Microstrip Antenna Array with Dual Notched and Defected Ground Structures for 5G C-band Applications

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Abstract : The 5th generation mobile communication provides various advance application with high quality of services. The research is continuing going on 5G network communications applications. The expectation from 5G antenna is to meet the higher speed, low latency and large bandwidth. An antenna array is a set of multiple connected antennas which work together as a single antenna, to transmit or receive radio waves. Microstrip Patch Antenna (MPA) is array design is also very emerging research area for 5th generation communication application. This paper proposed a novel design of microstrip antenna array with dual notched and defected ground structures for 5G C-band applications. The CST microwave studio software is used to antenna design and simulation. The resonant frequency of this antenna is 5.4GHz and 6.4GHz. Overall bandwidth achieved by proposed antenna is 3.06GHz. The large bandwidth is applicable for next generation or 5G communication mobile applications.

***IndexTerms* - Microstrip, Dipole, Antenna, CST, FR4, VSWR, Return loss.**

I. INTRODUCTION

With the advancement of remote correspondence advances, it has gotten progressively alluring for present day specialized gadgets to coordinate different correspondence guidelines, for example, 2G/3G/4G/5G. Hence, radio wires with broadband execution are popular for multi-standard inclusion. Array receiving wires are generally utilized in remote correspondence frameworks. To accomplish broadband activity, different plans of array reception apparatuses have been accounted for, for example, altering the state of the array arms, improving taking care of strategies, stacking parasitic radiators, and utilizing magnetoelectric reciprocal structures.[1]

Moreover, radiation execution is additionally required for some remote correspondence applications, for example, indoor sign inclusion, remote passages, and small scale base stations. In view of the multi-mode PFDA, a straightforward and powerful structure to accomplish radiation execution is created by setting two of the proposed PFDAs consecutive. The subsequent reception apparatus displays great radiation designs in the even plane with level increase variety of fewer than 1.27 dB. The introduced conservative broadband radio wire is a decent contender for indoor sign inclusion.

Three resounding modes are gotten by utilizing a changed planar collapsed array and its coupled taking care of structure. Consolidating the shorting pins and parasitic patches, numerous resounding modes in the receiving wire are controlled, moved, and afterward joined to build the impedance data transmission. Utilizing this idea, a model of a multimode collapsed array is planned, manufactured, and estimated [1]. Common coupling between two array receiving wires with various measurements put at self-assertive equal positions is broke down utilizing synchronous indispensable conditions with definite parts and limited hole feeds[2]. A tale plan technique for a wideband double enraptured reception apparatus is introduced by utilizing shorted dipoles, incorporated baluns, and crossed feed lines. Reenactment and proportionate circuit investigation of the receiving wire are given. To approve the plan technique, a receiving wire model is planned, upgraded, manufactured, and estimated [3]. An epic ultra-wide-band firmly coupled array reflect array (TCDR) radio wire is introduced in this work. This reflects array receiving wire comprises of a wideband feed and a wideband reflecting surface. The feed is a log-occasional array cluster reception apparatus. The reflecting surface comprises of 26 × 11 unit cells. Every cell is made out of a firmly coupled array and a defer line. The base separation between nearby cells is 8 mm, which is around 1/10 frequency at the most minimal working recurrence. By joining the benefits of reflect array reception apparatuses and those of firmly coupled exhibit radio wires, the proposed TCDR recieving wire accomplishes ultra wide transfer speed with decreased unpredictability and creation cost[4].

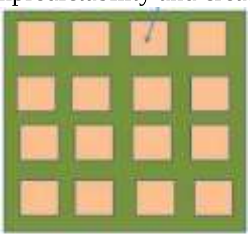


Figure 1: Array Antenna

Microstrip array radio wire is exceptionally well known in light of the fact that the data transmission of smaller scale strip array receiving wire is high when contrasted with the miniaturized scale strip fix reception apparatus. Small scale strip array reception apparatus will be the principle focal point of this work. A miniaturized scale strip array is a usage of the customary array radio wire on a dielectric chunk, which can be effortlessly created with existing PCB strategies. In contrast to regular small scale strip reception apparatus, that utilization one side of the chunk as the ground plane, the smaller scale strip array essentially utilizes the dielectric section as the host material.

II. BACKGROUND

A. Yadav, et al.,[1] presents antenna, which is two layered antenna array and low profile is a decent up-and-comer of antenna for 5G C band passageway applications. the paper shows consequences of examination, for example, return misfortune, efficiencies, radiation design, and so forth of both single component and array antenna.

