Research Article
Volume 11:03, 2022

Journal of Telecommunications System & Management

ISSN: 2165-7920 **Open Access**

Comparative Analyses of 5G Antennas

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Abstract

Fringe ideas about 5G might not be implemented, but the core ideas probably will be. This does not provide us with a complete specification of 5G yet, but it gives us the ability to foresee its core features. Antenna design depends upon the operating frequency and required bandwidth. The candidate for 5G spectrum are 28GHz, 38GHz and 60GHz many more. Different researcher have used different antenna design based on adaptive technologies such as Multiple Input, Multiple Output (MIMO), Complementary Metal Oxide Semiconductor (CMOS), Adaptive Beam Forming, Teaching-Learning-Based Optimization (TLBO) algorithm, Butler Matrix Network.

Keywords: Component • f5G • mmWave • DoA

Introduction

The mobile communication business is developing quickly, it has been begun from 1G and now 4G sent in the market for business utilize. The primary contrast between the distinctive ages of portable correspondence is the information rate which is expanding day by day from Kbps to Mbps and now intending to Gbps. Due to high data rate of 4g , 4g is lunched in many country and is doing good but as smart devices are coming very fast in market so in future it will concentrate 4g so we need 5th generation mobile communication, which will be capable of higher data rate then 1 Gbps>10 Gbps, power efficient , having low latency and higher no. of smart devices connected.

Materials and Methods

Future fifth era (5G) structure of cell frameworks will utilize millimeter wave frequencies and is relied upon to offer to a great degree wide range and multi-Gigabit-per-second (Gbps) information rates for versatile interchanges. Receiving wire outline for the new cell phones is by all accounts a testing assignment. Applications, for example, mixed media and intelligent gaming. The productive organization of the 5G frameworks requires the plan of smaller yet proficient antennas. Antenna design depends upon the operating frequency and required band width. The candidate for 5g spectrum are 28GHz, 38GHzand 60GHz many more [1,2]. Different researcher have used different antenna design based on adaptive technologies such as MIMO, CMOS, Adaptive Beam Forming, TLBO algorithm, Butler Matrix Network [3-7].

Results

In this survey paper, phased array, micro strip patch antenna and dual-band antenna design and their characteristics are studied. Both antennas have their own advantage and disadvantages. Micro strip patch antenna is low profile, small in size, dual polarization capable and having the large band width, Band width and frequency can be controlled by introducing slots. We can change its radiation pattern and operating frequency or can be tuned to the higher frequency. Phased array antennas have high gain, high directivity, power efferent, capable of reconfigurable and wide beam steering angle. Different paper of phased array and micro strip patch antenna are reviewed based on their design, radiation pattern and return loss.

Phased array antennas design for 5G.

5G Antenna array with dual linear polarizations and wide-angle beam steering: High data rate goal can be encouraged by the use of antenna array, which can work with two orthogonal straight polarizations. The two polarizations can upgrade the limit and in this way can support the ghostly productivity of 5G correspondence joins. Beam steering can be accomplished by two routes, (1) By various kinds of beam forming systems, such as Head servant framework, Nolen matrix, Butler matrix, (2) By the utilization of phase shifters for every component of an exhibit.

The Design of a 16-components antenna array exhibit appears in Figure 1a. The Butler matrix feed network depends on the Rogers RO3003 cover with a thickness of 0.13 mm. The Butler matrix incorporates four 3-dB quadrature directional couplers, two hybrids, and two defer lines. The Figure 1b demonstrates that VSWR of the antenna is under 2 for the frequencies 27 GHz-33.7 GHz. Disengagement between the encourage ports is more than 15 dB.

The Figure 1c indicates radiation examples of the cluster when distinctive ports are energized. The direction of the main beam is -42°, -13°, 13° what's more, 42° when port 3, 1, 4 and 2 is energized, separately. It creates width impedance bandwidth [7].

