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# SRR Slotted Multiband Antenna in Sub 6-GHz for Futuristic Communication

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## Abstract

Futuristic communication in sub 6-GHz demands a compact antenna with multi-band resonance. This would be necessary to cater to the need in LTE, Wireless Fidelity, and 5G applications. A compact microstrip inverted slotted antenna for the future sub 6 -GHz wireless and mobile applications employs an important role in the present scenario. In this investigation, a slotted antenna especially for multi-band mobile applications in sub 6-GHz is presented. The slotted rectangular patch is matched with a microstrip offset feed line and stub matching. The performance of the single-layer slotted antenna is significantly improved using a slotted SRR structure. The designed antenna shows good reflections co-efficient at 3 GHz and 4 GHz with good return loss. The antenna exhibits impedance bandwidth up to 200 MHz and peak gain up to 4 dBi. It finds its application at the precise frequency for mobile wireless communication in LTE and sub 6-GHz for future 5G applications.

**Keywords:** 5G application, LTE, Microstrip antenna, Multi-Band, Stacked Slot, SRR techniques, Stub Matching

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## 1. Introduction

Antenna is the foremost and prime component in wireless communication system, and its main role is for the transmission and the reception of signals via air or space. Over time, numerous types of an antenna having different shapes, sizes, orientations, are designed using diverse materials, are found its applications in wireless communication systems. The type of antenna structure is characterised by the category of applications [1]. All popular wireless communication devices, such as mobile phones, Wi-Fi devices, primarily utilise microstrip antenna that meets the requirement very comprehensively [2]. Further applications of microstrip antenna can be in the wearable devices and other modern wireless devices in the form of embedded patch [3]. The patch antenna is designed by engraving regular patterns on the top metallic layer, the radiating one, over the substrate and consequently the shape and the size of this top layer predominately determine the characteristics of the antenna. However, transmission characteristics of the antenna are also affected by its proper impedance matching with the feedline, position of feedline, and introduction of the slot on the metallic surface. All these not only play favourable for bandwidth but also affect the resonance frequency, which is an important parameter in determining the applications of the antenna. [4]. However, a huge progression in wireless communication needs antennas

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having a lightweight, low profile, prevalent execution, and multiband activity [5]. For these prerequisites, a microstrip antenna is a decent competitor because of its low profile, lightweight, minimal effort in carving over the surface, integration with the device, and simple manufacturing process [6]. Wideband and multiband antennas are of high demand liked to for the utilization in various working frequencies. Since 4G has been introduced and picked up its development very rapidly, numerous wireless communication standards and protocols orders are presently concentrating on future 5G communication frameworks. Large portions of the endeavours are focusing on the implementation of this futuristic communication [7] with transformative and progressive services over existing LTE and UMTS services [8]. The 5G has a many-advanced format of existing 4G technology. The coming age of mobile services vow to convey improved end-client experience by offering new applications and administrations through consistent data flow, high information rate, high mobility, low latency with improved execution of wireless communication [9]. It will increase vitality effectiveness, range productivity, and proficiency in various services. It improves the assortment and extent of the utilization cases that LTE can insignificantly address today, and brings new streams to the users by developing new provisions that are lagging in existing networks [10]. 5G communication network-enabled cellular base stations and user devices are going to incorporate the new antenna structure, for taking the usefulness of future wireless communication [11]. Thus, the structure of an antenna is the most basic point for mobile and other 5G communication networks. The size of an antenna along with its unique features is the focal point for its incorporation in 5Gcommunication systems. Remembering these prerequisites, many researchers proposed various antennas structure for 5G systems [12].

Microstrip patch antenna has gained a wide acknowledgment of the innovative wireless communication networks. A normal rectangular microstrip antenna resonates at a single frequency. A couple of techniques of shifting the frequency is the insertion of the notch at the corner, cutting of slot over the patch [13]. SRR is the symmetric combination of these two, and in this technique, either the slots are carved over the patch or at the edge of it. This technique not only use in controlling the resonant frequency, but it also yields in multiple bands, and hence become the choice of the researcher for achieving a controlled resonance and multi-band [14]. In this paper, a traditional rectangular microstrip patch antenna is structured at sub 6- GHz of frequency, which is the chosen frequency zone for the futuristic 5G communication. Symmetric slots and notch are etched on the patch, which as a whole constitutes SRR structure, resulting in multiple-band under sub 6-GHz of frequency. Moreover, the appropriate dimension and placement of slots result in a shift in the resonant frequency [15]. Besides the operating frequency, the choice of the substrate is an important parameter in the design process. The metallic antenna and ground plane are clubbed together with the substrate, and the radiation characteristics are largely dependent on the substrate property.

