

Bandwidth Enhancement of Compact Circular Slot Antenna for UWB Applications

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Received: 12 December 2016 Accepted: 4 January 2017 Published: 15 January 2017

Abstract

In this paper the compact circular slot antenna suitable for UWB applications is presented. The bandwidth enhancement technique introduced in this design is using modified patch and ground plane of the antenna with ring and circular shaped slots on the patch. The diagonal cuts at the top corners and the rectangular slots can increase the bandwidth of antenna. The proposed antenna is excited with a simple 50- microstrip line. The simulated and measured results indicate that the proposed antenna with dimensions of 30mm (Wsub) x 50mm (Lsub) x 1.6mm (H) has a large bandwidth over the frequency band from 2.75 GHz to 20 GHz with VSWR less than 2. The presented results also depict the radiation behavior which exhibit good radiation pattern, and impedance bandwidth over the entire band of operation.

Index terms— microstrip antenna, return loss, UWB antenna.

1 Introduction

With the rapid development of wireless communication systems and increase in their applications, compact and wideband antenna design has become a challenging topic [1]. Printed slot antennas are widely used in a variety of communication systems because wide-slot antennas have two orthogonal resonance modes, which are merged to create a wide impedance bandwidth [2]. Thus, printed slot antennas have recently received a great deal of attention from researchers. As is well known, an antenna with various shapes such as circle [3], ellipse [4], and triangle [5] were reported for wide bandwidth. Each slot shape requires a feed stub of appropriate shape. An optimum impedance bandwidth can be obtained by the coupling between the feeding structure and the slot. There are some more methods of Bandwidth of antenna Increases Like bandwidth of a dual patch antenna is improved by etching dummy EBG pattern on the feed-line [6] and proximity coupled feed and aperture coupled feed methods are used [7]. The slots etched on the ground plane and split square ring slots etched on the patch has been designed with wide bandwidth and minimal return loss characteristic for UWB applications [8]. The new method of enhancing the bandwidth of a proximity coupled microstrip patch antenna using an integrated impedance matching network (IMN) is presented [9]. Patch antenna possesses many advantages such as low profile light weight small volume and compatibility with monolithic microwave integrated circuits (MMIC) and MIC. The narrow bandwidth is the major obstacle in wide application for the micro strip antenna [10]. Basically, the maximum achievable data rate or capacity for the ideal band-limited additive White Gaussian noise (AWGN) channel is related to the bandwidth and the signal-to-noise ratio through Shannon-Nyquist criterion [12]. $C = B \log_2 (1 + \text{SNR})$

Where C denotes the maximum transmit data rate, B stands for the channel bandwidth, and SNR is the signal-to-noise ratio. From this principle, the transmit data rate can be enhanced by increasing either the bandwidth occupation or the transmission power.

In this article, we report a technique to enhance the bandwidth using a microstrip-fed planar circular disc monopole. The circular disc monopole with a 50- Ω microstrip feed line is fabricated on the FR4 substrate. To improve the bandwidth, we modified the original ground plane to be T-shaped with diagonal cuts at the

top corners and rectangular slots on the body with the ring and slot introduced in the patch of the antenna. Applications of corner cut technique have been previously employed to improve the impedance bandwidth for microstrip patch antennas [4][5][6]. The preliminary simulation results of our proposed antenna are compared with the measured ones. Following this introduction, the rest of the paper is organized as follows.

The detail of the antenna design and preliminary results from simulations are described in Section 2, and Section 3 presents the modifications done to achieve UWB operation. Experimental validation and discussions are presented in Section 4 followed by conclusions of the work carried out in Section 5.

W Year 2017 F II. The geometry of the proposed antenna is shown in Figure 1. The proposed antenna, with overall dimensions of only 30x41 mm² is fabricated on a FR4 substrate with a relative permittivity of 4.4 and a thickness of 1.6 mm. On one side of the substrate, two ring-shaped slots are etched to create a relatively wide frequency band since the larger inverted slot affects the lower frequency mode, while the smaller one influences the higher frequency mode. Moreover, at the end of the feed line, a rectangular conducting patch is applied to create a good impedance matching for the proposed antenna to attain the bandwidth enhancement for the UWB applications. By properly varying the lengths of L and W, a wider impedance matching is achieved. To investigate the performance of the proposed antenna, the electromagnetic simulation software Ansoft HFSS is used for parameter studies and other parameters are also described in Figure 1. Unlike most of the ultrawideband printed antennas which have partial or defected ground planes (DGS) for ultra-wide bandwidth enhancement, this antenna has a full ground plane. In order to increase the impedance bandwidth, two C-shaped slots are inserted in the ground plane of the designed antenna as shown in Figure 1. The slotted ground planes that provide one more resonance is shown in Figure 2. The monopole antenna with slotted ground plane has wider impedance matching in comparison to the same antenna without slot in ground plane. The Results in Figure 2 indicate the varying radius values increase the impedance bandwidth of the antenna and for this we have chosen the 10 mm radius for optimum impedance bandwidth.

