A C – Shaped Microstrip Patch Antenna for 5G Applications

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Abstract- A C-shaped Multi band patch antenna with wide bands has been designed using epoxy substrate. The designed antenna is simulated, using simulation software HFSS. Further, the antenna parameters are optimized for wide bands and low return loss at the resonant frequencies 2.5 GHz and above 6 GHz. The proposed antenna also performances well at mm wave range frequencies. So that the antenna covers the low frequency bands in addition to mm wave range frequencies. These resonance frequencies are used for Wi-Fi applications, 5G communications etc. The antenna performance is analyzed in term of bandwidth, VSWR, directivity, gain and radiation pattern.
Keywords – microstrip patch antenna, WLAN, Wi-MAX, 5G.

I. INTRODUCTION

Wireless communication systems gained a lot of interest during recent years. The development and applications of wireless technology has been increased a lot. Because of the flexibility to carry the devices anywhere within the range of network these systems usage has been increased drastically. There will be a need for performance wise as well as quality wise improvement for future wireless communication systems [1]. The design of an antenna is one of the prominent issues in today communication systems. So, the designed antenna has to meet the new specifications. The advantages of microstrip patch antennas are low fabrication cost, capable to mass production, can be integrated easily with microwave devices, broad and multiple resonant frequency ranges, feed lines and matching networks can be simultaneously fabricated along with the antenna model, low profile configuration and also multifunctional so that they can be made easily compatible with devices which have multifunctional operations [2,3,4]. The limitations of the patch antenna are narrow impendence and axial ratio band width [5][6]. To overcome these disadvantages, several techniques are proposed and developed such as increasing the substrate thickness, defected ground structure [7], introduction of slots [8], modifying the shape of patch, introduction of parasitic patch, probe feed stacked antenna, and different feeding techniques such as grounded co-planar wave feed. [9][10].

Due to the increase in number of users in wireless communication systems, there is a spectrum shortage problem. In future wireless communication is done by mm-wave range frequencies, so there is a need to develop communication systems that will able to access frequencies in mm range in addition to existing lower frequency bands. Antenna is a major part in communication systems therefore there is a necessity to develop an antenna that is able to access the frequencies that are in mm-wave range and also available low frequency bands. So, the design antenna should have multiple resonant frequencies. As the compactness of system is desirable, the antenna should have low profile.

II. BACKGROUND WORK

A large number of designs and shapes and have been designed till today [11,12,13]but those designed antennas have resonance frequencies below 6GHz. Several 5G antennas are designed but they resonate only at mm wave frequencies like the antenna in [14]. It has wide band in the range of 22.97–35.04 GHz with an 8-element array configuration of the antenna providing maximum absolute gain of 14.9 dBi. The 5G mm- wave antenna [15] resonates at band of 37 GHz and 54 GHz with maximum bandwidth of 5.5 GHz and 8.67 GHz respectively. As compared to [16], the proposed structure has high band width at the frequencies above 6GHz and it has a small amount of increase in the gain also. The antenna should have more than one resonating frequency, wide band and acceptable gain to get used in 5 G networks for which the shape change of the antenna, introduction of slots and partial ground plane are introduced in it. The bands, for 5G systems are 24.25-27.5GHz, 31.8-33.4GHz, 37-43.5GHz, 45.5-52.6GHz, 66GHz-76GHz and 81GHz-86GHz [17]

In this paper Section III list, the geometry and design parameters of antenna. In Section IV the performance of antenna is analyzed by observing various parameters such as Return loss, VSWR, radiation pattern, Directivity and gain.