## 2. Design Procedure

The antenna is designed and simulated with the help of licensed software HFSS, and then engineered to enhance its performance by operating at desired frequency with adequate bandwidth, by amply considering the slotted ring structure. The initial step in designing the rectangular-shaped antenna is governed by the set of equations [16]. Besides the operating frequency, the choice of the substrate is an important one in the design process. The material used in the designing of the antenna is RT/Duriod having permittivity of 2.2 and loss tangent of 0.002.

The effective length, $L$, and width, $W$, of the patch have been calculated by using the following equations:

$$L = \frac{c}{2f}\left(\frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\sqrt{\left[1+12\frac{h}{W}\right]}\right)^{\frac{-1}{2}} - 2\Delta L \quad (1)$$

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r+1}} = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \quad (2)$$

In the proposed design, a rectangular-shaped microstrip patch with stacked slot is used to get the proper resonant frequency. The antenna is engineered with a symmetric double line stacked slot, also known as SRR slotted structure, on the top left and bottom right of the patch. The dimension of slots are optimized manually to get the best performance of a proposed antenna.

The optimized dimension of the different parts of the proposed antenna are listed as follows:
Dimension of Antenna is 35 mm × 50 mm.
Dimension of Rectangular Patch is 34 mm × 36 mm.
Dimension of Feedline is 15 mm × 3.5 mm.
The dimension of SRR slot is 8.6 mm × 0.75 mm.
Height of the Antenna is 1.57 mm.

The designed geometry of the slot-loaded antenna structure is shown in Figure 1.

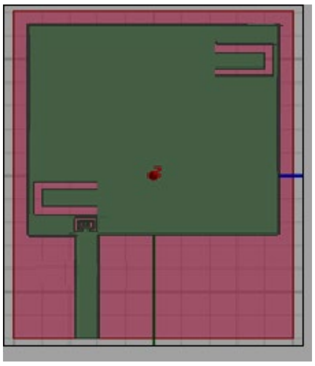

**Figure 1.** Antenna structure with SRR slots

The simulated return loss as a function of frequency for proposed antenna is plotted in Figure. 2, which reveals three bands with resonating frequencies of 3.2 GHz, 4.2 GHz, and 5.1 GHz, respectively. The reflection coefficient corresponding to these frequencies is -16 dB, -12 dB, and -11 dB, respectively. However, the distinct bands under sub 6-GHz are obtained, but the reflection coefficients at resonating frequencies are not encouraging.

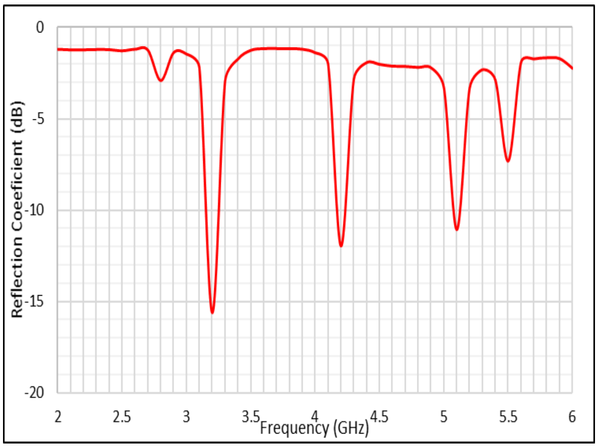


**Figure 2.** Reflection Coefficient Plot

To improve the reflection coefficients, and getting the desired band, the impedance matching is enhanced by considering the matching stub on the microstrip feedline is shown in Figure 3. The position of matching stub is adjusted along the feedline to get the best reflection coefficients at resonating frequencies.

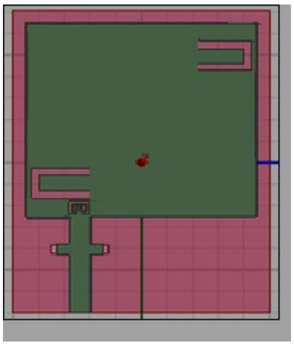

**Figure 3.** Antenna structure with Matching Stubs

The simulated reflection coefficient of an antenna with matching stub versus frequency plot is shown in Figure 4, which reveals the significant improvement in reflection coefficient at 4.0 GHz. Note that impedance matching not only results enhanced reflection coefficient but also shift the resonating frequencies towards lower end of the frequency scale to get the desired resonance exactly at 3 GHz, 4GHz and 5 GHz.