2 Basic Antenna Geometry

3 Global

While the next parameter for selection of the gap (G) between the ground planes of the UWB antenna with respect to the feed line of the UWB antenna. Whenever the h is positive the bottom of the disc is at the higher level than the top of the ground plane. The same can be said for the negative value of h in the opposite direction. The results of the return loss and bandwidth as a function of the parameter h are shown in Figure 2(b). By analysing the h parameters we select it is zero value for the good frequency resonance. Later the length of the ground plane of the UWB antenna is analysis on the basis of parametric study. The length equal to L=15 mm for the high impedance bandwidth of the antenna. Second, the length of the ground plane affects the impedance matching more significantly at higher frequencies than at lower frequencies as shown in Figure 3. In this study, a change in the dielectric constant leads to a shift in the characteristic impedance of the feeding strip from 50 ohm [13]. The corner cut used here plays an important role in balancing resistive part and reactive part which affect the impedance matching shown in Figure 3(a). Triangle slot at the Ground plane of the antenna increases radiating edges which results in improved bandwidth [14]. A parametric analysis for the effect of the position of rectangular slot with respect to the ground plane on the return loss is shown in Figure 3(b). To meet the required objectives, some geometrical alterations have been made in the antenna when compared to the conventional microstrip patch antenna. By varying the radii of the ring in the patch of UWB antenna is shown in Figure ??.

The comparison over the different slot of the antenna shown in Figure ?? over the bandwidth and return loss and gain frequency shown in Table ?. Fractional bandwidth is also calculated and gain of the UWB antenna is also shown in Table ?.

4 Results and Discussions

The comparison between the simulated using commercial high frequency structure simulator (HFSS) and the results from the measurement of the fabricated antenna using a ROHDE N SCHWARZ ZVL Vector Network Analysers is shown in Figure ??(b). The measured result is relatively close to that obtained from simulation. The discrepancy of the return loss at the first resonant frequency would be caused by the size difference of the circular discs [17][18][19] between the simulation model and the fabrication as mentioned in the previous section. The electric field (E) and magnetic field (H) planes at different frequencies are shown in Figure ?. It is obvious that the antenna behaves like a typical monopole antenna that acquires Omni-directional pattern in the lower frequencies and quasi Omnidirectional pattern in the higher ones. It is known that a conventional thin patch antenna with a full ground plane is inherently narrow band. Thus, to achieve a very wide bandwidth, several bandwidth enhancement techniques, such as inclusion of multiple resonators [13], slots [15], and parasitic element [16] are applied.

The 10 dB return loss bandwidth is indeed slightly decreased (4.2 to 9.3 GHz) compare to the flat one. This shows that the antenna is relatively robust against the physical deformation. The peak gain of the antenna is shown in Figure 10.

5 Conclusions

In this paper, a compact small square monopole antenna suitable for UWB applications has been investigated and presented. By inserting the ring shaped structure and circular slot on the patch of antenna which resulted in the good impedance bandwidth. The length of the ground plane at the bottom layer and the position of the slot with respect to the ground plane play a great role in optimizing the return loss, and the antenna radiation parameters. The radiation patterns of this antenna show good omnidirectional performance throughout the UWB frequency range and positive gain. Because of its simple structure, compact size, and good performance the proposed antenna is expected to be a good candidate in various UWB systems.

