



# Optimized Bandwidth Enhanced Wideband Microstrip Antenna for 5G Applications

Navneet Singh, Amit Jain, Dinesh Kumar Singh

**Abstract:** In this article, a single port with truncated corner and common T-shaped notch loaded microstrip patch antenna for bandwidth enhancement is presented which is useable for mid band of 5G applications. The design of this prototyped antenna is obtained by loading truncated corner and T-shaped notch on rectangular patch antenna having 50 Ω microstrip line feed. The optimized antenna is selected as proposed antenna at design frequency 3 GHz among antenna 1- antenna 5 after study of simulated results through IE3D Mentor Graphics simulation software. Proposed antenna covers a wide bandwidth from 2.39 to 4.04 GHz and fractional bandwidth of 51.3% with pair of resonance frequency having return loss of -23.38 dB and -29.65 dB respectively.

**Keywords:** Truncated corner; Notch; Bandwidth; Resonance frequency; Return loss.

## I. INTRODUCTION

Due to advantages of light weight, low profile, simple structure and easy fabrication, so many investigations have been performed on the traditional microstrip patch antennas. There are so many design methods have been performed and developed for the enhancement of the bandwidth of these antennas. Based on above attractive features, microstrip antenna is a good candidate for fifth generation (5G) mobile communication system.

5G can be implemented in three bands like low-band (600-850 MHz), mid-band (2.3-4.7 GHz) and high band millimeter wave (24 – 40 GHz).

The bands ranging from 3 GHz to 5 GHz have been promoted in many countries for 5G services such as 3.1- 3.55 GHz and 3.7- 3.8 GHz in USA, 3.3-3.6 GHz in India and 3.4-3.8 GHz in Europe [1].

Several studies have been performed on the development of low-profile and broad band microstrip antenna. The impedance bandwidth of antenna structure can also be improved by loading the slots.

Using elliptical slot and placing inverted T-shaped stub with three reverse U-shape stubs, different parameters of proposed antenna has been observed also have better return

loss with compact size [2]. The impedance bandwidth of radiating patch enhanced by loaded with slots and different shapes of fractal boundary [3]. By placing the slot which may be of different shapes like inverted U-shape, L-shape addition with rectangular ring strip as well as defected ground plane, a multiband antenna has been studied and designed [4],[5].

By loading the slot of H and U- shaped bandwidth of 14% and 30 % have been observed respectively in microstrip patch antenna [6],[7].

Although with the help of stub loading and E-shaped loading in patch antenna, a better impedance bandwidth of approx. 40% has been achieved [8],[9]. Irrespective to the rectangular and square patch, a triangular patch antenna also shows the enhanced bandwidth by loading the notch and slot [10].

In this article, a broadband and low-profile patch antenna is designed and discussed for the 5G wireless communication system. Truncated corner and multi-notched structure are designed to shift the resonance frequency and enhance the impedance bandwidth. The prototype design of antenna has been simulated with Mentor Graphics IE3D software.

## II. EXPLANATION OF THE PROPOSED STRUCTURE

The final optimized geometry of proposed antenna is illustrated in Figure1, which is implemented on FR4 dielectric material having constant 4.4, thickness of 1.6 mm and loss tangent of 0.01[11].

For a design frequency of 3 GHz, the calculated area of rectangular patch is 23.4 ×30.4 mm<sup>2</sup>. For impedance matching, 50 Ω microstrip line feed is used having area 5× 3 mm<sup>2</sup>. The design specifications of proposed antenna geometry are given in Table 1.

