# Miniaturized Quintuple Band Antenna for Wireless Applications

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**Abstract:** This paper presents a miniaturized quintuple band can be used for multiband activity with the point of building up a little and basic construction antenna that can work at multiband frequency. The proposed antenna contains a microstrip of rectangular shaped, a transmission line with 50 Ω coplanar waveguide (CPW), and six L- Shaped slots. By presenting these L-shaped slots along the X and Y axis, in the radiating element, the antenna yields at five resonance modes at 3.8, 4.6, 6.4, and 8.4 GHz while keeping the size of $28 \times 24$ $mm^2$. The prototype of the proposed antenna is constructed and experimentally studied. The measured results and stimulated results demonstrate that the proposed multiband antenna is appropriate for Bluetooth, WLAN, WiMAX, LTE, and X band applications. The antenna is planned utilizing FR4 lossy substrate material with relative permittivity of 4.3 and thickness of 1.6 mm.

**Index terms:** Coplanar waveguide technique, Multiband antenna, gain, efficiency, bandwidth, L-shaped slots, CPW-fed antenna, wireless communications, microstrip patch antenna.

## 1. Introduction

Multiband antenna actually has a great deal of significance in cognitive and multiservice radios. They are integrating a huge number of bands into one antenna gets essential and significant in different applications. Conventional WLAN/WiMAX frequency bands can be arranged into three significant bands: (3.4–4.2 GHz), (4.4–5 GHz), (5.5–6.8 GHz) and (8.12-8.58 GHz). The researchers have endeavored to make improvement and forestall impedance. As of now, most remote specialized gadgets are in low profile, simple and economical to fabricate, so the planned antenna should be zero in on numerous frequency bands covering S (2–4 GHz), C (4–8 GHz), X (7–12 GHz) groups and little designs that are basic and simple to make. In the integration of more than one norm into same antenna, such optimization increases the complexity. There are multiple techniques to design multiband antennas, such as L, T, U and V-shaped slots, which we cut on the top of the radiating elements of the antenna called as patch in the design. slots or spaces at rectangular emanating patch with the substrate called as ground plane. on the other hand, abandoned ground plane utilizing L U-formed openings Utilize a fix radio wire with slanted spaces, tow grooves as a square shape on the roundabout surface of the circle, with an unevenness hole of the coplanar waveguide (CPW) taking care of design, and a multi-branch structure is utilized in, whose each branch is tuned by the reverberation length of the ideal recurrence band and the coupling of each subsequent branch into various bands. A radar composed of two other sub branches and with a short stub is also used in. But few multi-band antennas can have more than three bands. Which includes WiMAX and WLAN bands in it.

In this Paper, a CPW-fed antenna that uses L-shaped slots or spaces in the patch to generate multiple bands is presented. The antenna includes a rectangular patch with L-shaped slots with different dimensions in the patch with different arrangements in the radiating element. The design is designed with the help of CPW coplanar waveguide technique, designed on a single metal side of an FR-4 substrate.

L-shaped slots are inserted in the radiating element in well studied locations to affect the current density, enabling the suggested design to function at four frequency bands (3.4–4.2 GHz), (4.49–5.01 GHz), (5.5–6.82 GHz), and finely (8.12–8.58 GHz) to cover WiMAX also known as IEEE 802.16 with its three allocation frequency bands which are: low band (from 2.4 to 2.8 GHz), middle band (from 3.2 to 3.8 GHz), and high band (from 5.15 to 5.75 GHz), Bluetooth (2.4– 2.48 GHz), LTE (2.384–2.574, 3.2–3.3 GHz), WLAN (2.4–2.48 GHz), and WLAN bands at 3.6 GHz (802.11y), 4.9 GHz (802.11y public safety WLAN), 5 GHz (802.11 a/h/j/n/ac), 5.9 GHz (801.11 p) bands, and 7.7 GHz for X band.