6 Global

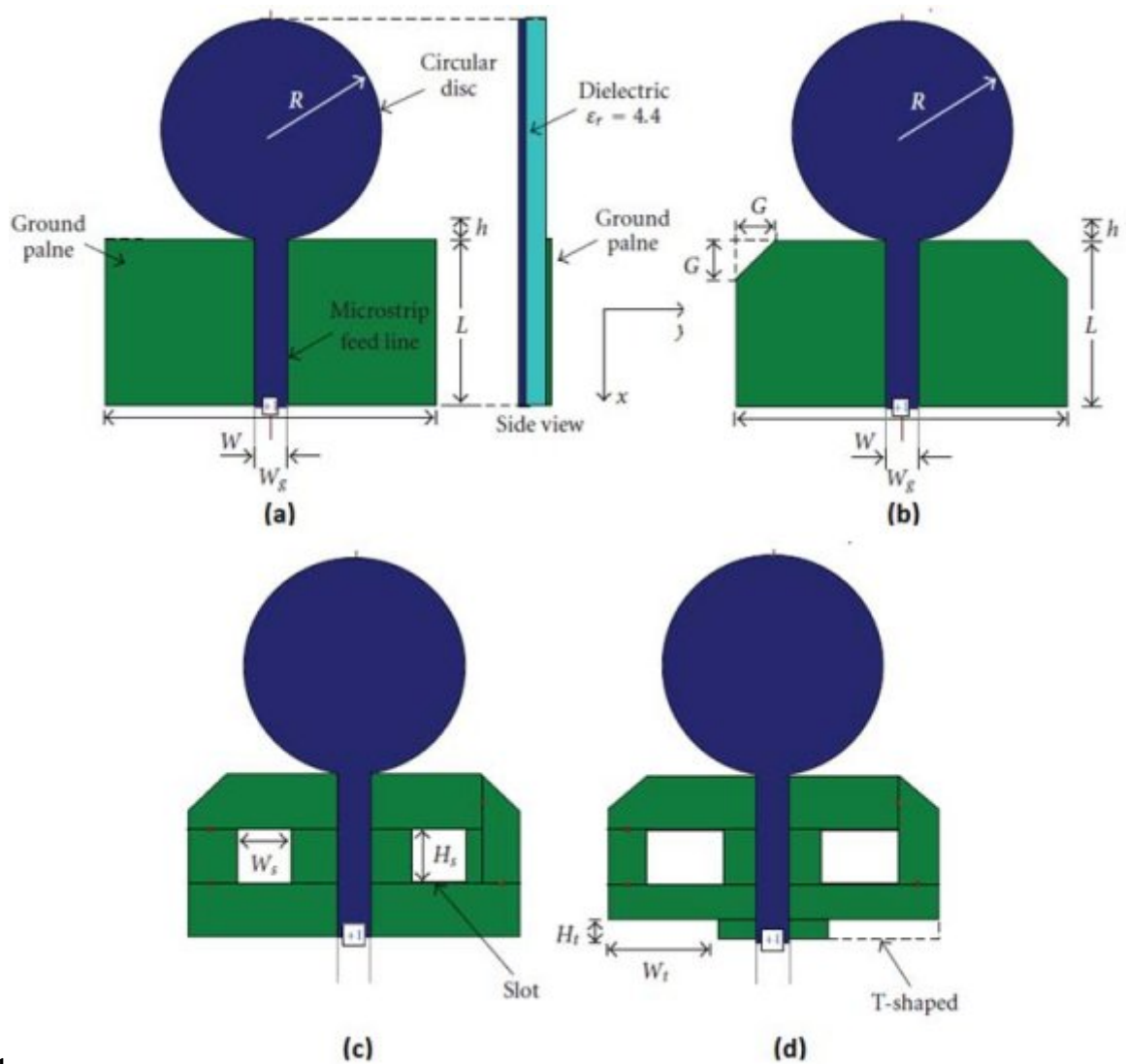


Figure 1: Figure 1 :