5G Low-profile 28 GHz Beam steering mesh-grid antenna design: In this design, we are using mash grid structure by introducing 10-layer PCB FR-4 substrate with Er=4.2 and tan D'=0.02.Mash grid structure is designed vertically along the z-axis with 7 layers of micro strip array total height of h=512 μm. The operating frequency was got by devising the length of mash grid with the x-axis. Feeding is done by 5th layer micro strip feed line as shown is Figure 2a. By such configuration, undesired back lodes are suppressed. The metallic layer at an 8th layer is provided to isolate RF circuit from the antenna array. 16-element is arranged as shown is Figure 2b to have beam steering in azimuth direction. It can observe from result that 16-element array antenna gave -10 dB bandwidth from 26 GHz to 29 GHz. The antenna gain is measured to more 10.9 dB and having beam steering angle ±75 in azimuth plane [8].

5G Phased array antenna with air-filled slot-loop structure: This antenna is designed to have improved efficiency and gain. The air filled slot antenna is used as compared to conventional slot antenna, as most of the current flow at the edges of the slot which affect the gain and efficiency of the antenna. Design parameter of the antenna is as follow in Figure 3a.

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Received: 02-Aug-2019, Manuscript No. JTSM-19-001-PreQc-22; **Editor assigned:** 05-Aug-2019, Pre QC No. JTSM-19-001-PreQc-22 (PQ); **Reviewed:** 30-Aug-2019, QC No. JTSM-19-001-PreQc-22; **Revised:** 13-Sep-2019, Manuscript No. JTSM-19-001-PreQc-22 (R); **Published:** 13-Nov-19, DOI: 10.37421/JTSM.2022.11.313

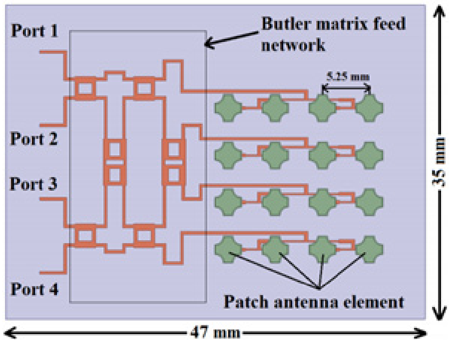

Figure 1a. Design of array antenna with butler matrix network.

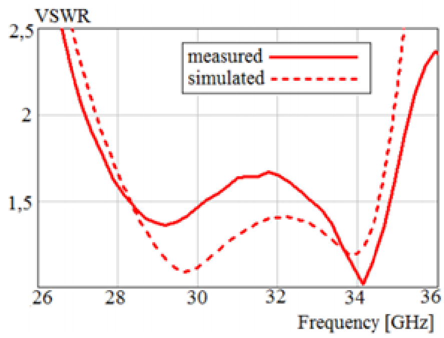

Figure 1b. Voltage Standing Wave Ratio (VSWR).
Note: (——) Measured; (– –) Simulated.

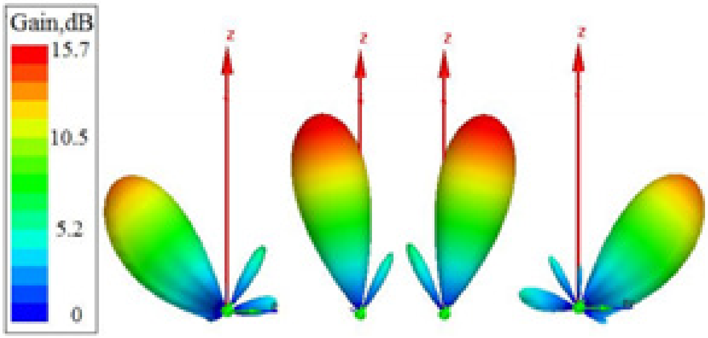

Figure 1c. Radiation patterns of the antenna array with different port excitation.

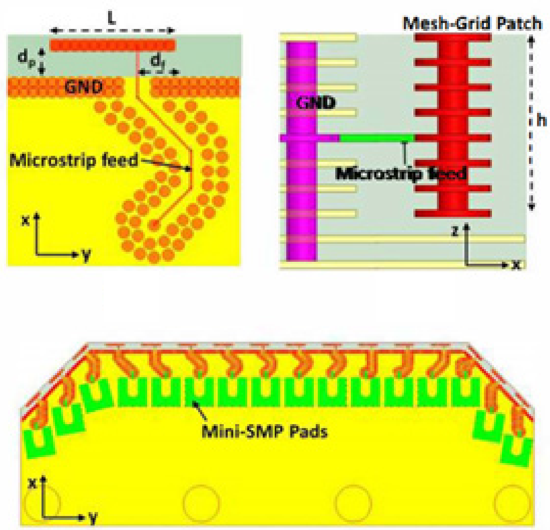

Figure 2a. Mash grid 28 GHz antenna array design, Side view (zx plane), Phased-array configuration.