**Table1: Design Specifications of Proposed Antenna Geometry**

S. No.	Parameters	Value (mm)
1.	A	33.4
2.	B	54.4
3.	C	23.4
4.	D	30.4
5.	a	5
6.	b	3
7.	c	5
8.	d	2

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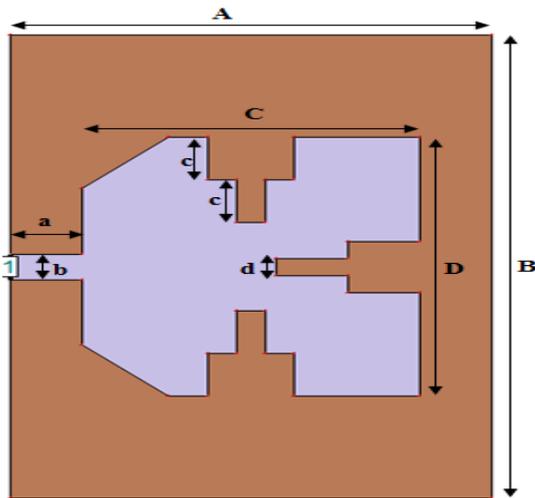
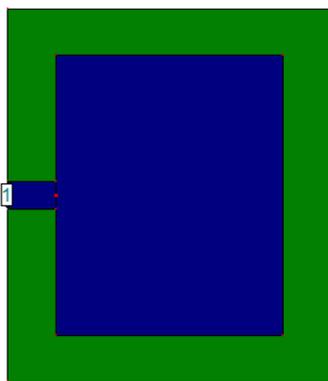


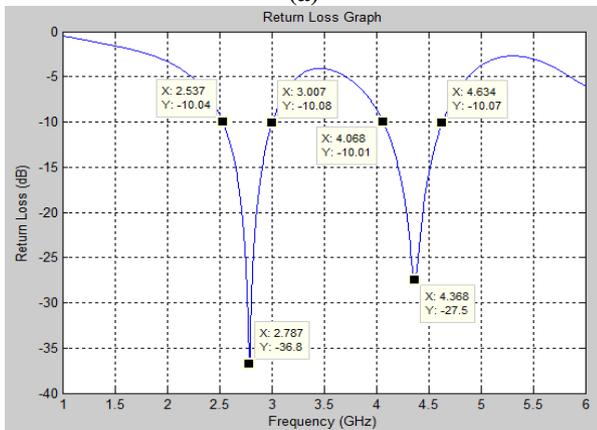
Figure 1: Final Optimized Geometry of Proposed Antenna

### III. CONVERSION OF DESIGN STEPS AND SIMULATION RESULTS

For the designing the structure of proposed antenna, the initial basic area of the rectangular patch is  $23.4 \times 30.4 \text{ mm}^2$  and the ground plane area is  $33.4 \times 40.4 \text{ mm}^2$ . In simulation process, a single port  $50 \Omega$  microstrip line feed has been used with area  $5 \times 3 \text{ mm}^2$  for impedance matching. The initial structure and the simulated return loss graph of the basic patch antenna is shown in Figure. 2. From the Figure 2 (b) it is observed that graph has two frequency band having bandwidth 16.96% in range from

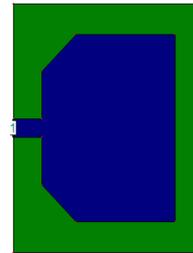


(a)

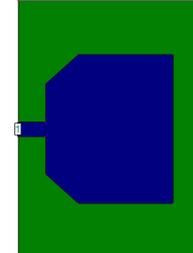


(b)

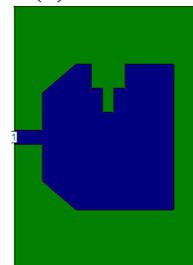
Figure 2: (a) Basic Structure of Patch antenna (b) Return Loss Graph of Basic Structure of Patch Antenna