III. PROPOSED ANTENNA DESIGN

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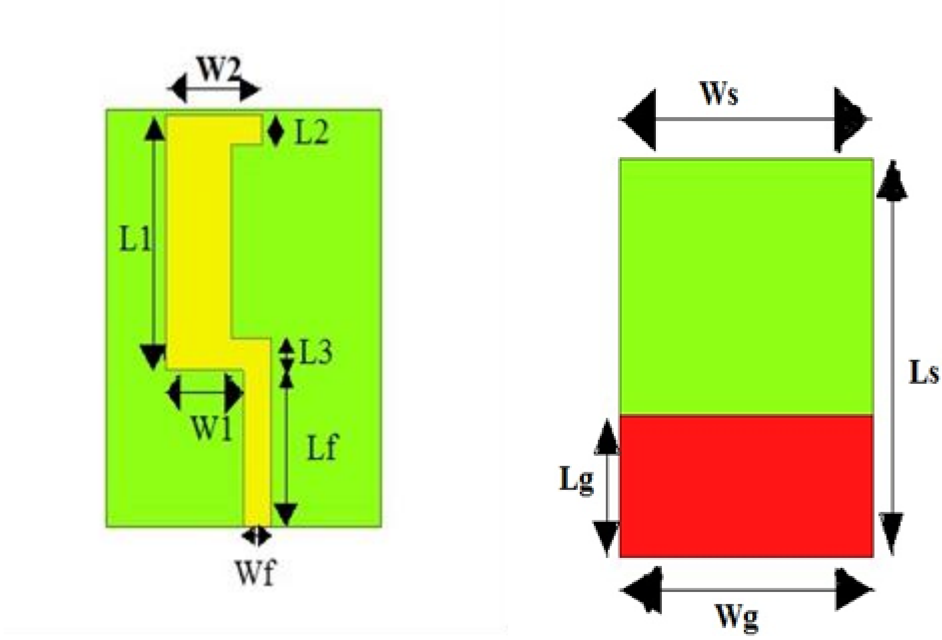

Figure. 1: The proposed antenna design

This antenna is designed using FR4 substrate. This substrate is widely available and low cost. The antenna is designed on this substrate has width and length would be 30*40 mm, thickness of substrate is 1.6mm, loss tangent is 0.02 and dielectric constant is 4.4. The length ground plane is 14.3 mm. The resonance frequency and the length of the antenna are inversely proportional to each other. The quality factor of microstrip patch antenna is decreases with the introduction of slots. The presence of slot decreases the conduction area due to this the conduction losses can be minimized and also the dielectric loss of substrate, so that the Q factor decreases. As the Q factor value decreases the bandwidth of the patch antenna increases.

Ground plane is modified to partial ground plane to improve bandwidth and return loss. Microstrip antennas have less radiation efficiency at higher frequencies due to high cross polarization. Defected ground structure reduces the cross polarization at higher frequencies for effective radiation. The partial ground technique has been proposed to minimize the cross-polarization of a microstrip patch antenna without affecting the input impedance, dominant modes and co- polarization of antenna. The length of the ground plane has major importance because it leads to impedance matching and there by increases the bandwidth. The length of the ground plane is optimized to get the desired values of bandwidth and return loss.

The proposed antenna parameters are listed in the table below.

Structure	Length	(mm)	Width	(mm)
Substrate	Ls	40	Ws	30
Feed	Lf	15	Wf	3.06
Patch	L1 L2 L3	24 3 3	W1 W2	11.46 10.46
Ground plane	Lg	14	Wg	30

Table 1: Antenna Dimensions

IV. EXPERIMENT AND RESULT

The simulation of the antenna is done by HFSS (High Frequency Structure Simulator) software. The antenna performance is evaluated by its bandwidth, return loss, gain, directivity, VSWR and radiation pattern. The resonance frequency of an antenna is estimated by observing its return loss and VSWR. A good radiating element must have its S(1,1) should be below -10 dB and its corresponding VSWR is 2.

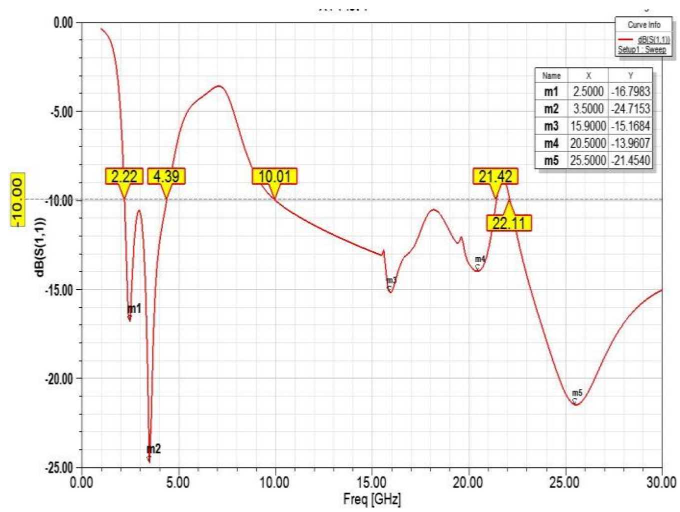

Figure 2. Simulated return loss of the antenna.