M. Patriotis et al., [2] The antenna can be utilized at the same time in the getting mode (Rx) and transmitting mode (Tx) by choosing the implanted reconfigurable channels. A PIN diode reconfigurable bandpass channel (BPF) is utilized at the Tx port so as to choose the band of activity. The antenna array delivers a gain of 12 - 15 dB over its working frequencies and a pivotal proportion under 0.56 dB over its working bands. This reconfigurable antenna array can be utilized for K/Ka-band CubeSat correspondence.

A. M. Yusuf, et al., [3] In this examination, a double band microstrip antenna array 1×8 at C-band (5.8 GHz) and X-band (9.65 GHz) has been planned and fabricated on FR-4 substrate. E-Formed patch has been actualized in this antenna to accomplish double reaction recurrence.

N. Yan, et al., [4] The antenna is intended to act naturally bundled utilizing five substrate layers with installed air holes. By means of is used to associate the antenna driven patch with the feed line, and afterward resounding recurrence at 5.2 GHz is produced. U-formed opening is scratched on the antenna driven patch for impedance coordinating. So as to additionally expand the impedance bandwidth, a stacked patch with incline space is presented and afterward another resounding recurrence at 6.2 GHz is created.

M. Long, et al., [5] The changed customary square-rings, with focus edges twisted internal into empty crosses and eight resistors welt on each side, are embraced to shape the main layer metasurface. It is for the out-of-band episode wave assimilation. The subsequent layer comprises of four Angular polygonal metallic patches and four resistors. Every resistor associates two neighboring Angular patches together.

W. Lin et al., [6] It presents controllable RF turns on a cross-gap to energize a square patch for two symmetrical polarizations. The RF switches are constrained by two arrangements of DC predispositions, which could choose the polarization through the reconfigurable opening. Second, two patch antennas dependent on cross-opening excitation are talked about.

A. A. Gheethan, et al., [7] This bar examining strategy depends on a patch antenna component that can be microfluidically repositioned at the central plane of a microwave focal point. The feed organize is deliberately intended to be aloof and suit the position variety in the antenna component. This work, just because, considers the plan subtleties and execution assessment of three distinctive aloof system formats that can conceivably be used to energize MFPAs.

Q. Bai, et al., [8] The antenna comprises of eight inset-bolstered patch components and a microstrip corporate encouraging system. A full-wave electromagnetic test system is utilized to help the antenna structure and hypothetical reenactments are affirmed by estimations.

III. PROPOSED ANTENNA

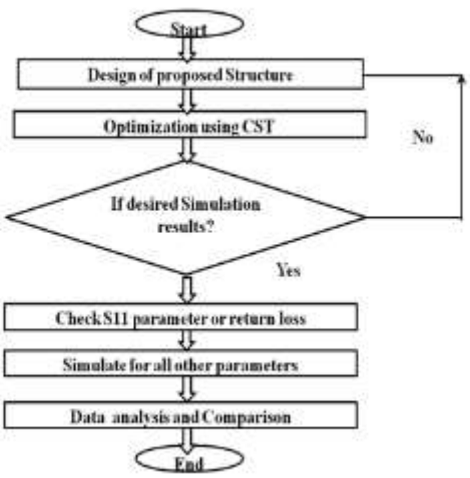


Figure 2: Flow Chart

The flow chart work as following steps-

1. First find application and define requirement.
2. Next steps is finding out major specification of antenna
    a. Resonating Frequency of antenna (according to application define in initial step of CST).
3. Choose a suitable substrate, it may depend upon various factor like availability of material, integration of antenna with other circuit components on board. Dielectric constant and height of substrate are important for microstrip antenna parameter calculation.
4. Calculate Microstrip antenna dimension. Most of the time antenna used in wireless communication is not simple antenna, these are customized structure.
5. Calculate antenna width and length using standard formula.

6. Antenna height (Its define in substrate material already for microstrip antenna its usually 1.5mm-1.6 mm). It can be selected using CST

7. Draw antenna geometry and define materials.

8. Define feed-point and radiation boundary

9. Run simulation and check performance parameters values.

Firstly, identified the advance or upcoming application like antenna design for 5G communication application, it is identified through previous papers studied. Then find the technical specification. Now find out the appropriate model or design for desired application and outcomes. The next step is to set the target objective of research work. At last focus on the various challenges which occur during research and make the design strategy.

After the selection antenna band and application of design, the next step is to calculate the radiating patch width and length.