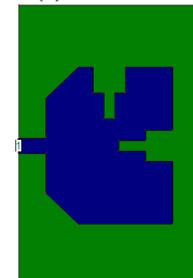
(a)Antenna 1



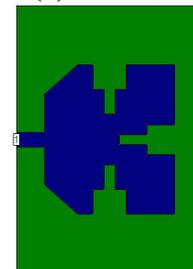
(b)Antenna 2



(c)Antenna 3



(d)Antenna 4



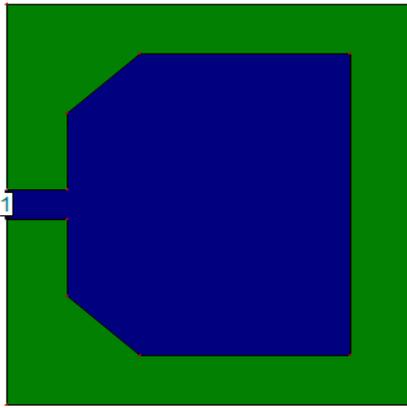
(e)Antenna 5

Figure.3: Design Steps for Optimized Proposed Antenna

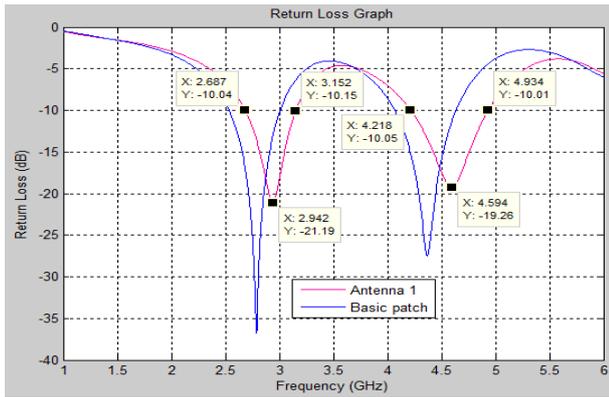
2.537 GHz to 3.007 GHz and 13 % in range from 4.068 GHz to 4.634 GHz respectively. The resonance frequencies of these bands are 2.787 GHz and 4.368 GHz with return loss of -36.8 dB and -27.5 dB respectively.

For getting the enhanced bandwidth, the different design steps of optimized proposed antenna (from antenna1 to proposed antenna) having truncated corner and T-shaped notch is shown in Figure 3.



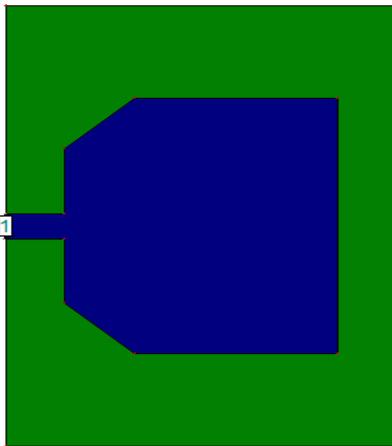


(a)

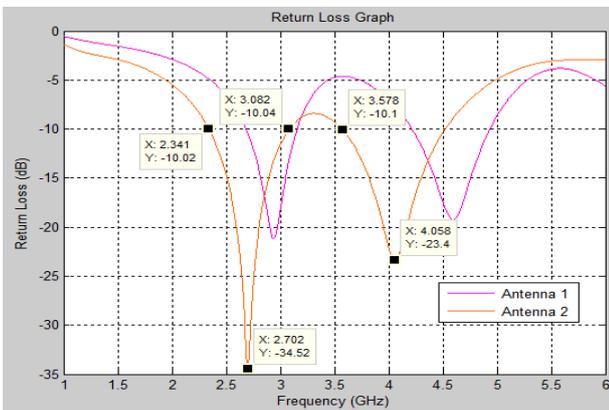


(b)

Figure 4: (a) Design of Antenna 1 (b) Return Loss Graph of Antenna 1



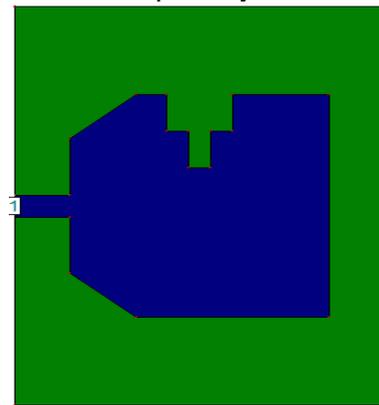
(a)