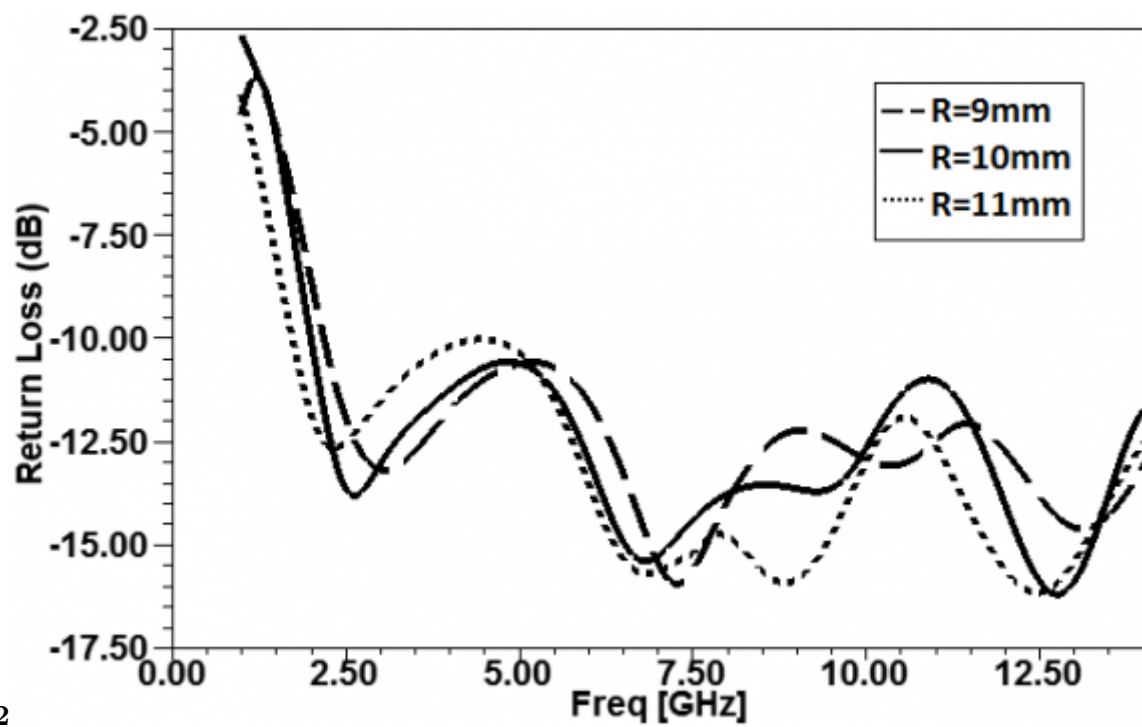


Figure 2: Figure 2 :