Step 1: Calculation of Width (W)

For an efficient radiator, practical width that leads to good radiation efficiencies is:

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r+1}}$$

Where, μ_0 is the free permeability, ε_0 is the free space permittivity and ε_r is relative permittivity.

Step 2: Calculation of Effective Dielectric Coefficient (ε_{reff}) the effective dielectric constant is

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}[1+12\frac{h}{W}]^{1/2}$$

Step 3: Calculation of Effective Length (Leff)

The effective length is $L_{eff} = \frac{C}{2f_0\sqrt{\varepsilon_{reff}}}$

Step 4: Calculation of Length Extension (ΔL)

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{rff}-0.258)(\frac{W}{h}+0.8)}$$

Step 5: Calculation of actual Length of Patch (L)

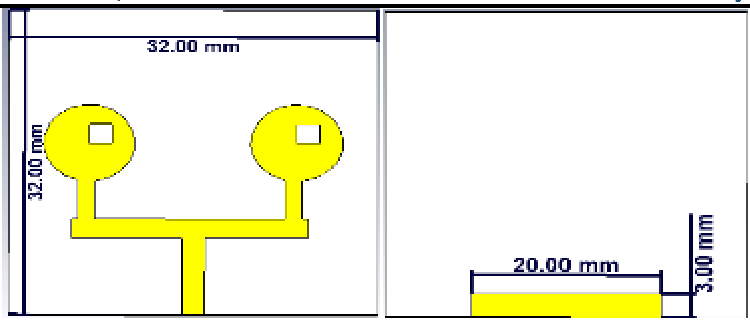
The actual length of radiating patch is obtained by

$$L=L_{eff} - 2\Delta L$$

Step 6: Calculation of Ground Dimensions (Lg, Wg)

Now the use of CST microwave studio software, make the design using calculated dimensions.

Figure 3, showing top perspective on proposed microstrip array recieving wire, one side of a dielectric substrate goes about as an emanating array and opposite side of substrate goes about as ground plane. As in figure 3 demonstrated as follows, top perspectives on a rectangular array radio wire with microstrip feed has array and ground plane together makes bordering fields and this field is answerable for making the radiation from the recieving wire. Microstip array reception apparatus is proposed because of little size and better reference. Resonant frequency of proposed reception apparatus is approx 5.4GHz and 6.4GHz that implies it work under C-band. Thusly proposed radio wire ought to be valuable for all C-band application.



(a) (b)

Figure 3: (a) Top view (b) Defected Ground Structure of proposed microstrip array antenna

Figure 3 is indicating proposed microstip array antenna of plan. The top and ground layer is made by lossy copper material and substrate is made by FR4 material which having 4.4 dielectric steady worth.

IV. Simulation and Result

The geometry of the proposed structure of microstrip array for C-band applications is appeared in figure 3. The general size of the structure is 32mm × 32mm × 1.64mm (L × W × H) and imprinted on FR4, with an overall permittivity of 4.4, and a loss digression of 0.024. Table 1 records the element of the proposed antenna. The antenna is taken care of by 50-Ω and 0.5W coaxial link or straightforward. The antenna utilizes the microstrip array structure with one opening for C-Band applications.

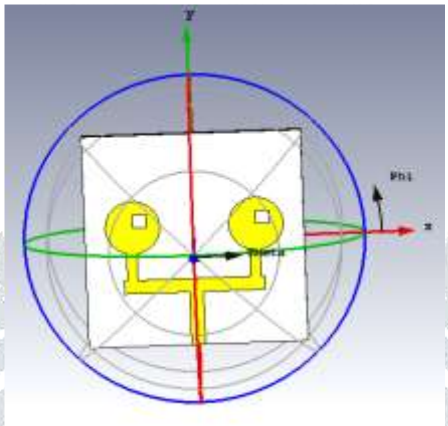


Figure 4: Simulation and fields of proposed antenna

CST microwave studio used to recreate the proposed plan. Figure 4 is demonstrating reenacted electric and attractive field in round organize framework.