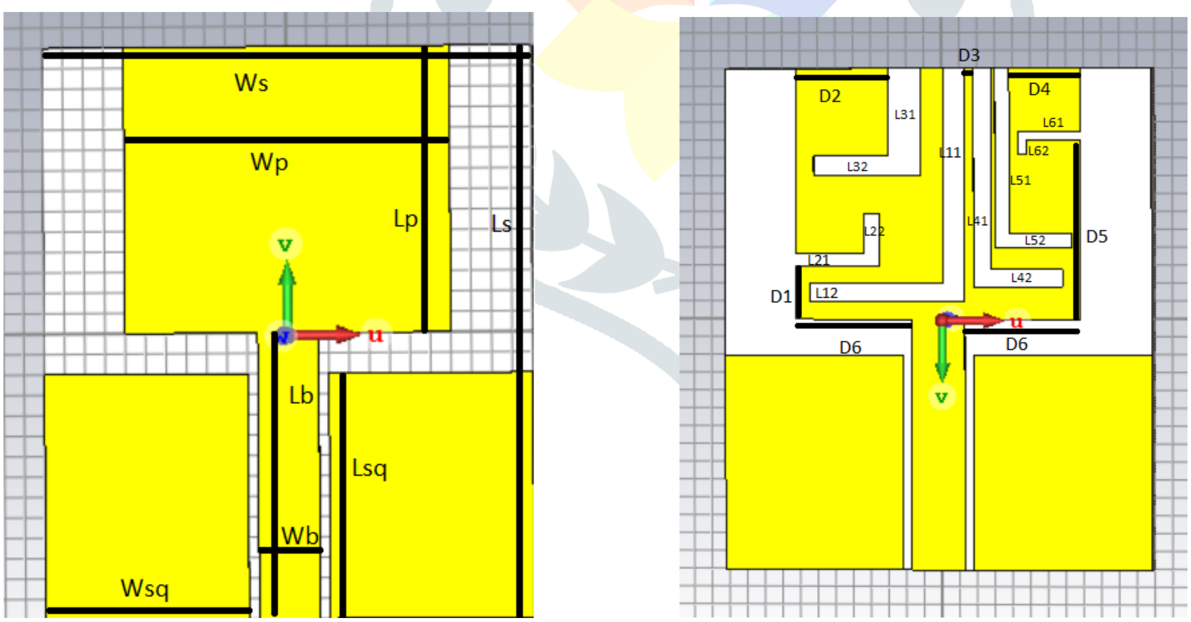
## 2. Antenna Design and Configuration

In this section, the geometric design of the proposed is discussed in detail. For the antenna design configuration has multiple sub-bands for WiMAX /WLAN and other multiband applications. This design is based on L-shaped slots monopole antenna structure.

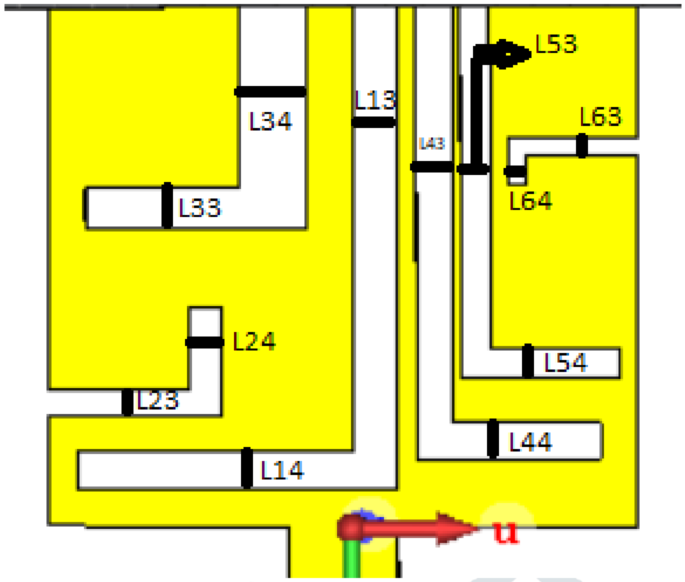
### 2.1. Antenna Configuration

Figure 1 below describes the evolution process for the proposed antenna configuration, and the antenna has been designed on the front face of the dielectric substrate FR4 of thickness 0.0035mm with a relative permittivity εr of 4.4 and dielectric loss tangent of 0.02. The total substrate footprint ($L_{sub} \times W_{sub}$) of the antenna is (24×28 $mm^2$), and the radiating patch is designed as a simple rectangle with dimensions (Lp×Wp) of (14 × 16 $mm^2$). The antenna is supplied by CPW technique.