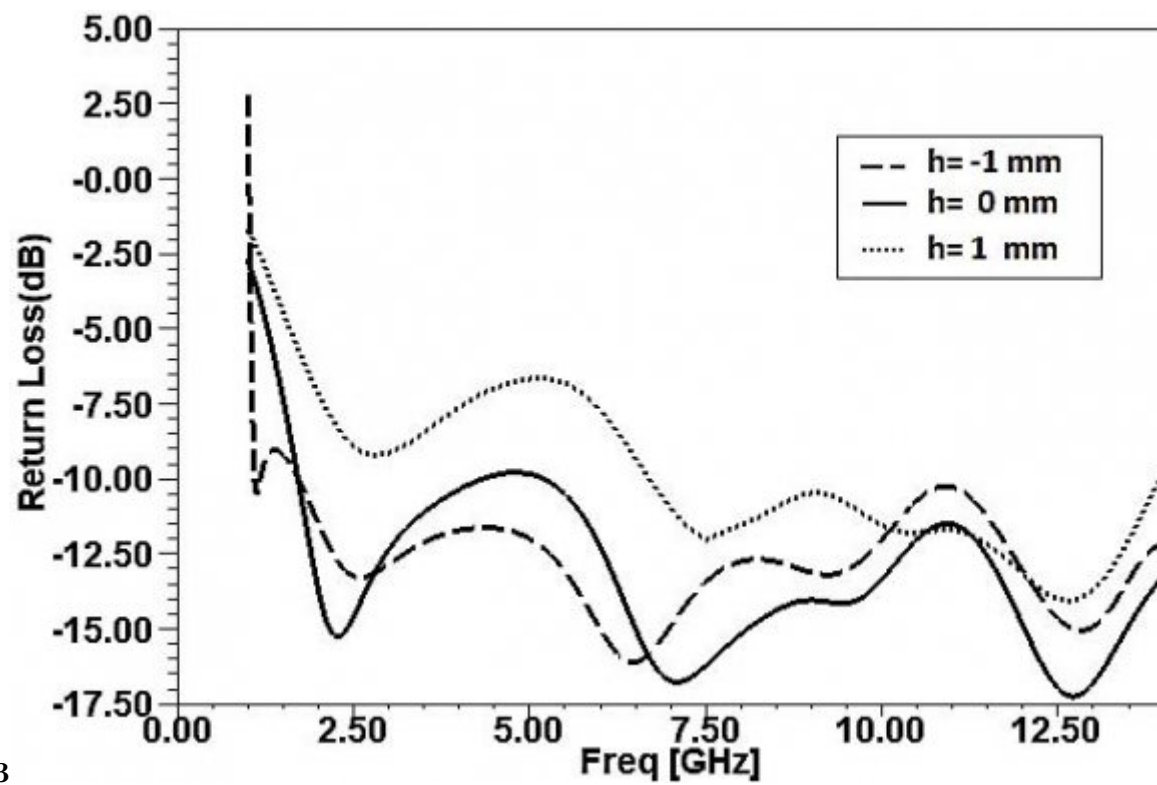
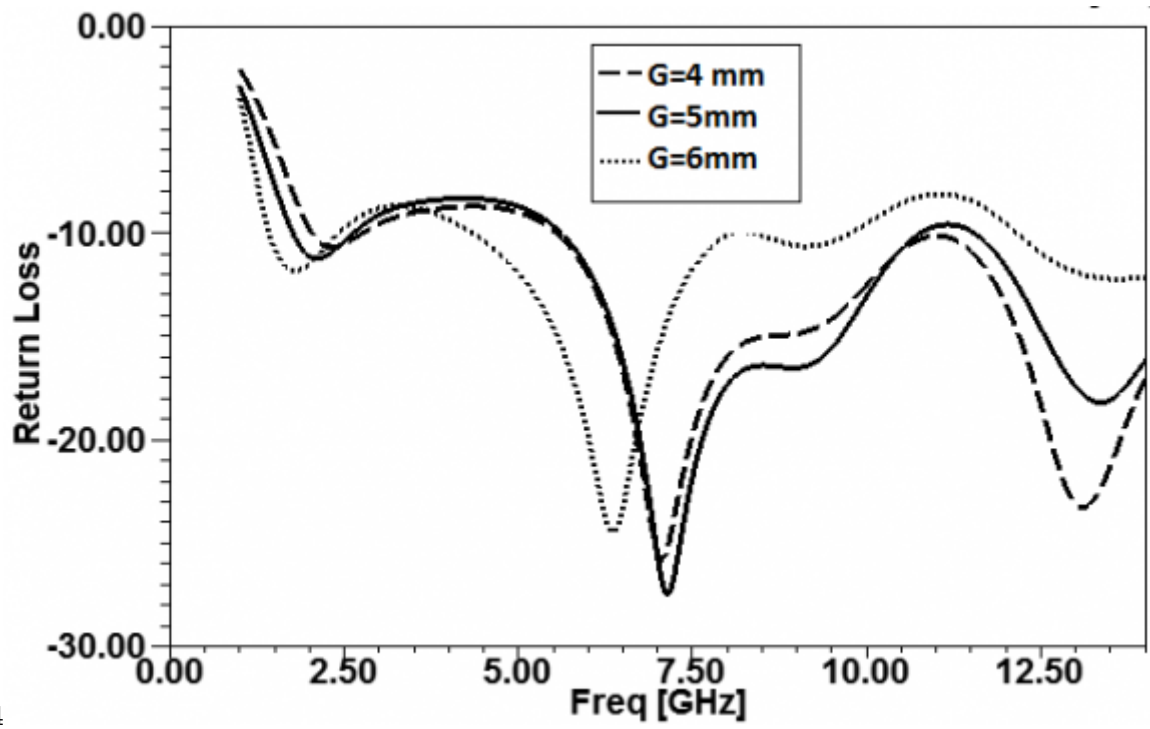
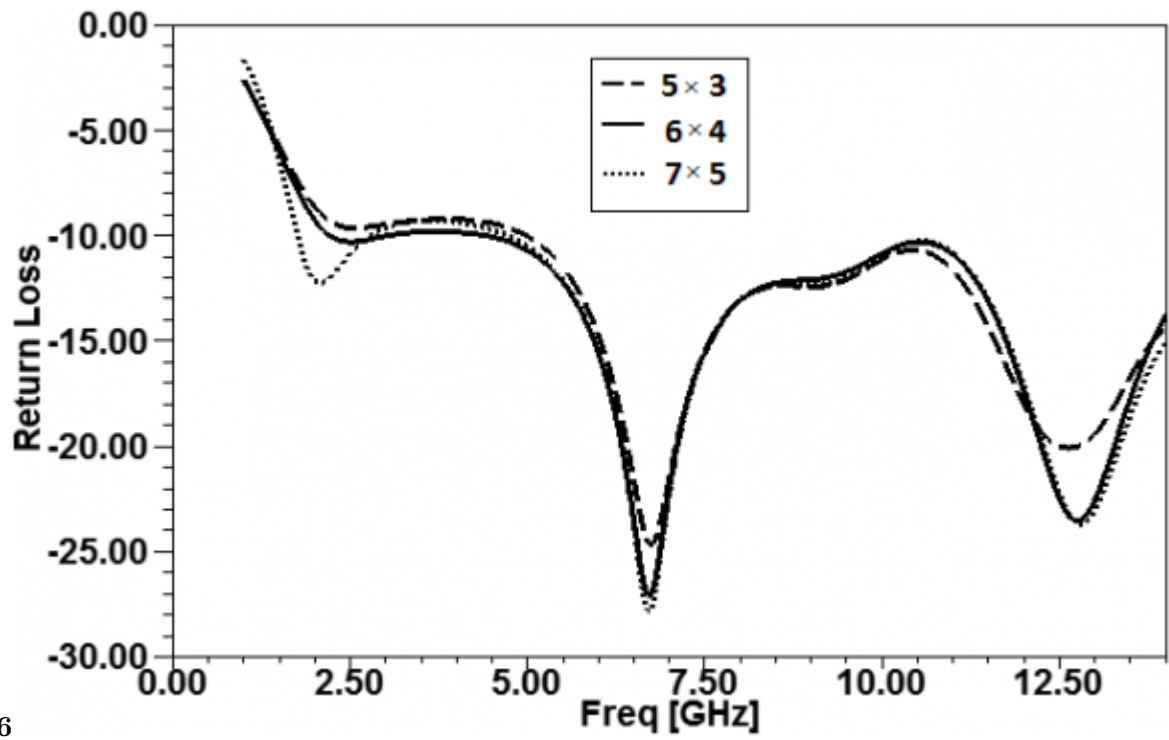