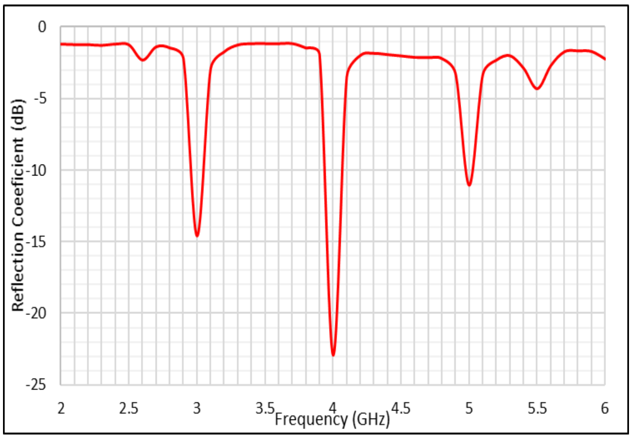


**Figure 4.** Reflection Coefficient Plot

## 3. Hardware and Validation of Simulated Results

The final antenna is fabricated on RT droid with precise notches and stub matching at the feedline. The fabricated antenna is shown in Figure 5.

**Figure 5.** Image of Fabricated Antenna

This fabricated antenna is characterized by using Agilent high precision vector network analyzer. The measured and simulated values S11 versus frequency of the final designed antenna is plotted in Figure 6, which reveals a very good match between the fabricated and simulated results. The final antenna got three bands, operating precisely at 3 GHz (having S11 of -15 dB), 4 GHz (having S11 of -17 dB) and at 5 GHz (around -10 dB of S11 parameter). The resonance at 5 GHz is very feeble, but the resonance and matching at 3 and 4 GHz is very good. This validates the design and its application.

Moreover, the three bands are sharp and well distinct from each other. The bandwidth of the first and third band is 150 MHz each, whereas the second band exhibits a bandwidth of 200 MHz. The measured gain of the antenna is 4 dBi, which is adequate for sub 6-GHz 5G applications.

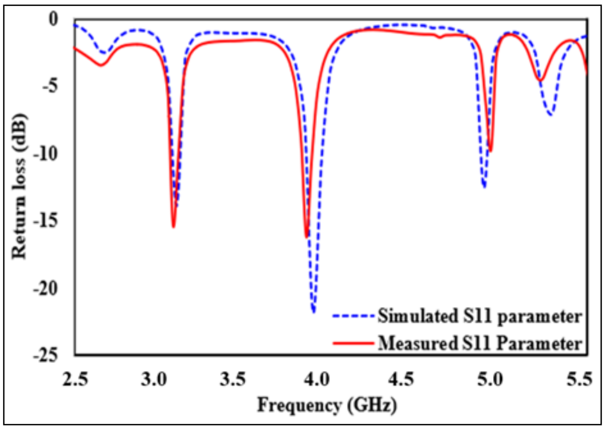


**Figure 6.** Simulated and Measured Results

Figure 7 is the radiation patterns (simulated) in E-plane and H-plane for 3 GHz, and 4 GHz, respectively. Figure 7 depicts that the proposed antenna has realized decent far field characteristics both in the E-plane and H-plane.

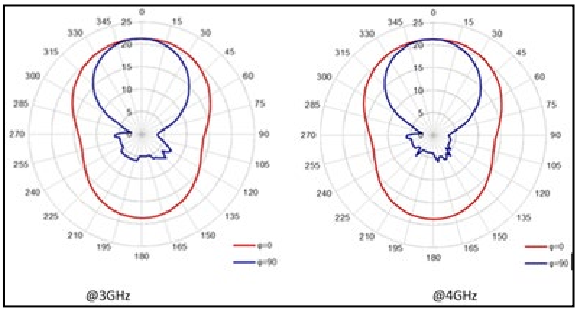


**Figure 7.** Radiation pattern plot

## Conclusion

SRR Slotted Multiband Antenna, with impedance matching stub, operating in Sub 6-GHz for the futuristic 5G Communication is presented. Three resonating bands with adequate reflection coefficient and bandwidth are demonstrated. The proposed antenna brand its suitability for future wireless communication in the area of 5G and extended wireless fidelity, and claims the novelty of this design, and exploits over recently planned antenna regarding effortlessness in structure and improved performance.

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