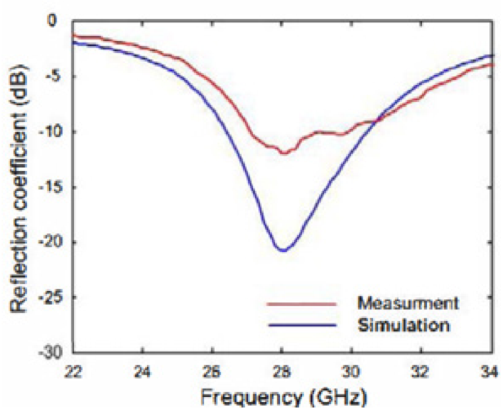

Figure 2b. Reflection coefficient of mash gird array antenna.

Note: ( ) Measurment, ( ) Simulation.

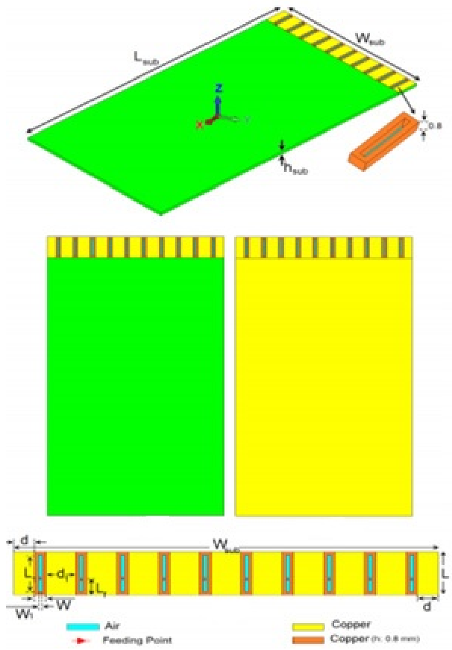

Figure 3a. Air filled slot antenna shows side view, top layer, bottom layer, design of antenna array.

Note: ( ) Air, ( ) Copper, ( ) Feeding Paint, ( ) Copper (h 0.8mm).

Air filled slot antenna efficiency is improved 0.5dB from 27 GHz to 28 GHz frequency over conventional slot antenna as shown is Figure 3b. It has more than 13dB gain for 0 to 50 degree of scan [2].

Phased array antenna for 5G mm-wave beam forming system: CMOS processing has introduced very reliable low cost and easy way to design complex antenna design with great accuracy on nm chip. So this antenna is designed on standard 65 nm CMOS technology, to has beam steering in width angle 8 × 8 butler matrix is integrated with antenna array, chip has 2.4 × 2.5 mm^2 size including pads as shown in Figure 4a. By this approach beam pattern is improved as shown, that beam is tilt from -30 to +30 with -20 HPBW. Solid line is applied Chebyshev Weighting beam pattern for side lobe level rejection. Conventional beam pattern SRR is under -20 dB. Proposed beam pattern is improved SRR and it can be obtained Bore sight Pattern as shown in Figure 4b [4].

Phased array 5G antenna design using leaf-shaped bow-tie: A new design has been introduced for 5G mm-wave application, a leaf shaped bow tie antenna has been design with eight element of linear phased array this structure as shown in Figure 5a. The bow tie is feed by micro strip line of 50 Ω discrete port. Two set of arrays are used at different place to have large range of beam steering area and having good coverage, so for two set array system is MIMO based.

Gain of 10 dB is achieved at different scanning angle. A wide bandwidth is got from 25 GHz to 40 GHz with 45% fractional bandwidth as shown in Figure 5b. Two set of array shows a very good improved in scanning angle, gain and efficiency, it can also be used for diversity as shown in Figure 5c [1].