By doing parametric analysis, we conclude that the value of w1 has impact on the 3.5Ghz resonant frequency. As the value of w1 decreases the resonance frequency shifts to higher value and as the value of w1 increases the resonance frequency shifts to lower value. As the value of L3 increases the 3.5GHz resonance frequency shifts to lower value it has negligible impact on 2.5GHz frequency. As the value of L1 decreases by 5mm the resonance frequencies become 2.7GHz and3.3GHz. As the value of L1 decreases by 8mm the antenna does not resonant below 6GHz.As W2 increases the2.5GHz resonating frequency shifts to lower value and it has negligible impact on 3.5GHz resonating frequency. The values of L1 and W1 simultaneously maintained to get reasonable bandwidth at lower frequencies.

This proposed antenna design has many applications. By observing these simulated results we conclude that these designed antenna shape has multiband covering with frequency ranges 2.22GHz to 4.39 GHz which covers the many wireless applications such as Wi-Fi (wireless fidelity), Wi-max (world interoperability for microwave access), Bluetooth and various S & C band applications. This design also covers the band 24.5-27.5 GHz, which is worked by European strategy. Particularly the frequency bands 24.5GHz-27.5GHz, 31.8GHz-33.4 GHz and 40.5GHz-43.5 GHz according to IMT and Ofcom. In WRC-15 it was decided to assign the frequency band of 13.40GHz - 13.65 GHz to downlink (space to earth) the fixed satellite service (FSS). Thus, gain takes into account the antenna efficiency as well as its directional properties. The efficiency factor k is the ratio of the power radiated by the antenna to the total input power. The gain and directivity is related by G=k D. The value of k lies between $0 \leqslant k \leqslant 1$ which considers dissipative(R-resistence) losses. The gain of the proposed design is (2.02 dB, fig-3) is quite applicable for mobile phones.