Table 1: Design parameters for proposed Antenna

Sr No.	Parameter	Value
1	Lower Frequency(fL)	4 GHz
2	Higher Frequency(fH)	12 GHz
3	Dielectric constant(εr)	4.4 / FR4
4	Ground (LxW)	3 mm X 20 mm
5	Ground height	0.0.35mm
6	Substrate(LxW)	32mm X 32mm
7	Substrate Height(h)	1.57 mm
8	Line Impedance	50 Ω
9	Tangent Loss	0.06
10	Input watt	0.5W

Band-I:

Return loss

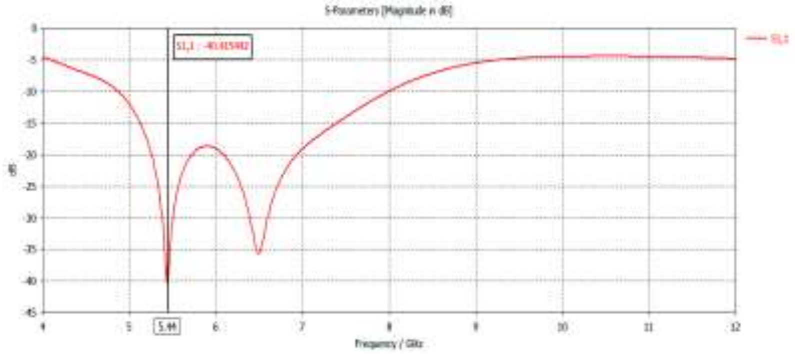


Figure 5: Return loss

Figure 5 presents return loss of proposed structure. It is obvious to see this chart, the return loss estimation of proposed antenna is –40.11 dB with 5.4GHz resonant frequency.

Bandwidth

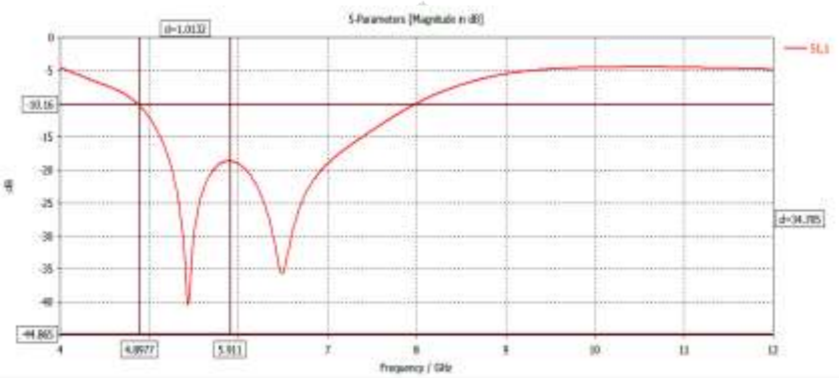


Figure 6: Bandwidth

For broadband antennas, the bandwidth is communicated as a level of the recurrence contrast (upper less lower) over the inside recurrence of the bandwidth.

The bandwidth of proposed antenna is 1013MHz, (5.911GHz-4.897GHz), for first band.

Voltage Standing Wave Ratio (VSWR)

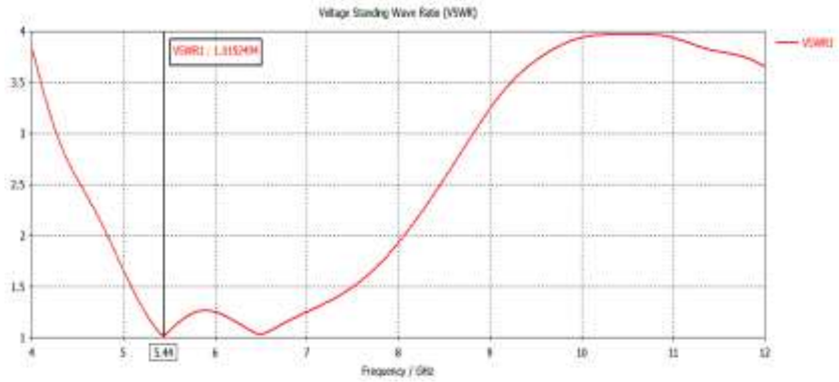


Figure 7: VSWR

Figure 7 shows VSWR esteem, it is voltage standing wave proportion, and is likewise alluded to as Standing Wave Proportion (SWR). VSWR is an element of the reflection coefficient, which portrays the force reflected from the antenna. The VSWR estimation of this antenna is 1.0192.

