An Invariant Dual-beam Snowflake Antenna for Future 5G Communications

Hidayat Ullah[1], Farooq A. Tahir[1], Hassan Tariq Chattha[2], Qammer H. Abbasi[3]

[1]Research Institute for Microwave and Millimeter-wave Studies, National University of Sciences and Technology, Islamabad, Pakistan

[2]Department of Electrical Engineering, Faculty of Engineering, Islamic University of Madinah, Al-Madinah, Saudi Arabia

[3]Department of Electrical and Electronic Engineering, University of Glasgow, Glasgow, UK

{hidayat.ullah, farooq.tahir}@seecs.edu.pk, chattha43@hotmail.com, qammer.abbasi@glasgow.ac.uk

***Abstract*— A broadband snowflake antenna for future 5G and millimeter-wave communications is presented. The proposed antenna has a size of 8×5 mm^2. The antenna consists of a central hexagon surrounded by a series of symmetrically placed smaller hexagons around it, resulting in broadband characteristics. The impedance bandwidth of the proposed antenna ranges from 25.284 – 29.252 GHz. The antenna has a gain of 3.12 dBi at 28 GHz and is more than 98% efficient. A distinct feature of the proposed antenna is its dual-beam radiation pattern. The two beams remain fixed at ±50º even if the frequency is varied with in its operating band. The proposed antenna is modelled on thin Rogers substrate which makes it very useful for future 5G smart phones.**

Keywords—5G; millimeter-wave; smart phones; broadband; monopole; dual-beam antennas.

I. Introduction

An increased research is seen in recent years for 5G communications that has a launch target of 2020. Unlimited bandwidth is available at millimeter-wave spectrum above 6 GHz. If this bandwidth is harnessed well, it will pave the way for researchers to solve problems of the already chocked spectrum used by various communication devices below 6 GHz [1].

Modern nature of social activities has put enormous demands from mobile communication networks. The existing communication infra-structure is under severe strain to provide highest data-rates possible and is thus moving towards Gbps speeds. Feasibility studies for dense urban areas have shown that millimeter-wave communication above 6 GHz is very much possible and will provide the necessary Gbps data-rates [2].

Some key requirements by future 5G communication networks from antenna's perspective includes large impedance bandwidth, very high gain, narrow beam-width, bream steerability and small size. Various 5G antennas [3]-[5] have been reported which attain these specific requirements. For instance, a dual-band antenna [3] covers the standard 28 and 38 GHz 5G bands. A robust antenna [4] with low side-lobe-level acquires a gain of 13.97 dBi. A 12.5 dBi dipole array antenna [5] uses small center-to-center spacing to maximize its performance. Extra features such as minimizing interference effects from adjacent channels and obtaining spacial diversity are also desirable for future 5G systems. This will require the antennas to have multiple beams at different angles which do not change their orientation with variations in frequency [6].

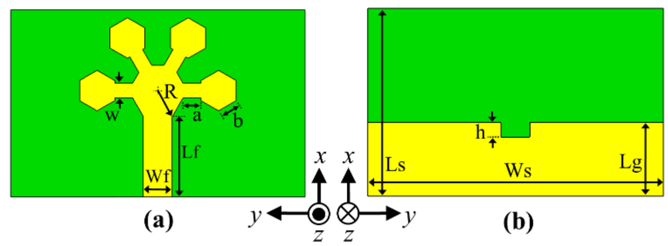

Fig. 1. Geometry of the proposed antenna (a) front view (b) back view

II. Antenna Design

The antenna structure is modelled upon Rogers RT/Duroid 5880 substrate with 0.254 mm thickness, dielectric constant εr = 2.2 and loss tangent tanδ = 0.0009. The antenna has dimensions 8×5mm^2, and its geometry is shown in Fig. 1. The optimized parameter list is given in Table I.

TABLE I. Optimized Parameters Of The Antenna.

Parameter	a	b	R	h	w
Value (mm)	0.49	0.55	0.8	0.4	0.4
Parameter	Ws	Ls	Wf	Lf	Lg
Value (mm)	8	5	0.8	2.2	2

The antenna geometric structure is a two-stage snowflake design obtained by using fractals. The structure has a main hexagon at its middle, surrounded by four smaller hexagons. The smaller hexagons are placed symmetrically at a relative angle of 60º around the main hexagon. The smaller hexagons are connected to the main hexagon by rectangular extension arms. The main hexagon is then connected to input feed line from one side. The ground plane is truncated and a rectangular notch is placed right below the feed line for improved matching.

III. Simulation Results

The reflection coefficient S11 shown in Fig. 2 indicates that the antenna has an impedance response 25.284 – 29.252 GHz that is 3.968 GHz of bandwidth (i.e. 14.17% @ 28 GHz). The proposed antenna radiation efficiency and IEEE gain is shown in Fig. 3. The antenna has more about 98% radiation efficiency throughout its operating bandwidth. The gain varies linearly between 1.78-3.76 dBi with in the operating band. The antenna has a gain of 3.12 dBi at 28 GHz.