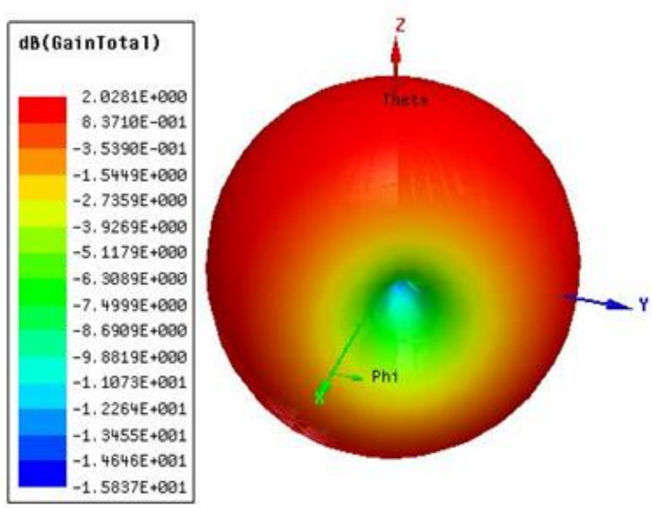

Figure 3: Gain of antenna at 2.5Ghz

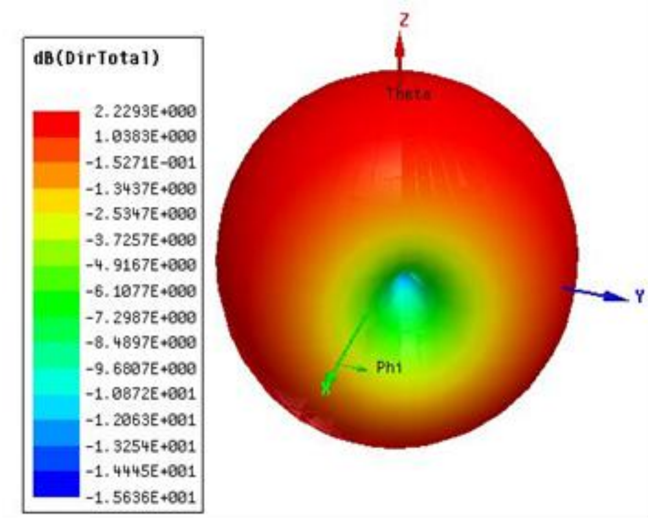

Figure 4: Directivity of antenna at 2.5Ghz

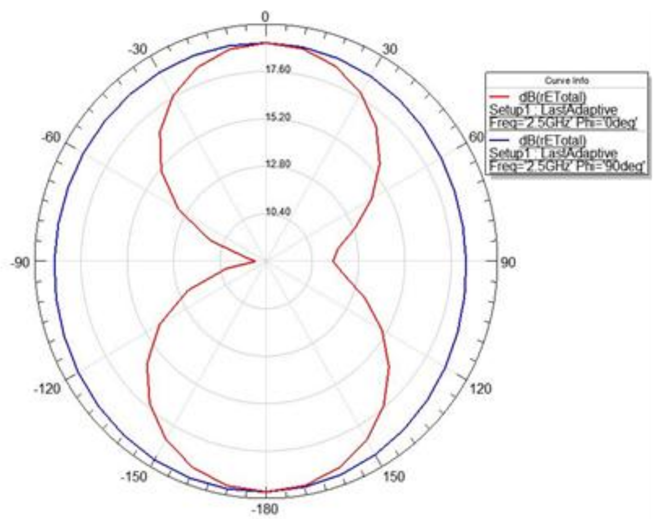

Figure 5: Radiation Pattern at 2.5Ghz

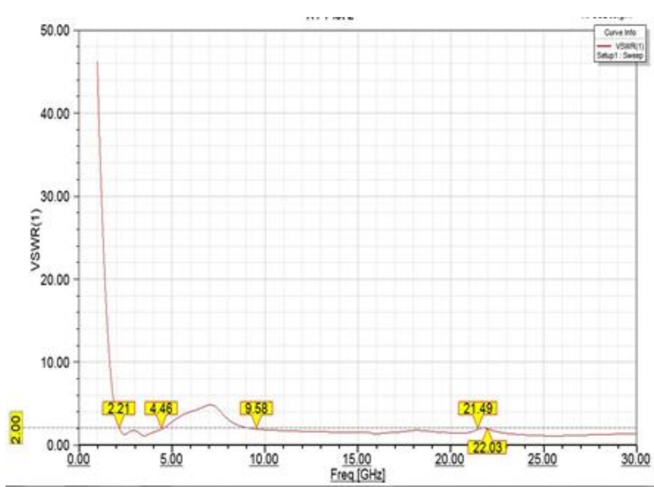

Figure 6:Antenna's VSWR coefficient

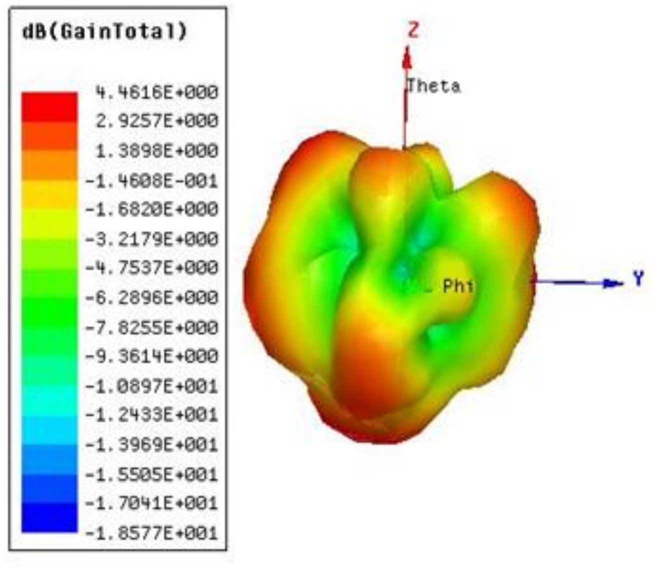

Figure 7: Gain of antenna at 15.9Ghz

V. CONCLUSION

The simulated results show that the proposed antenna design covers the multiple bands at low frequencies as well as high (mm wave) frequencies which include Wi-Fi, Wi-MAX, Bluetooth bands etc. This structure has many advantages such as easy to fabricate, occupies less area so that it could be embedded in different portable devices which are used in wireless applications. In the future work, the antenna performance can be improved in terms of its different parameters such as gain, directivity.

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