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Dual Band Antenna Covering Millimeter Wave and Sub-6 GHz Bands for 5G Mobile Applications

Abubakar Salisu[1*], Atta Ullah[1], Umar Musa[2], Muhammad Sani Yahya[3], Murtala Aminu-Baba[3] , Mobayode O. Akinsolu[4] , A. S. Hussaini[1] and Raed A Abd-Alhameed[1]

[1]Department of Electronics and Biomedical Engineering, University of Bradford, United Kingdom

[2]Department of Electrical Engineering, Bayero University Kano, Nigeria

[3]Department of Electrical and Electronics Engineering, A.T.B.U Bauchi, Nigeria

[4]Faculty of Arts, Science and Technology, Wrexham Glyndwr University, LL11 2AW Wrexham, U.K.

[*]email: a.salisu@bradford.ac.uk

Abstract* - The proposed dual-band antenna covering millimeter wave and sub-6 GHz bands is a necktie round shape patch design connected with a meandered radiating patch element at the top front with an H slot shape and a fractional or truncated ground plane at the back to enhance the antenna's functionality and performance. The antenna is designed using CST microwave studio on a substrate Rogers 3003 with a dimension of 27.8 mm, 14mm, and thickness of 1.52 mm with a dielectric constant of 2.2 and a loss tangent of 0.0009 respectively. The proposed antenna has an ultra-wide bandwidth of 19.65 GHz covering almost all the milli meter wave bands of 23 GHz, 28 GHz, and 38 GHz (from 22.65 – 42.30 GHz) while the sub-6 GHz band has a bandwidth of 962 MHz (3.02 – 3.99 GHz) respectively. The return loss of the antenna is -31.33 dB and -49.72 dB at 3.5 GHz and 28 GHz respectively. However, this antenna is compact and combines two different frequency bands, the large frequency ratio between the millimeter wave band to the sub-6 GHz band is 8.

***Keywords* — Dual Band, Ultra-Wide, Antenna, Milli Meter.**

I. INTRODUCTION

High-speed data transmission is required for contemporary wireless networks with minimal latency due to the exponential expansion of data and information. It is anticipated that mobile and local area networks on the 5G standard would provide a potential way to get over the drawbacks of present communication technology [1]. The millimeter-wave (mm-wave) spectrum, which includes 24, 28, 37-39, and 60 GHz, has been recommended by the (FCC) Federal Communications Commission as the operational frequency for 5G communication [2]–[4].

Short-range indoor communications in millimetre-wave (mm-wave) bands, on the other hand, are still in the research and development stage [5]. For greater coverage, macro-cells may be used in these frequency ranges. For the quickest 5G services to handle a heavy traffic with a rapid transfer rate, they need 100 MHz of 5G mid-band (3.5 GHz) capacity and 1 GHz of mm-wave band bandwidth (28 GHz). The combining of sub-6 GHz and mm-wave bands has gained importance for the next fifth generation (5G) of wireless communications because of their substantial frequency ratios. For the quickest 5G services to handle a lot of traffic at a high data rate, they need 100 MHz of 5G mid-band (3.5 GHz) capacity and 1 GHz of mm-wave band bandwidth (28 GHz).

A technique is presented in this paper to achieve a dual band antenna covering both sub-6 GHz band and ultra-wide bandwidth millimeter waves with a high frequency ratio to support 5G wireless networks. The proposed dual-band microstrip patch antenna covering a millimeter wave band of 28 GHz and 3.5 GHz respectively, is a neck-tide round shape patch design connected with a meandered radiating patch element at the top front with an H slot shape and a fractional or truncated ground plane at the back to improve the performance of the antenna. The antenna is built on a Rogers 03003 substrate that measures 27.8 mm x 14 mm and has a thickness of 1.52 mm; the substrate has a dielectric constant of 2.2 and a loss tangent of 0.0009. In order to model the antenna, CST Microwave Studio is employed.

II. ANTENNA DESIGN AND CONSIDERATION

The geometry of a dual-band antenna covering millimeter wave and sub-6 GHz bands operating at 3.5 GHz and 28 GHz is shown in Figure 1. The antenna is employed using Rogers 03003 as a substrate which has a dielectric constant of 2.2, a loss tangent of 0.0009, and a thickness of 1.52 mm. The neck-tide round shape microstrip patch antenna is resonating at a millimeter wave band (28 GHz) before it is linked to meandered radiating patch with an H-shaped slot at the top to provide the second frequency at the sub-6 GHz band (3.5 GHz). The result shows a frequency ratio between the millimeter wave band and the sub-6 GHz band of 8. The proposed antenna dimensions are illustrated in Table 1.