The optimized physical values of the antenna parameters are listed in Table1.




(a) (b)




(c)

Figure 1. (a) First constructed design (b) L-shaped slots on the radiating element (c) Thickness of L-slots.

## 2.2 Design Procedure

The given figure displays the evolution process of the antenna, using the standard transmission line equations as a guide whose purpose is to design a conventional microstrip patch fed by CPW line. As like the Figure 1 (a), That is the first step and the suggestion for the evolution of the design. We started by a conventional patch antenna by identifying the dimensions. Few dimensions, D1is the height of L2. D2 is the width of the L3, D5 is the length of L6. D6 is the width of the patch from the width of Wb. Width and length of the radio wire are then determined as Wp = 16 mm and Lp = 14 mm, to have fr = 3.5 GHz, which is considered as the initial step to arrange the proposed multiband antenna. A full wave electromagnetic CST MWS simulator is utilized to study the multiband antenna. Figure 2 shows the simulated s11 for the design multiband antenna. It has an Omnidirectional radiation pattern appropriate for wireless communication applications.

## 2.4 Optimized parameters of the proposed antenna

Table 1. dimensions (in mm) of antenna.

| Dimensions | Length (mm) | Dimensions | Length (mm) |
|---|---|---|---|
| Ls | 24 | Lp | 14 |
| Ws | 28 | Wp | 16 |
| Lb | 14 | Lsq | 12 |
| Wb | 3 | Wsq | 10 |
| S | 0.5 | T | 0.0035 |
| D1 | 3 | D4 | 4 |
| D2 | 5.2 | D5 | 10 |
| D3 | 0.5 | D6 | 6.52 |
| L1 | 13 | L12 | 8.7 |
| L21 | 3.5 | L22 | 1,3 |
| L31 | 4.7 | L32 | 2.9 |
| L41 | 6 | L42 | 6 |
| L51 | 12.2 | L52 | 5 |
| L61 | 10 | L62 | 4.3 |
| L13 | 1 | L14 | 1.2 |

| | | | |
|---|---|---|---|
| L23 | 0.5 | L24 | 0.5 |
| L33 | 0.7 | L34 | 0.9 |
| L43 | 1.1 | L44 | 1.8 |
| L53 | 1 | L54 | 1 |
| L63 | 0.8 | L64 | 0.8 |

In the design, L1 is placed at the center of the rectangular patch. And with dimensions above, L2 and L3 are also incorporated as per the design on the radiating element. And following the other slots also incorporated with dimensions above.

### 3. Parametric analysis

The sizes of L-shaped slots are calculated as the sum of the perpendicular segment length plus the horizontal segment length. Figure 2 shows the layout of L-shaped slot dimensions.

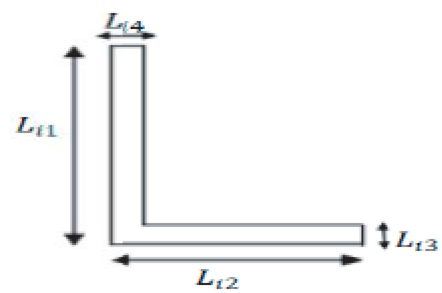



Figure 2. Geometry of $L_{ij}$-slot, i indicates the number of L-slot and j indicates the dimensions of L-slot number i.

$$\text{Slot length} \approx \frac{3 \times 10^8}{4 f_{n\sqrt{((\varepsilon_r+1)/2)}}} \quad (1)$$

where $\varepsilon_r$ and $f_n$ are dielectric constant of the substrate and a desired frequency respectively, and the slot length implies the perpendicular length rib plus the horizontal length rib of the L-shaped slot.