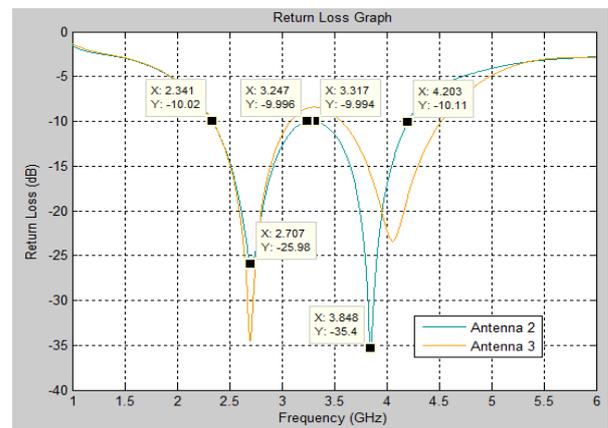
(b)

Figure 5: (a) Design of Antenna 2 (b) Return Loss Graph of Antenna 2

For getting the design of the proposed antenna, the first step is shown in Figure. 4(a) as antenna 1. For this design there is truncating the corners of the basic patch from the side of the radiating patch edge. The dimensions of both the truncated corners are same having 6 mm across length side and 6 mm across width side of radiating patch edge. Doing this process the simulated return loss graph is shown in Figure 4(b). From figure it is observed that the frequency band graph is shifted towards the higher band side in comparison to basic patch frequency band graph with dual frequency band having bandwidth 15.93 % in range from 2.687 GHz to 3.152 GHz and 15.65 % in range from 4.218 GHz to 4.934 GHz respectively. The resonance frequencies of these bands are 2.942 GHz and 4.594 GHz with return loss of -21.19 dB and -19.26 dB respectively. For getting the design of the proposed antenna, the second step is shown in Figure.5 (a) as antenna 2. For this design the width of the ground has been increased. The simulated return loss graph for this design is shown in Figure 5 (b). From figure it has been observed that the frequency band graph is shifted towards the lower band side in comparison to antenna 1 frequency band graph with dual frequency band having bandwidth 27.33 % in range from 2.341 GHz to 3.082 GHz and 23.32 % in range from 3.578 GHz to 4.519 GHz respectively. The resonance frequencies of these bands are 2.702 GHz and 4.058 GHz with return loss of -34.52 dB and -23.4 respectively.



(a)

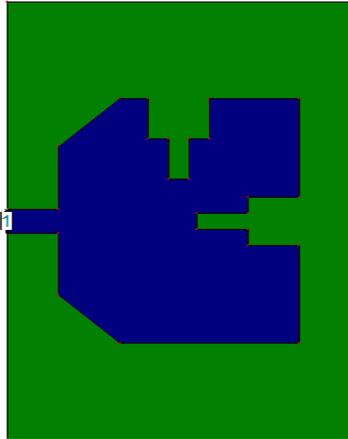


(b)

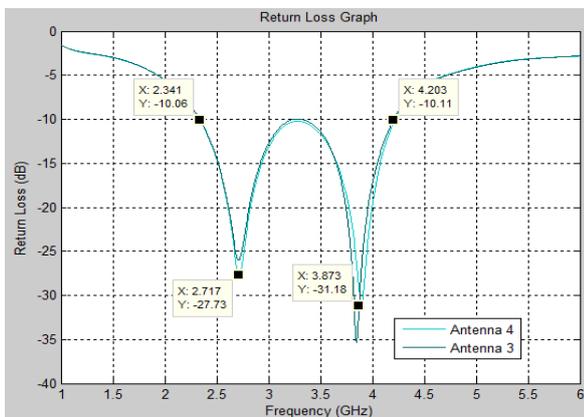
Figure 6: (a) Design of Antenna 3 (b) Return Loss Graph of Antenna 3

## Optimized Bandwidth Enhanced Wideband Microstrip Antenna for 5G Applications

The third step for getting the design of the proposed antenna is shown in Figure. 6 (a) as antenna 3. For this design a T-shaped notch has been loaded at the center of the upper side length of the patch up to 10 mm. The simulated return loss graph for this design is shown in Figure 6 (b). From figure it has been observed that the left side portion of the frequency band graph is remains same but the right portion of the shifted towards the lower band side in comparison to antenna 2 frequency band graph with dual frequency band having bandwidth 32.43 % in range from 2.341 GHz to 3.247 GHz and 23.56 % in range from 3.317 GHz to 4.203 GHz respectively. The resonance frequencies of these bands are 2.707 GHz and 3.848 GHz with return loss of -25.98 dB and -35.4 respectively.