The surface current distribution of the snowflake antenna is depicted in Fig. 4. It is observed that current is symmetrically distributed around the middle hexagon. The current symmetry will result in two distinct radiation beams. This dual-beam can easily be seen in normalized radiation pattern of the proposed antenna shown in Fig. 5. At 28 GHz, the antenna has two beams in θ=90º plane at φ=-50º and φ =+50º respectively. Each beam has a half power beam width (HPBW) of 58º.

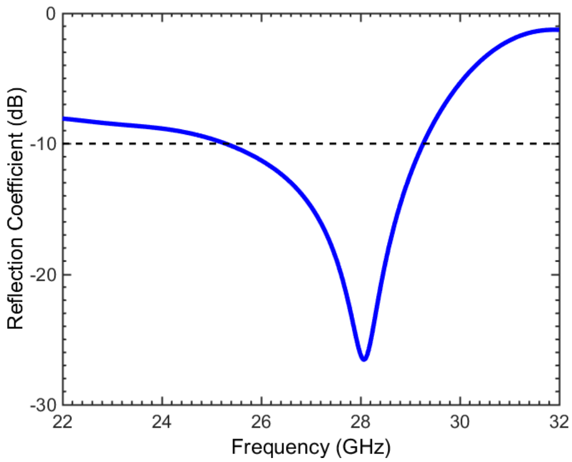

Fig. 2: Simulated reflection coefficient (S11) magnitude.

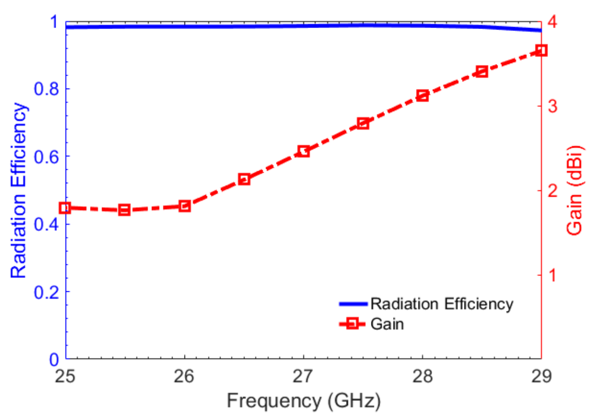

Fig. 3: Radiation efficiency and maximum gain of the antenna

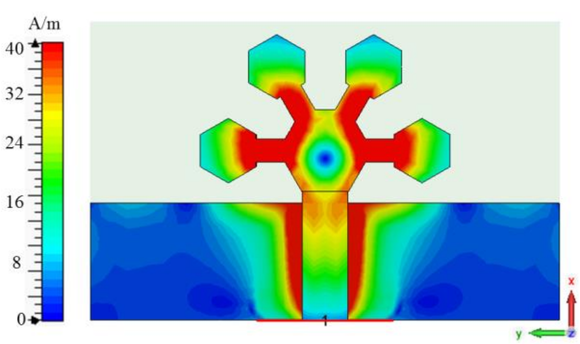

Fig. 4. Surface current distribution at 28 GHz

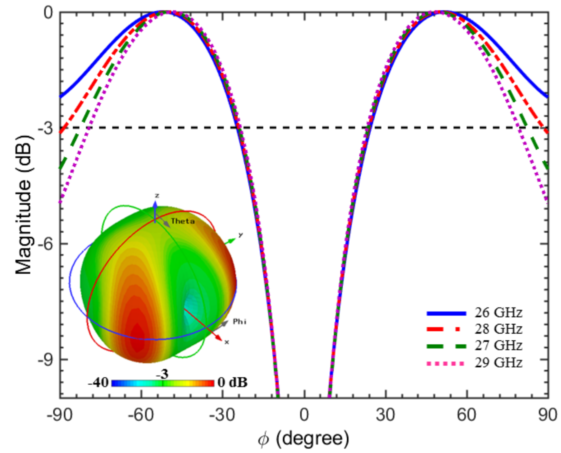

Fig. 5. Radiation patterns at 26, 27, 28 and 29 GHz in θ= 90º plane. Inset shows normalized 3D gain @ 28 GHz.

To show that the dual beams remain stable with variation in frequency, the radiation patterns at different frequencies have been plotted in Fig. 5. It can be observed that the beam maxima remain fixed at ±50º even if the frequency is changed. The HPBW, however, has an inverse relationship with frequency and widens slightly as frequency of the antenna is reduced. There is a strong null at 0º which splits the two beams by a separation angle of approximately 50º.

IV. Conclusion

A broadband simple snowflake antenna was proposed for 5G communications. The antenna covers 25.284 – 29.252 GHz band with a gain of 3.12 dBi at 28 GHz. The antenna is more than 98% efficient. The proposed antenna has two beams with symmetrically located maximas at ±50º which do not vary too much with frequency variations. The unique geometric structural features, dual-beam operation, wide bandwidth and compact size makes the antenna characteristics attractive for use in future 5G communication systems.

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