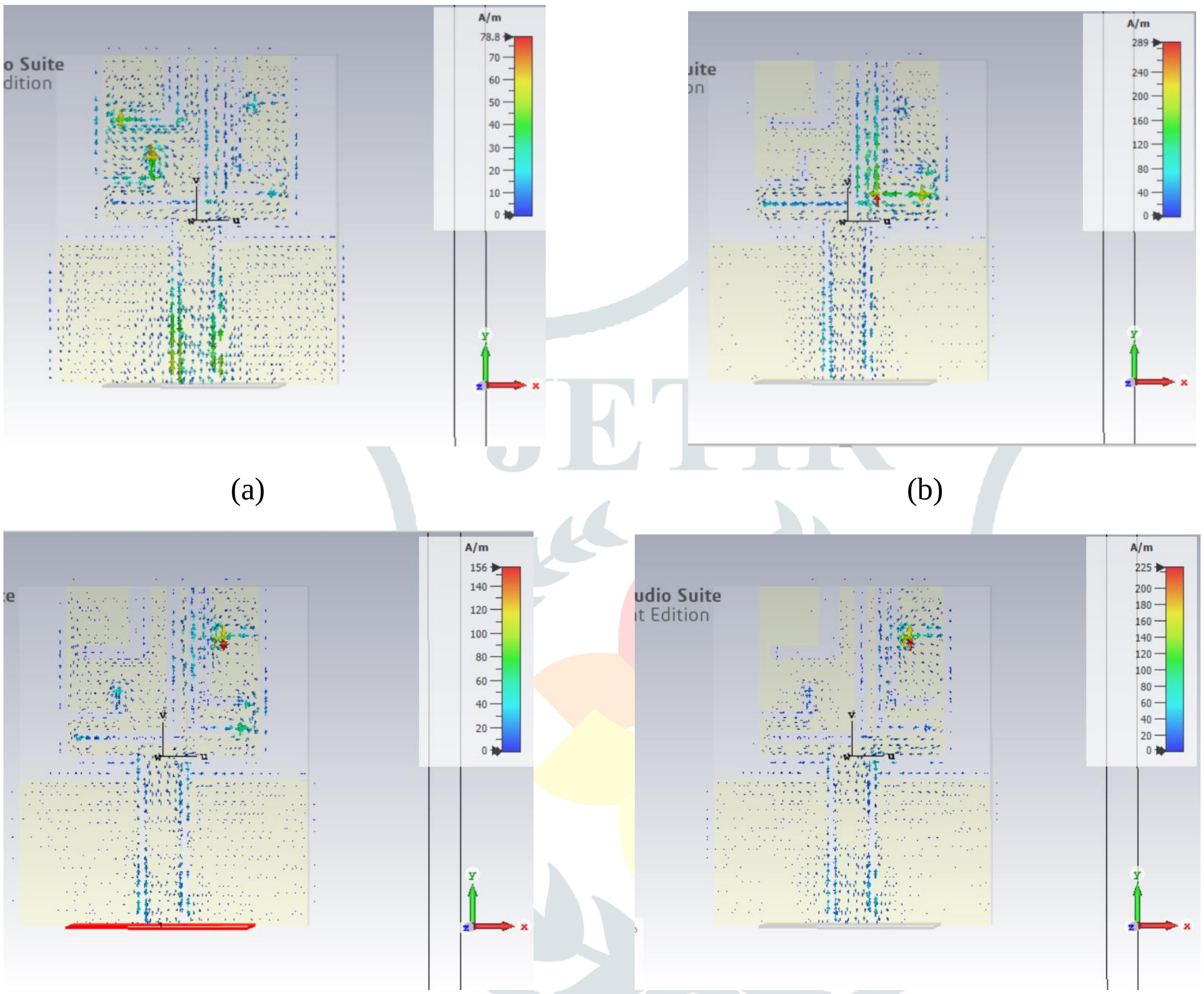
### 4. Results and Discussion

The following antenna is simulated and designed using CST microwave studio software V2020 with various parameters of table1. And also, the stimulated results are also presented. From the stimulations that there is a better agreement between measured and stimulated results with slit differences in the frequencies. That small changes are due to fabrication tolerance and measurement circumstances between the designed L-shaped slots.