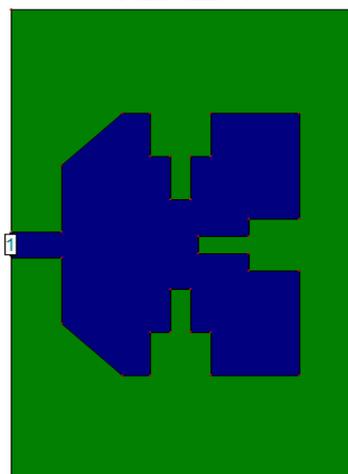


(a)

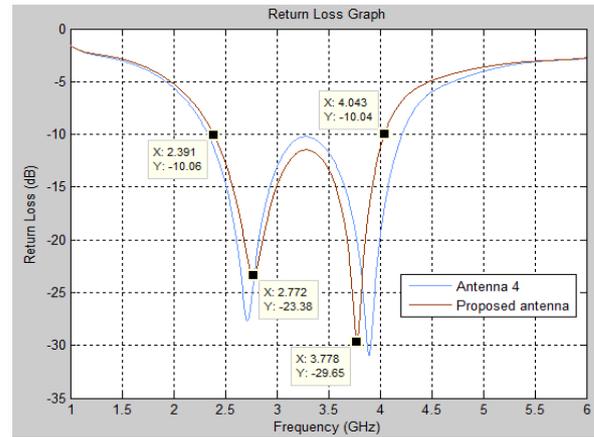


(b)

Figure. 7: (a) Design of Antenna 4 (b) Return Loss Graph of Antenna 4



(a)



(b)

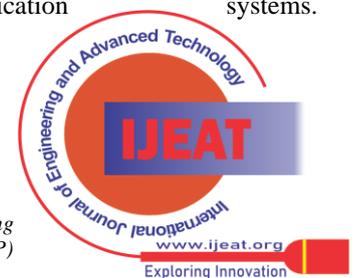
Figure. 8: (a) Design of Proposed Antenna (b) Return Loss Graph of Proposed Antenna

Figure 7 (a) shows the fourth step for getting the design of the proposed antenna as antenna 4. For this design and another T-shaped notch has been loaded at the center of the right-side width of the patch up to 10 mm. The simulated return loss graph for this design is shown in Figure 7 (b). From figure it has been observed that graph have single wideband having the bandwidth 56.9 % in range from 2.341 to 4.203 GHz with two resonance peaks. The resonance frequencies of this band are 2.717 GHz and 3.873 GHz with return loss of -27.73 dB and -31.18 respectively. From figure it is also observed that the lobe of the band is just nearer to the -10 db line that may create this single broad band to the two bands while taking measurement of the hardware of this design.

For care of above problem another T- shaped notch having the same area as other two notches, is loaded to center of the bottom side of length of the patch. This is the final step for design of the proposed antenna which is shown in Figure 8 (a). The simulated return loss graph is shown in Figure 8 (b) from where it has been observed that graph has single wideband having impedance bandwidth for  $S_{11}$  less -10 dB is from 2.391 GHz to 4.043 with the relative bandwidth of 51.3 % as well as two resonance peaks. The resonance frequency of this band is 2.772 GHz and 3.778 having return loss of -23.38 and -29.65 respectively.

## IV. CONCLUSION

A truncated corner and T-shaped notch loaded low-profile and wideband rectangular microstrip patch antenna with 50Ω microstrip feed has been designed and simulated for 5G applications. This antenna has been designed from rectangular patch by means of two truncated corner and three T-shaped notch having same area for getting improved bandwidth. The proposed design has enhanced bandwidth of 51.3% (2.391 GHz–4.043 GHz) with return loss of -23.38 dB and -29.65 dB at resonance frequencies 2.772 GHz and 3.778 GHz respectively which is a remarkable result covering frequency bands between 3 GHz and 5 GHz which is required for mid band of the 5G frequency band. With the above favorable outcomes, the proposed antenna can be useful for the 5G wireless communication systems.



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