5G Dual-Band Millimeter Wave SIW Array Antenna: Slotted SIW antenna is a good option for directional and dual-band antenna with high gain. By introducing unequal slots in patch, resonance can be found on dual frequency. As one conducting layer is the ground and other is radiating surface so by introducing slots, current distribution change and disturb the antenna to radiate differently shown in Figure 6a.

SIW slotted antenna has substrate of RT/duroid 5880 (εr = 2.2, tan δ = 0.003) with thickness 0.254. S11 graph is shown in Figure 6b which shows that antenna is tuned on two frequencies 28 GHz and 38 GHz -25 dB return loss, 28 GHz has spectral bandwidth 0.45 GHz with 5.2 dB gain and 38 GHz has 2.20 spectral band widths with 5.9 dB gain.

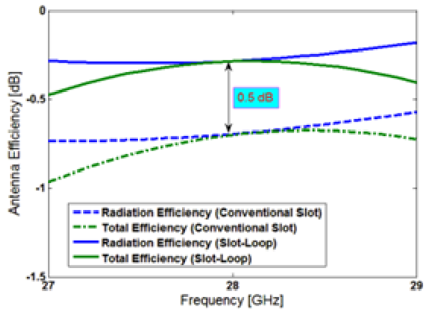

Figure 3b. Comparison of total efficiency of conventional and proposed slot antenna.

Note: (– –) Radiation Efficiency (Conventional Slot); (– –) Total Efficiency (Conventional Slot); (——) Radiation Efficiency (Slot-Loop); (——) Total Efficiency (Slot-Loop)

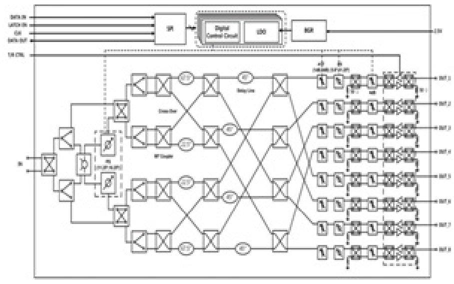

Figure 4a. Butler matrix network.

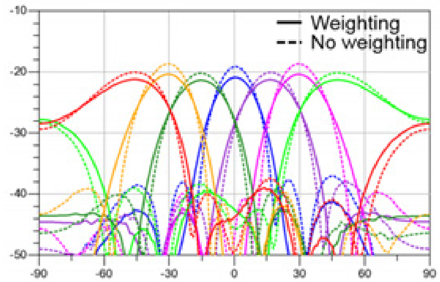

Figure 4b. Conventional beampattern SRR is under -20 dB.

Note: (——) Weighting; (– –) No weighting

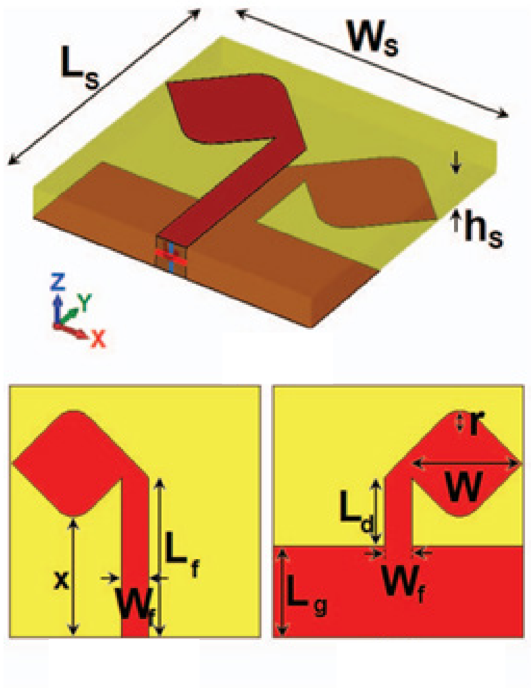

Figure 5a. Leaf shaped bow tie design.

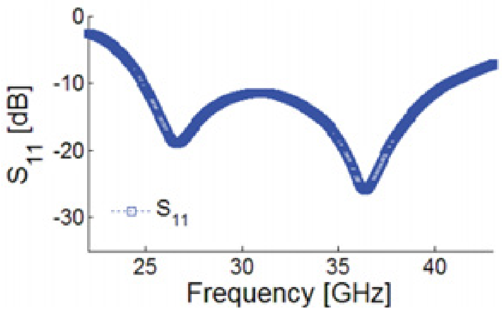

Figure 5b. S11 response of antenna.