### 4.1 Gain Vs Frequency

Gain is mostly calculated in the figure of merit. Here, the gain is denoted by G or power gain $G_p$. we can calculate the antenna radiation pattern using gain. "Antenna gain is defined as the ratio between maximum radiation intensity of a subject antenna in a given direction to the max. the radiation intensity of an isotropic antenna" when the same amount of power is applied to both antennas. The gain value indicates how much your antenna succeeded while converting the input power into radio waves in a specific direction and how it converts the radio waves into electrical form at the receiver side. Sometimes, the gain is discussed as a function of angle. By the gain value, we can know how much amount of signal boosting is provided to the input by the antenna.

### 4.2. Surface Current



(a) (b) (c) (d)

Figure 3. The current distribution across the simulated design at (a) 3.8 GHz, (b) 4.6 GHz (c) 6.3 GHz and (d) 8.3 GHz.

For the further study of the operating mechanism and clarification of the return loss performance of the proposed antenna, the surface resonant current distributions of the above images are at different frequencies are displayed. These resonant frequencies are can be controlled by adjusting the length of the L slots in the antenna design. And the simulated results of the surface current distributions are proposed at the different frequencies: 3.8, 4.6, 6.3 and 8.3 GHz.

### 4.3 Return Loss

In this subsection division of return loss, each and every corner points of return loss been discussed in detail such as the influence of geometric parameter and thoroughly investigated in depth. The furnished figure shows the S11 plot for different geometric parameters. The results been simulated of the proposed antenna screens about the antenna that been proposed is capable enough to put together five individual frequency bands of about −10 dB return loss, which are supportable values for the decided antenna to co-operate with the work efficiently for practical wireless applications. The performance of the antenna that been proposed is related to the geometry of the antenna, and it becomes possible all after by changing numerous parameters of the geometry and makes it possible to adjust to resonate at the frequencies that been desired. Each and every parameter of the geometry has been ameliorated with respect to the band of all that we yearn for. There were few more parameters have an out-come that could be considerable up-shot on the characteristics of the antenna contrasted to the other individuals, because a minute change in of these sizes of the parameters influence the multiple bands at the similar time, and consequently, the unconventional control of the bands of the frequencies is highly laborious. Six slots of antenna and five bands of frequencies can make that one or more frequency can be managed by various slots. Therefore, the contrast in the parameters is restricted to L1, L2, L4 and L6, and they are studied by differing their length (the change is in the length of the perpendicular segment or the horizontal segment of the L-slot) while the others are determined. According to Figure furnished in the paper a small change in the horizontal segment of L1-slot (L12) with 0.1 mm influence the lowest frequency band 3.4 GHz. This means that when decreasing the slot size L1, the center of the band of the frequency shifts to high frequencies, and contrary, when the size of L1 increments with 0.5 mm, it is found that the frequency of the shifts of the band is too low.

Frequencies and a risk rising above the −10 dB bar. In order to restrict redundancy, a recapitulation study in the following points:

• Frequency band (3.4–4.2 GHz): L11 ± 1 mm.

• Frequency band (4.4–5.0 GHz): L22 ± 0.5 mm.

• Frequency band (5.5–6.8 GHz): L52 ± 1 mm.

• Frequency band (8.1–8.5 GHz): L62 ± 0.8 mm.