Band-II:

Return loss

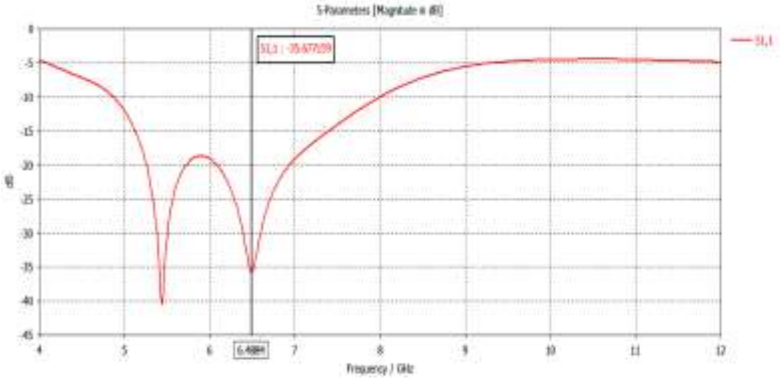


Figure 8: Return loss

Figure 8 presents return loss of proposed structure. It is obvious to see this chart, the return loss estimation of proposed antenna is -35.67dB with 6.4GHz thunderous recurrence.

Bandwidth

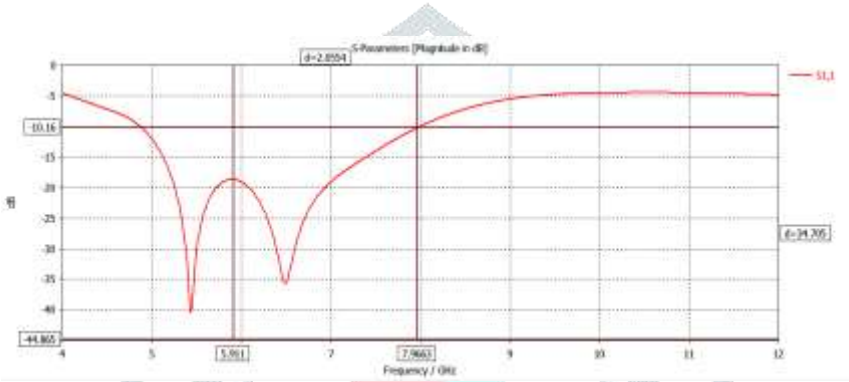


Figure 9: Bandwidth

The bandwidth of proposed antenna is 2055MHz, (7.966GHz-5.911GHz), for second band.

Voltage Standing Wave Ratio (VSWR)

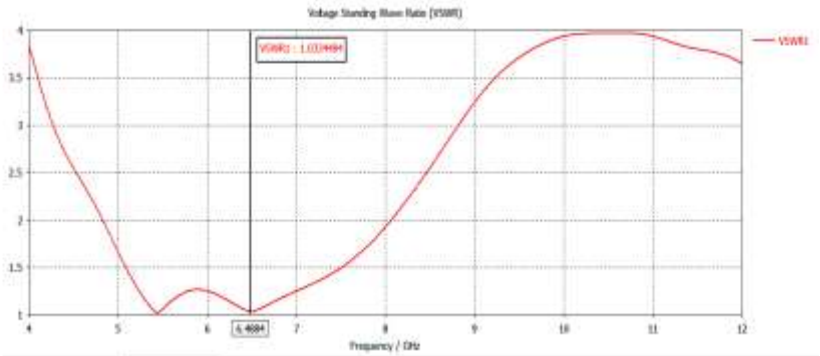


Figure 10: VSWR

Figure 10 shows VSWR esteem, it is voltage standing wave proportion, and is additionally alluded to as Standing Wave Proportion (SWR). VSWR is an element of the reflection coefficient, which portrays the force reflected from the antenna. The VSWR estimation of this antenna is 1.033.

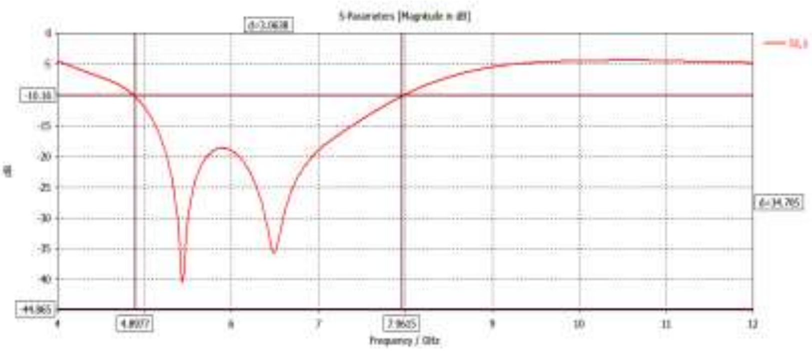


Figure 11: Bandwidth

The overall bandwidth of proposed antenna is 3063MHz, (7.96GHz-4.89GHz), for dual band.