Figure 3: Figure 3 :



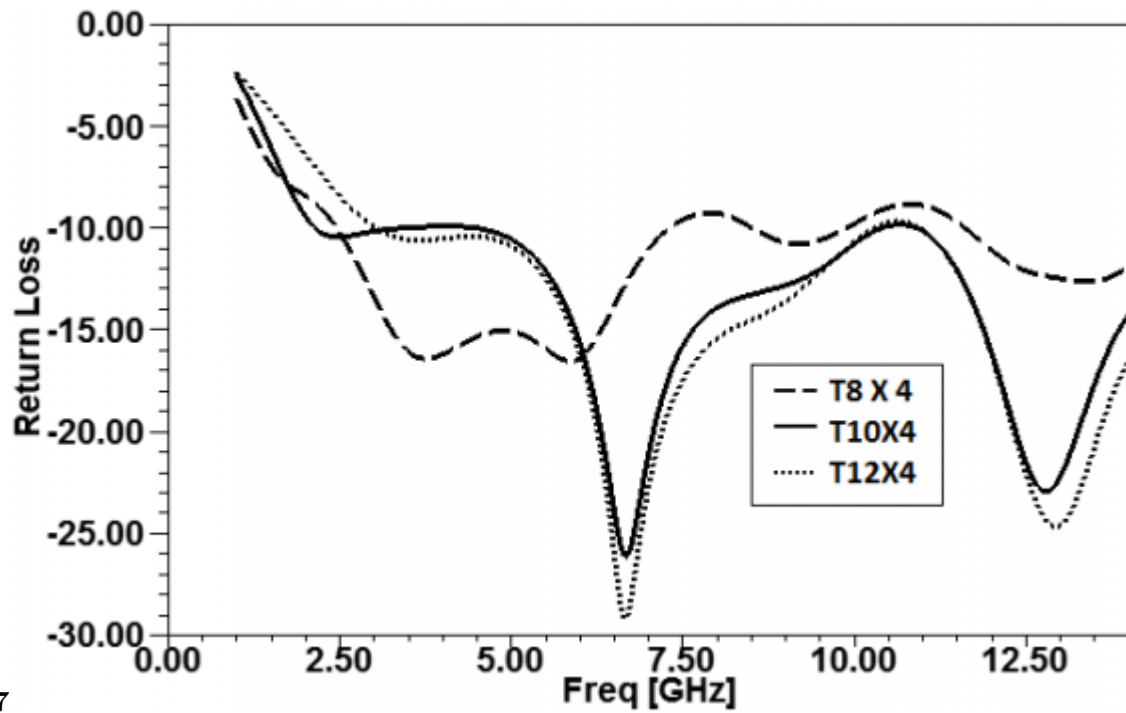
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Figure 4: Figure 4 :