Figure 5c. MIMO configuration.

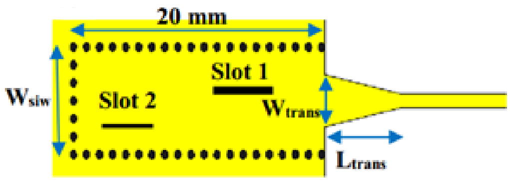

Figure 6a. SIW slotted antenna front view.

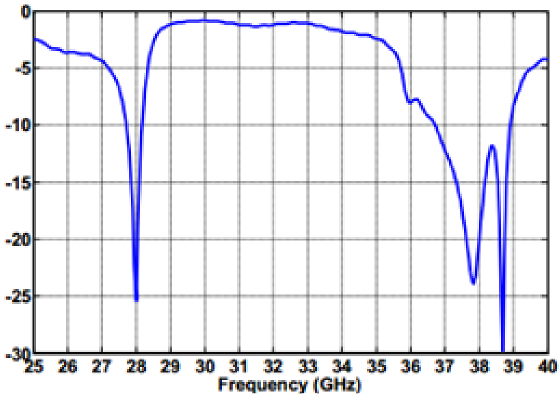

Figure 6b. S11 characteristics.

The 5.9 dB gains is not good for 5G application so arrays of this element can be used to increase the gain of antenna. A linear array of four elements of this is used to increase the gain and to improve the array radiation characteristics; a ground structure based on a compact uniplanar EBG unit cell has been used. Antenna is feed by 1 × 4 Wilkinson power divider around by EBG as shown in Figure 6c.

After this configuration, 28 GHz has spectral bandwidth .32 GHz with 11.9 dB gain and 38 GHz has 1.9 spectral bandwidth with 11.2 dB gain.

Antenna array Systems for 5G cellular devices: Mobile phone PCB, S has thickness of about 1mm which has 8 to 12 layers of low speed and high speed and power distribution network lines. These metallic lines restrict fan beam radiation characteristics of the planar dipole. Authors propose the use of a novel low-profile antenna design approach that can coexist with the signal line traces but also exhibit a fan beam radiation characteristic.

This structure exit in zx-plane which reduces the antenna footprint structure, so now can be fraction of a hundredth of normal dipole antenna. This layer structure of antenna shown in Figure 7a create mesh grid like structure.

Simulated output shows that less -10 dB return loss at 28.9 GHz with 1 GHz bandwidth which enough to support 520 MHz .Two set of 1×16 antenna array are arranged at top and bottom of PCB as shown in Figure 7b which is connected to 32-bit phase shifter to have high fan beam and gain in all directions. Top and bottom array with the help of MIMO technology further maximizes the range of the beam steering scanning angles in the azimuth plane it can also use for improvement of antenna diversity.

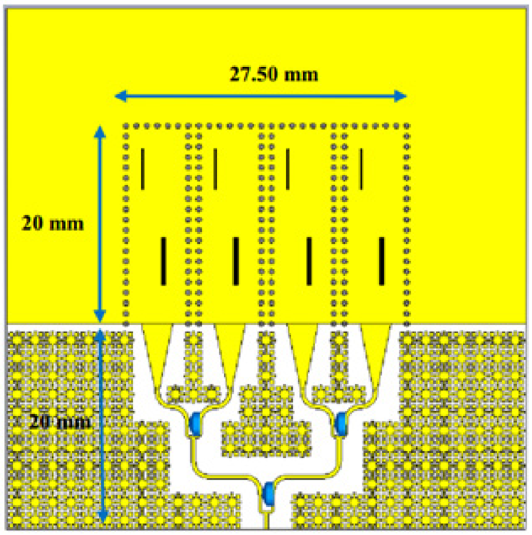

Figure 6c. 1 × 4 dual band slot antenna design.

