear Antenna Array Beamsteerig Basedon Phase-Locked Loops.2023, 12, 780.doi.org/10.3390/electronics1204
3) Ayaz, M.; Ullah, LA Phased Array Antenna with Novel Composite Right/Left-Hande Phase Shifters for Wi-Fi 6 Communication Systems. Appl. Sci. 2023, 13, 2010.3390/app13042085.
4) Jiménez, D.A.; Reyna, A.; Balderas, L.1.; Panduro, M.A. Design of 4 x 4 Low-Profile Antenna Array for CubeSat Applications. 2023, http://doi.org/10.3390/mil4010180.
5) Yu Zhao, Hao Luo, Wenhao Tan,Zengu Zhou,Guoqiang,. Design of a High-Gain Hybrid SlotAntenna Array Based on Bulk Silicon MEMS Process for W-Band Applications,2023, https://doi.org/10.3390/electronics 12092028.
6) Daniyal Ali Sehrai, Jalal Khan, Mujeeb Abdullah, Design of high gain base station antenna Array for mm-wave cellularcommunication systems ,2023, https://doi.org/10.1038/4159831728.
7) Junli Zhu, Mengfei Chen, Ziting Li, and Jingping Liu , A Compact Planar Ultra-Wideband ArrayAntenna ,2023, https://doi.org/10.1195/2023/1190236.
8) Yujun Li, Jing Jin, Zhengguang Yang, Low-RCS low-profile MIMO antenna and array antenna using a polarization conversion metasurface ,2023, doi.org/10.1364/OE.5 07087.
9) Yazan Al-Alem, Syed M. Sifa, Millimeter-wave planar antenna array augmented with a low-cost 3D printed dielectric polarizer for sensing and internet of things (IoT),applications, 2023,doi: 10.1038/s41598-023-35707-2.
10) Mohammad Alibakshikenari,,Bal Virdee,Dion Mariyanayagam Virtual antenna array for reduced energy per bit transmission at Sub-5 GHz mobile wireless communication systems 2023,https:// doi.org./10.10163 2023.03.156.
11) Aleksei Dubok and A. Bart Smolders, Senior Member, Focal-Plane Arrays With Improved Scan Capabilities,2023,IEEE, .DOI: 10.1109 /TAP 2022.3218931.
12) Amany A Megahed", Ehab H. Abdelhay, 5G millimeter wave wideband MIMO antenna arrays

with high isolation,2023, https://doi.org/10.1186/513638-023-02267.
13) Pushpa B.R,Pushpa P.V, Design and Simulation of Conformal Array Antennas for Avionics Applications,2023, doI:10.14445/23488379/IJEEE-V1019P116.
14) Zhiyun Zhang Yulong Zhou; Tong L, Low-profile shared-aperture metasurface array antenna with ultra-wideband radar cross section reduction and circularly polarization,2023 https:// doi.org/10.1063/5.0163625.
15) Lauri Mela, Alp Karakoc, Low-cost thin film patch antennas and antenna arrays with various background wall materials for indoor wireless communications 2023, doi : 10.1088 /2058-8585/accd05.
16) P. Castillo-Tapia et al., "Two-dimensional beam steering using a stacked modulated geodesic Luneburg lens array antenna for 5G and beyond", IEEE Trans. Antennas Propag., vol. 71, no. 1, pp. 487- 496, Jan. 2023.
17) Swapna SD, Karthikeya GSD, A High Gain Multi-Port Series Fed Array Realized with Micromachined Low-Cost 3D-Printed Substrate,2023 https:// doi.org/10.1080/02564602. 2023.2242828.
18) Kannan Pauliah Nadar, Vanitha Jeyaprakasam, Design and Analysis of Microstrip Patch Antenna Array and Electronic Beam Steering Linear Phased Antenna Array with High Directivity for Space Applications,2023 https://doi.org/10.1021/acsomega.3c06691.
19) Ali Abdulateef Abdulbari, Sharul Kamal Abdul Rahim, Tan KIM GEOK, et al. Compact 4x4 Butler matrix design-based switch beamforming antenna array for 5G applications. Authorea. 2023, doi:10.22541/au. 1 68310020 .08218751.
20) Myung Kyun Woo, Lance Delabarre, Matt Waks, Russell Lagore, Jeehoon Kim,A 32-Channel Sleeve Antenna Receiver Array for Human Head MRI Applications at 10.5 T,2023,doi: 10.1109/TMI.2023.3261922.