## 5. Simulation Result

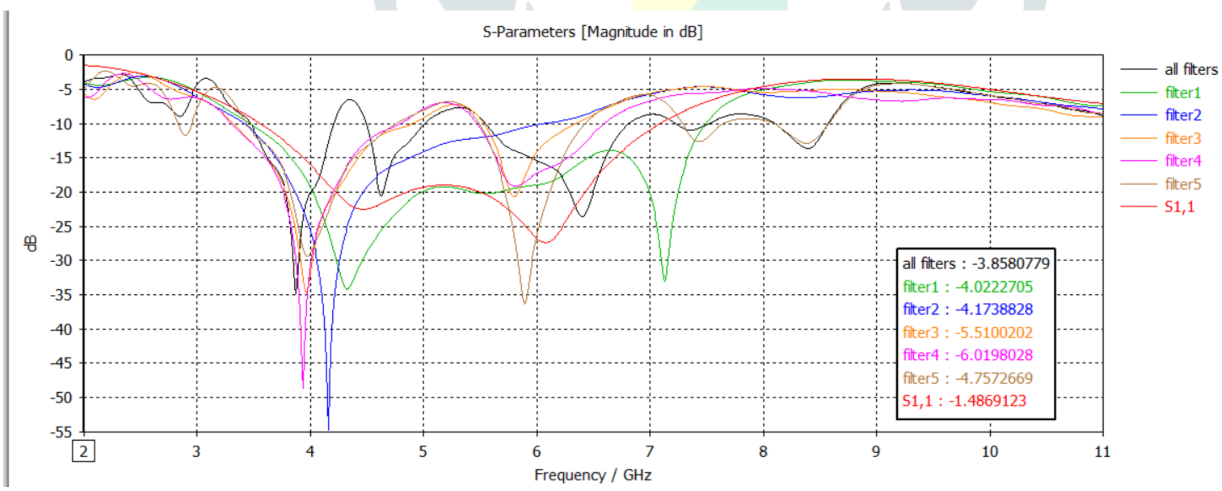



Figure 4. Demonstrating the plot of all the filter of the antenna design

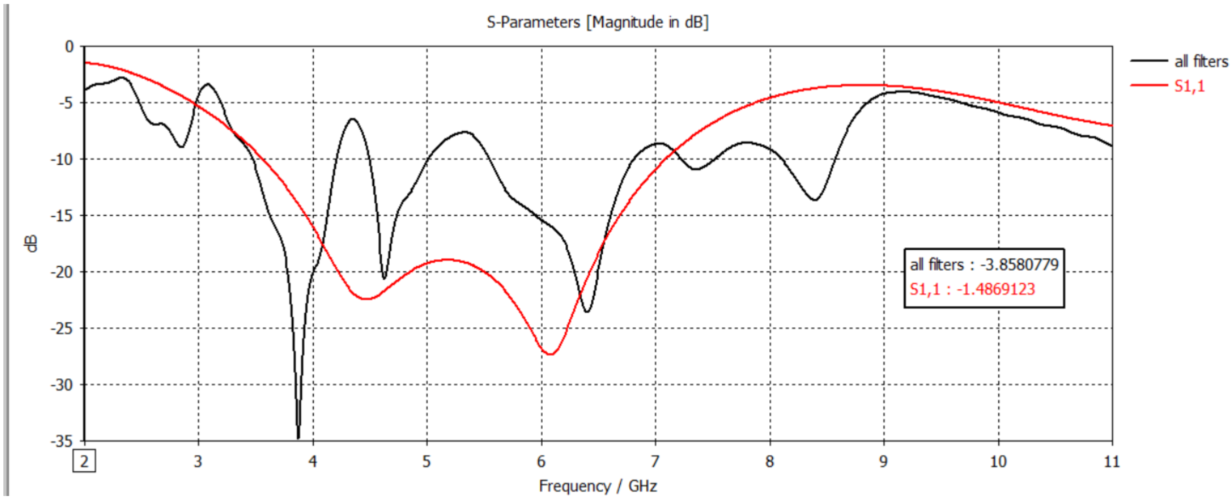



Figure 5. Demonstrating the plot of S11, and final plot of the design.

## 6. Conclusion

This paper proposed a multiband antenna for the use in different applications. In order to give more functionality to the antenna, six slots have been created in the design. Complete analysis of the geometrical parameters required are performed. Detail design consideration for the antenna described. The multiband nature, simple structure, and good omnidirectional radiation pattern has made this antenna an excellent candidate for Bluetooth, 2.4/5.8 GHz WLAN, 2.5/5.15 GHz WiMAX wireless standards, 5.9 GHz ITS band (5.85–5.925 GHz), and X-band satellite communication.

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