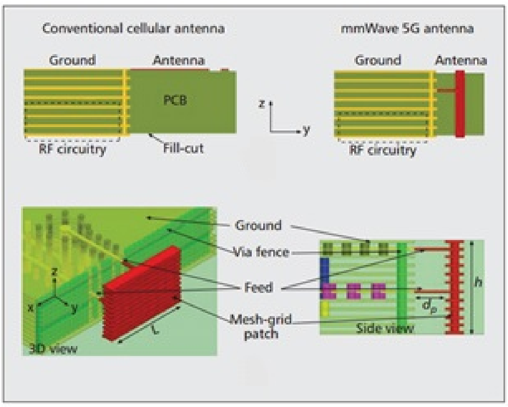

Figure 7a. Mash grid antenna design comparison.

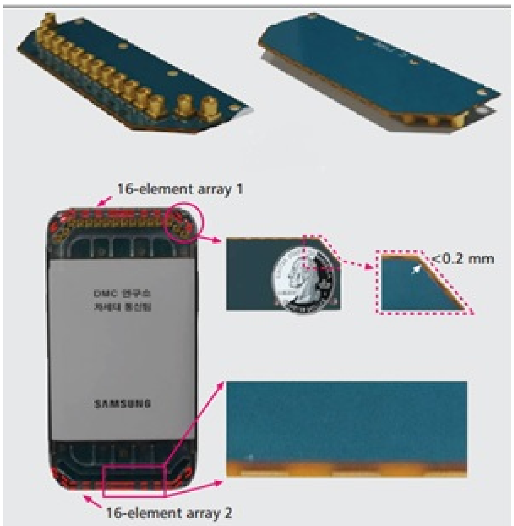

Figure 7b. Antenna arrangement.

Micro strip patch and slot antennas design for 5G

Dual band TLBO based E shaped 5G antenna: In this structure, a dual-band patch antenna is a design based on TLBO (Teaching-Learning Optimization Algorithm), in which population of the possible solution is N student and best solution is the teacher at each iteration. To have dual-band (25 GHz and 37 GHz) and S11 and VSWR less than -10 dB and 2 respectively two vertical slots are introduced as shown in Figure 8a.

It is very difficult to estimate all parameter through numerical analysis so TLBO algorithm is used to optimize S11 and VSWR on 25 GHz and 37 GHz to have perfect values. Following objective function is driven by required output and in order to have the algorithm in HFSS, a program is used to create MATLAB API file.

The simulated output is shown in Figure 8b S11 and VSWR are optimized for 25 GHz and 37 GHz along with 29 GHz. 37 GHz has larger bandwidth due to having current distribution over larger area.

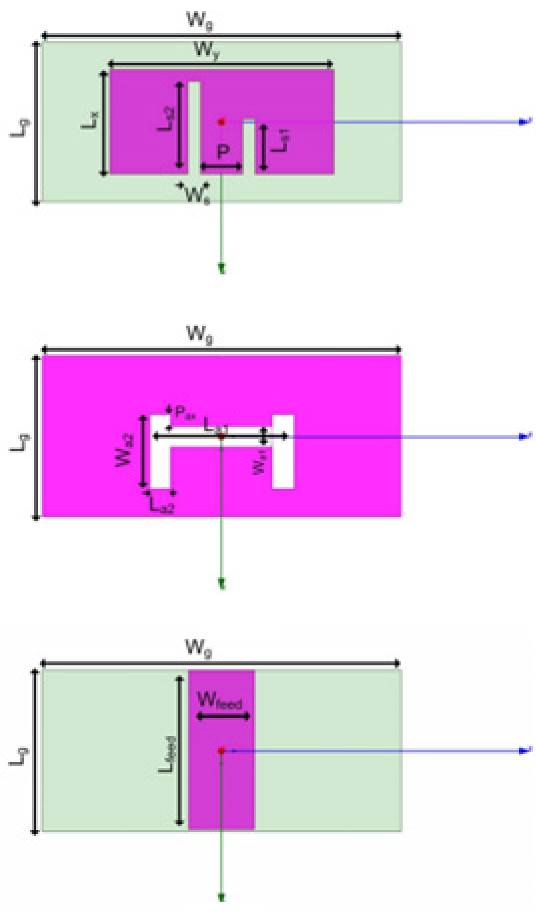

Figure 8a. E-shaped slot antenna design shows patch plane, ground palne with aperture and feed line plane.