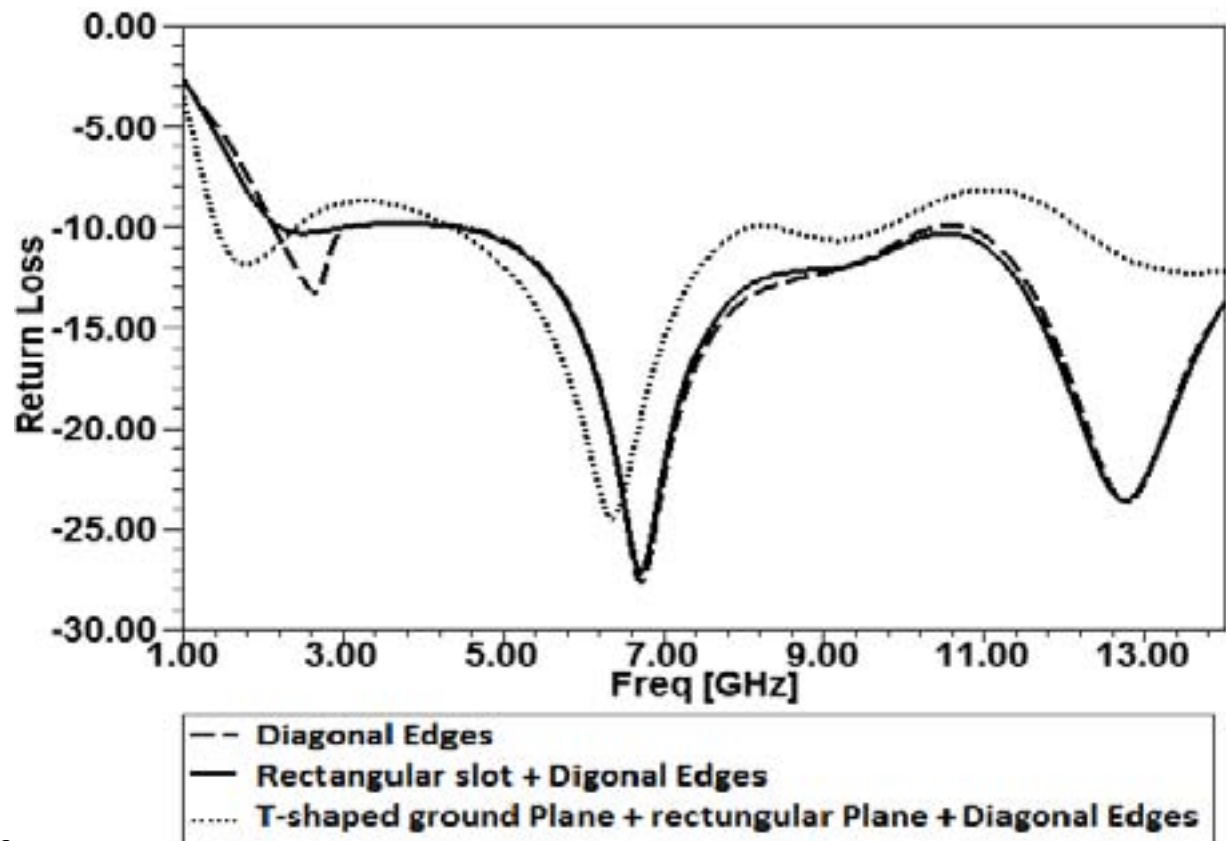
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Figure 5: Figure 5 :Figure 6 :



17

Figure 6: Table 1 :Figure 7 :



89

Figure 7: FFigure 8 :Figure 9 :