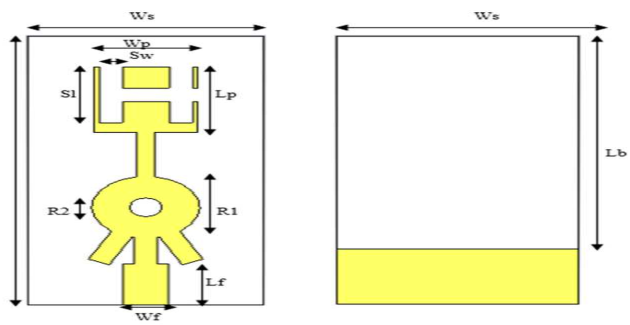

Figure 1: Geometry of the proposed Antenna (Front and Back)

TABLE 1 ANTENNA PARAMETERS

Parameters	Dimensions (mm)
Width of the substrate Ws	14
Length of the substate Ls	27.8
Inner/outer Radius R1/R2	0.967/3.2
Meandered patch width Wp	6.1
Meandered patch length Lp	6.78
Width of the feeding Wf	2.71
Length of feed Lf	4.28
Slot width Sw	2.79
Slot length Sl	5.76
Back Truncated length Lb	22.09

III. RESULTS AND DISCUSSION

CST MWS studio software was used to run simulations of the proposed antenna. Reflection coefficient (S11) simulation results for the proposed antenna are displayed in Figure 2. At 3.5 GHz, S11 is -31.33dB with an impedance bandwidth of 962 MHz (3.02 – 3.99 GHz), while at 28 GHz, S11 is -49.72dB with an ultra-wideband of 19.65 GHz covering 23 GHz, 28 GHz, and 38 GHz bands (22.65 – 42.30 GHz). Figures 3 shows the simulated 3D pattern of the proposed antenna with recorded gain of 2.67 dBi and 5.17 dBi at 3.5 GHz and 28 GHz frequency bands respectively. However, this antenna is compact and combines two different frequency bands, the large frequency ratio between the millimeter wave band to the sub-6 GHz band is found to be 8. The gain of the proposed antenna is recorded as 2.67 dBi and 5.17 dBi at 3.5 GHz and 28 GHz frequency bands respectively.

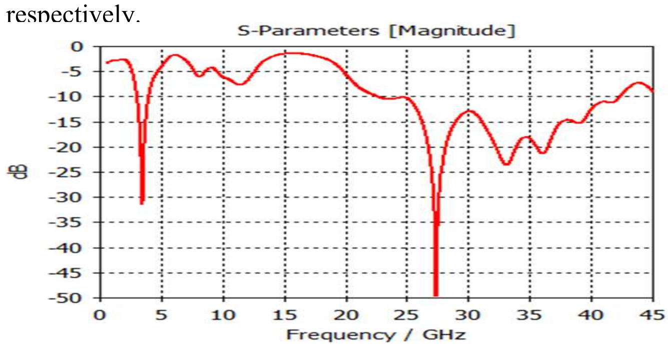

Figure 2. Simulated Reflection Coefficient , S_{11} Antenna

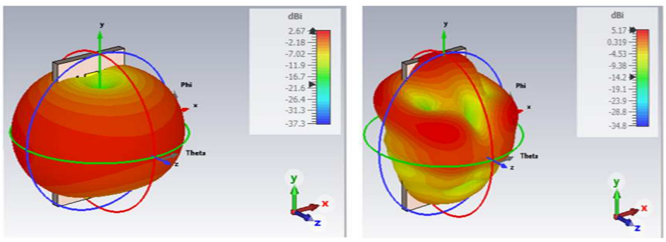

Figure 3. Gain of the proposed Antenna at 3.5 and 28 GHz

From the previous work [7], the maximum bandwidth achievable at 3.5 GHz and 28 GHz were 270MHz and 1200MHz, whereas the reflection coefficient was found to be -26 dB and -22 dB respectively. The gain of the antenna was 2.3 dBi and 7.7 dBi at 3.5 GHz and 28 GHz respectively. Table 2 shows a summary of the performance metrics of the antenna in terms of central frequency, return loss, gain, and bandwidth.

TABLE 2 PROPOSED ANTENNA COMPARED WITH [7]

Parameter	Proposed Work	[7]
Central Frequency	3.5 GHz	3.5 GHz
	28 GHz	28 GHz
Bandwidth	3.02 – 3.99 (970MHz)	3.39 – 3.66 (270MHz)
	22.65 – 42.30 (19.65GHz)	27.40 – 28.60 (1200MHz)
Return Loss (dB)	-49.72	-26
	-31.34	-22
Gain (dBi)	2.67	2.3
	5.17	7.7

IV. CONCLUSION

Designing a single antenna operating at two different bands with a larger frequency ratio is challenging. However, this work presents a solution by first designing a round neck-tie-shaped antenna operating at 28 GHz and then linking a meandered patch with an H-shaped slot at the top of the patch to provide the second frequency of 3.5 GHz. The antenna which operates at sub-6 GHz as well as millimeter wave bands provides an ultra-wideband at milli meter wave band covers almost all the millimeter wave bands up to 40 GHz. The proposed antenna has an ultra-wide bandwidth of 19.65 GHz covering bands of 23 GHz, 28 GHz, and 38 GHz (from 22.65 – 42.30 GHz) while at sub-6 GHz band has a bandwidth of 962 GHz (3.02 – 3.99 GHz) respectively. The antenna has a return loss of -31.33 dB and -49.72 dB at 3.5 GHz and 28 GHz respectively. The proposed antenna shows that it is suitable for 5G mobile communication systems.

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