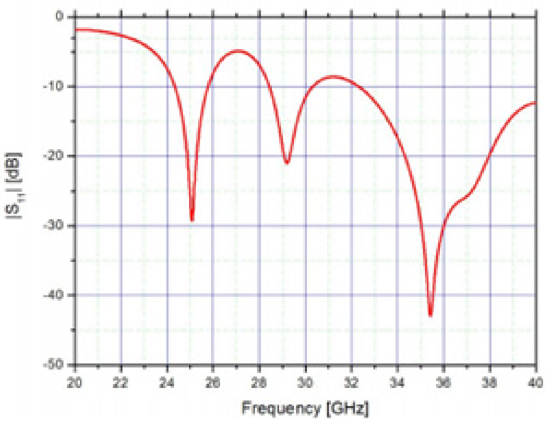

Figure 8b. S11 graph.

Dual-band slot antenna 32 and 42 GHz for 5G mobile communication: An elliptically shaped aperture antenna is used to have dual band (32 GHz and 42 GHz). To enhance the antenna band width an elliptically shaped aperture antenna is used to have dual band (32 GHz and 42 GHz) and to enhance the antenna bandwidth. The proposed antenna has the dimension of 10 x 10 mm2, is built on a 0.762 mm w Neltec NH9320 substrate with loss tangent tan δ =0.0024 and dielectric constant of εr = 3.2. Feed line is very carefully designed to create a notch in a band from 32 GHz to 40.5 GHz to have output in required band. Different dimensions are given below Figure 9a Elliptically etched slot antenna design a) front plane b) ground plane band.

Simulated result shows impedance match from 30.5 GHz to 32 GHz and from 40.5 GHz to 42 GHz. Gain is not mentioned in this graph of Figure 9b.

Single feed L-shaped dual band millimeter-wave antenna for 5G: To overcome the complex feed structure a mono-layer circularly polarized L-shaped patch antenna is proposed. Its fabrication is very easy as it is monolayer and has good gain 4dBi L-shaped slots at the edge of antenna created dual frequency resonance. By changing, length of L-slot center frequency can be changed shown in Figure 10a. By fixing one arm of the slots (t4, t5) and adjusting the other arms (t2, t3) lengths, the antenna can generate dual band CP operation at 28 GHz and 38 GHz. The antenna is fabricated by using photolithography, RT/Duroid 5880 with thickness 254 µm, Er 2,2, and tangent loss of 0.0009 shown in Figure 10b.

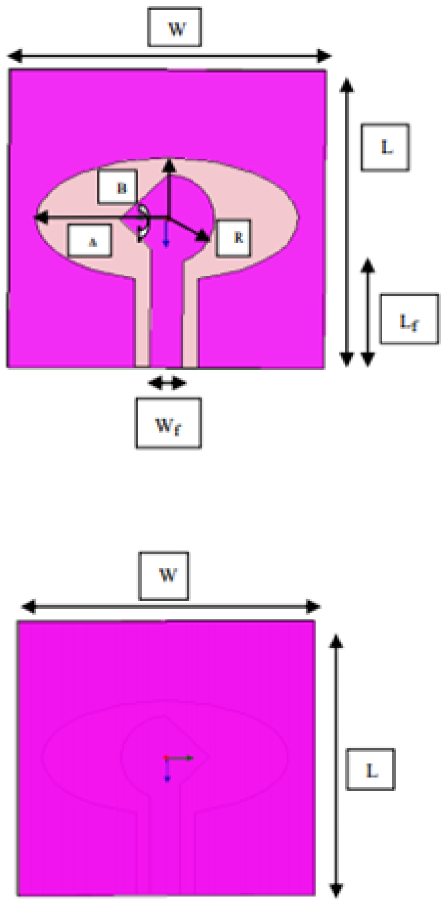

Figure 9a. Elliptically etched slot antenna design shows front plane, ground plane

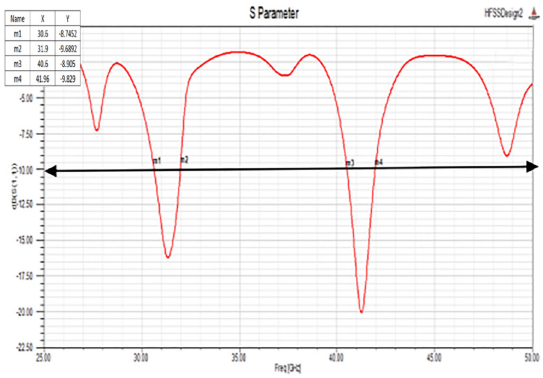

Figure 9b. Reture loss.