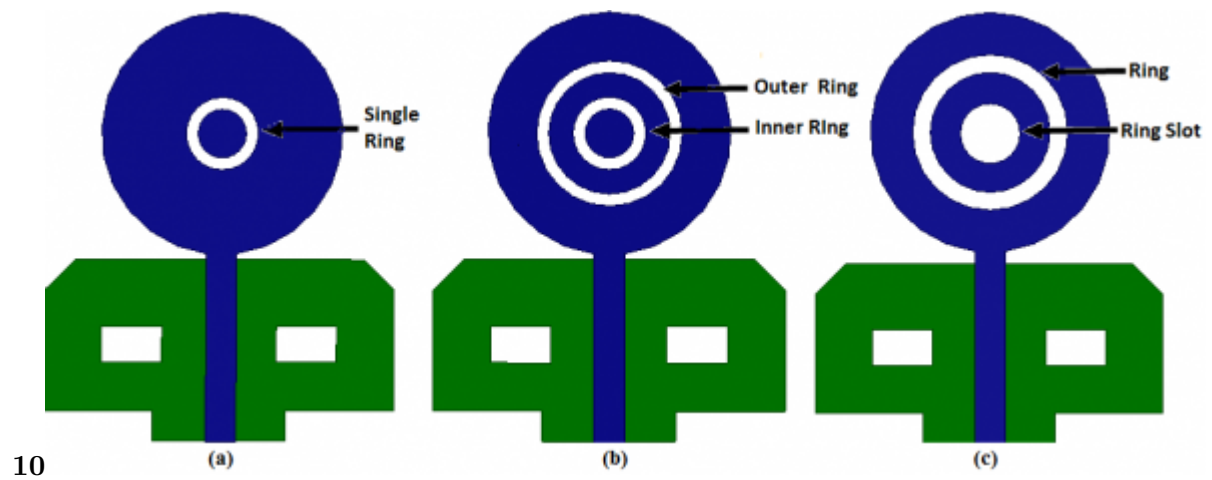


Figure 8: Figure 10 :

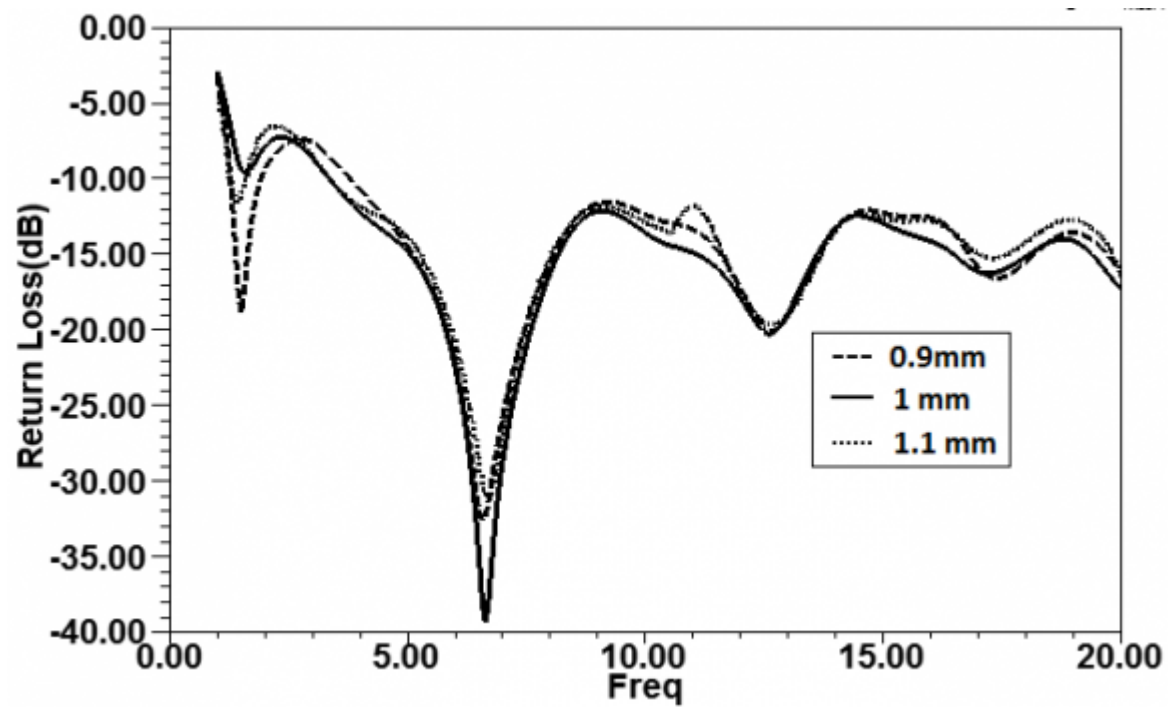


Figure 9:

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