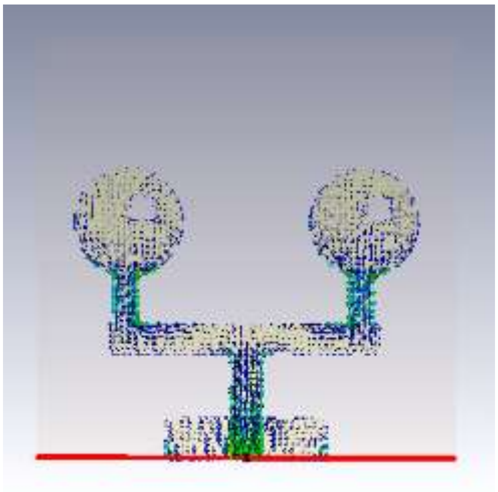


Figure 12: Current density

Figure 12 presents current thickness of proposed antenna. It is a real electric flow that is initiated by an applied electromagnetic field.

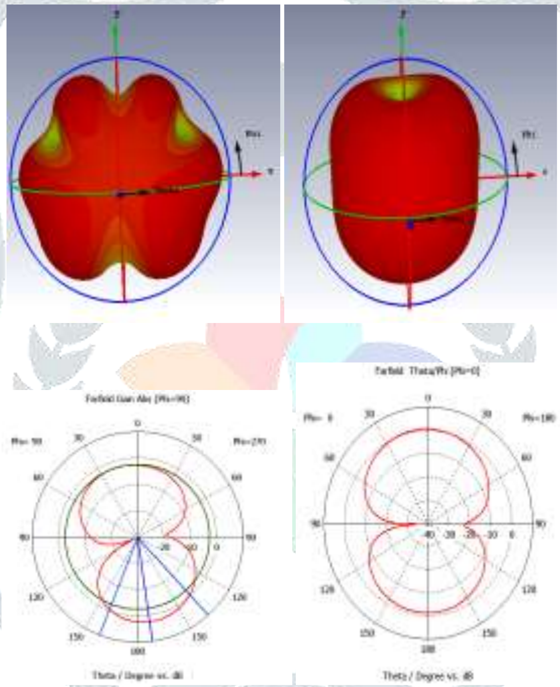


Figure 13: Radiation pattern

Figure 13 shows radiation pattern of proposed antenna at 5.4GHz and 6.4GHz band. It is a variety of the force transmitted by an antenna as an element of the heading ceaselessly from the antenna.

Table 2: Simulated Results of Proposed Antenna

Sr No.	Parameter	Band-I	Band-II
1	Return loss or S11	-40.41 dB	-35.67 dB
2	Bandwidth	1013MHz	2055MHz
3	VSWR	1.019	1.499
4	Resonant Frequency	5.44 GHz	6.48 GHz

Table 2 shows performance parameters like return loss, bandwidth, VSWR and resounding recurrence. It is clear by observing reenacted values from table 2, proposed antenna accomplish siginificant improved outcome.

Table 3: Comparison of proposed design result with previous design result

Sr No.	Parameter	Previous work	Proposed work
1	S11 or Return loss	-11dB and -18dB	-40.14 dB and -35.67
2	Band Width	50MHz and 200MHz	1013 MHz and 2055 MHz
3	VSWR	Aprox 1.031 and 1.132	1.019 and 1.499
4	Resonant Frequency	24.9 and 28 GHZ	21.8, 24.26 and 26.53 GHz
5	Number of band	2	2
6	Gain	Aprox 6dBi	8dBi
7	Design type	Array	Array
8	Dimension	80X51 mm2	32x32 mm2

Table 3 is showing comparison between previous design and proposed design. It is clear from this table and results the proposed antenna array design have significant good and improved result than previous results.

V. CONCLUSION

A double band, microstrip array antenna is planned and recreated utilizing CST microwave studio. The reproduction results are introduced and examined. Structure of proposed antenna is basic and reduced in size of 32 x32x1.6 mm3. Simulated results exhibit that the antenna bandwidth covers C-band, at full recurrence 5.4 GHz and 6.4 GHz for VSWR under 2, and S11 -40.14 dB and -35.67dB. The bandwidth is huge accomplished better than micorstrip fix antenna structure. Micorstrio array antenna configuration is recently explore theme among specialists. The general bandwidth is 3063MHz. Subsequently proposed antenna is reasonable and meets to current edge correspondence demands.

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