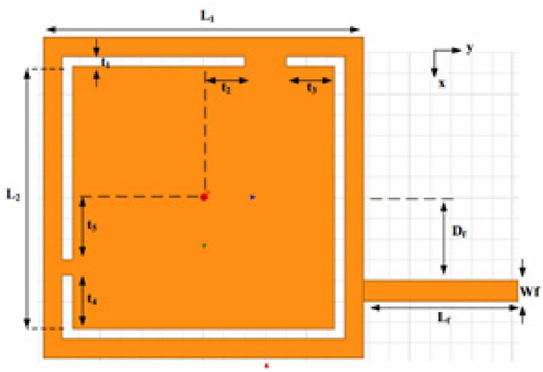

Figure 10a. Circularly polarized slot antenna design.

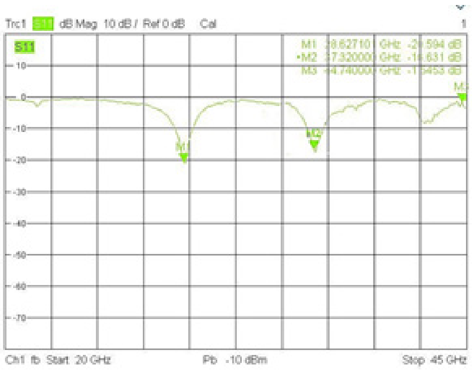

Figure 10b. Measured S11 Graph.

Simulated result shows that antenna has less than -10 return loss on 28 and 38 GHz as shown in Figure 10b and 850 MHz and 750 MHz impedance bandwidth around 28 GHz and 38 GHz respectively. Maximum measured gains of the dual band antenna are 4dBi at 28 GHz and 4.5 dBi at 38 GHz.

Single feed L-shaped dual band Millimeter-wave antenna for 5G: In this paper simple patch is optimized for 5g by using substrate properties of enhance impedance band width and gain of antenna. Roger 5880 is used with Er = 2.2 substrate thickness = 708 μm Dimensions (mm^2) 19 × 19 and Loss tangent (δ) 0.0009.

Simulation is done on both software CST and HFFS. Both show little different values as HFSS assumes an infinite ground plane where CST doesn't. S11 parameter shows impedance matching at 10.1 GHz and 28.1 GHz with follow parameters shown in Figure 11a.

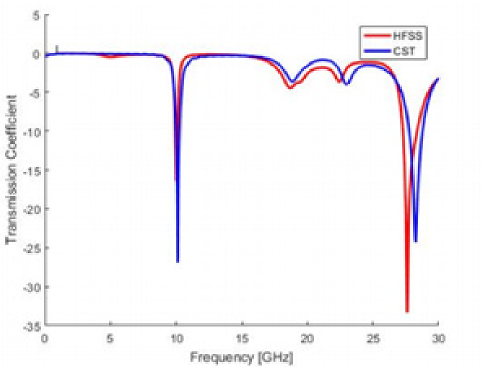

Figure 11a. Simulated return loss on both CST and HFFS.
Note: ( ) HFFS; ( ) CST

Discussion

Phased array, micro strip patch antenna and dual-band antenna design and their characteristics are studied. Both antennas have their own advantage and disadvantages. Micro strip patch antenna is low profile, small in size, dual polarization capable and having the large bandwidth, small band width and frequency can be controlled by introducing slots.

Conclusion

We can change its radiation pattern and operating frequency or can be tuned to the higher frequency. Phased array antennas have high gain, high directivity, power efferent, capable of reconfigurable and wide beam steering angle. Different paper of phased array and micro strip patch antenna are reviewed based on their design, radiation pattern and return loss.

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How to cite this article: Anas, Muhammad, Hifsa Rafiqul Islam and BA Hamida. "Comparative Analyses of 5G Antennas." *J Telecommun Syst Manage* 11(2022): 313