TRIPLE BAND CIRCULARLY POLARIZED MICROSTRIP PATCH ANTENNA FOR WIRELESS COMMUNICATION APPLICATIONS

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ABSTRACT

In recent years, great interest was focused on microstrip antennas for their small volumes, low profiles, good integration, low costs and good performance. With the continuous growth of wireless communication service and the constant miniaturization of communication equipment, there are higher and higher demands for the volume of antennas, integration and working band. This paper presents A circular polarized (CP) Circular microstrip antenna with triple band for wireless communications system application which are suitable for the 2.4-GHz, 3.5-GHz and the 5-GHz triple-band operations. These systems may include various combinations of Bluetooth, WiMAX (Worldwide Interoperability for Microwave Access) and wireless local-area network (WLAN). A circular microstrip patch antenna is designed to operate at 2.4 (GHz) with circular polarization, a U slot is inserted thereafter in the original patch to generate the second resonant at 5.2 (GHz). Another C-slot is inserted thereafter to generate the 3.5 (GHz) third band. The C slot insertion effect on the original patch is examined, first arc length effect on the return loss and axial ration is examined in order to get the optimum length, and then the arc orientation effect also is examined to find out the best orientation to place the arc. This design has several advantages as the total antenna volume can be reused, and therefore the overall antenna will be compact. The design is verified through both numerical simulations and measurement of a fabricated prototype. The results confirm good performance of the single and multiband antenna design.

Keywords: *Triple Band, Dual band, Circular Polarization Antenna (CPA), Circular Microstrip Patch Antenna (CMPA).*

1. INTRODUCTION

The rapid progress in wireless communications requires the development of lightweight, low-profile, flush-mounted and single-feed antennas. Also, it is highly desirable to integrate several RF modules for different frequencies into one piece of equipment. Hence, multi-band antennas that can be used simultaneously in different standards have been in the focus points of many research projects [1-3]. Among these standards, the following frequency bands can be mentioned:

- First frequency 2.4 GHz
- Second frequency 3.5 GHz
- Third frequency 5.2 GHz

Microstrip antennas are very attractive because of their low profile, low weight, conformal to the surface of objects and easy production. A large number of microstrip patches to be used in wireless applications have been developed [4–6]. Various shapes such as square, rectangle, ring, disc, triangle, elliptic, etc. have been introduced [7–10]. In comparison to patch elements, the antennas with slot configurations demonstrate enhanced characteristics, including wider bandwidth, less conductor loss and better isolation. Particularly, the multi-slot structure is a versatile approach for multi-band and broadband design. Also, feeding these structures could be simpler by using suitable points to slot techniques for different slots. WLAN has made rapid progress and there are several IEEE standards already, namely 802.11a, b, g and n. Which used the bands of 2.4 (GHz) band 2.4 to 2.483 and 5.2 (GHz) band 5.15 to 5.35 (GHz) with the development of WLAN. A dual band circularly polarized microstrip patch Antenna for Wi-Fi applications with an inserted U-slot with the dimension of according to high resonant frequency at 5.2 (GHz) to be inserted in the low frequency patch 2.4 (GHz) is designed operate at these frequency bands [11], simulated results are performed by using commercial software HFSS. Performance of the AR of the proposed antenna is examined through studying the effect of orientation angle of the slot. Also sweep displacement ranging vertically & horizontally is performed to examine the effect of the slot displacement on the return loss and find out the optimum place to get the best performance on the return loss. A fabrication to the final design has been implemented, and then a measurement performed to compare the actual results with those simulated as shown in figure 2. In this paper we are present a circular polarized (CP) circular microstrip antenna with triple band for wireless communications system applications which are suitable for the 2.4-GHz, 3.5-GHz and the 5-GHz triple-band operations. So a triple band is going to be generated to be operate on the third frequency band 3.5(GHz).

2. TRIPLE BAND CIRCULARLY POLARIZED MPA.

Triple-band operations of antenna have presented to satisfy wireless communications system needs. Triple-band antenna can be achieved by several techniques. Firstly one of the most popular techniques of designing multi-band printed antennas based on the ”window” concept having frequency band separation of 2:1 or 4:1 whereby windows were cut in a low frequency patch radiators to accommodate high frequency patch antennas. Or Slot loaded circular MPA [12]. As we see several multi band microstrip antennas design have been reported over the years [13-14]. A simple technique for achieving this has been to load the radiating patch with a slot inside the radiating patch. The triple frequency operation is achieved when the two slots perturb the fundamental resonant frequency of the patch exciting new resonance modes. The resonance frequency of the new modes can be either lower or higher than the original dominant mode with either the same or orthogonal polarization and is strongly dependent on the slot dimensions. According to our Previous presented antenna [11] we are restricted to the C-slot technique which is seems the most suitable one to be inserted into our antenna to generate the third frequency band 3.5(GHz). By using a substrate of FR4 ($\varepsilon r = 4.5$) and height ($h = 1.6$mm) and by using the same design shown in figure [19] a C-slot with an inner radius of (a=13 mm) and an outer radius of (b=14.5 mm) and arc angle of ($\beta = 180^o$) as shown below in figure 1.Simulated return loss result is performed by using commercial software HFSS version-(8.0) they are shown in figure 2.

3. C-SLOT EFFECT

The C- slot insertion has some effect on the original patch parameters performance, one of the main affected parameter was the return loss axial ratio. Which changes according to the arc length of the c-slot and the orientation angle of the C-slot itself,

A. Effect Of C-Slot Length Polarization Of The First Frequency.

As we see the C- slot insertion has some effect on the original patch parameters performance, one of the main affected parameter was the axial ratio also. Which changes according to the arc angle (β) of the C-slot itself, we examined these different angles which produce different arc length to see it's effect as shown in figure 4 and we found that the range of angles ($\beta = 170^o$ to $\beta = 200^o$) have the best axial ration performance as shown in figure 3.

B. Effect Of C-Slot Length On Return Loss Of Tripl Band Frequncy.

An important parameter is the return loss of the low and high frequency band, where the arc length of the C-slot has a direct effect on the return loss, since by changing the arc angle we can get a different length of the same arc radius therefore, we tried a sweep range of arc angles to get arcs with different lengths to examine the effect of the C-slot arc length as shown in figure 4 on the return loss of the first and third frequency and find out the optimum arc length at angle of ($\beta =200^o$) to get the best performance on the return loss of both first and third frequency in addition to return los of our new second band as shown in figure 5 and 6.

C. Effect Of C-Slot Orientation On Return Loss Of Tripl Band Frequncy.

The C-slot orientation has on the original patch affected the patch parameters performance, one of the main affected parameter was the return loss of both low and high frequency. Which changes according to the orientation angle (α) of the C-slot itself, we examined these orientation angles effect as shown in figure 7 and we found that ($\alpha = -10^o$ & $\alpha = 0^o$ & $\alpha = +10^o$) angles have the best return loss performance on the first and third frequency as shown in figure 8 and on the second frequency on figure 9.

4. CONCLUSION

A circular microstrip patch antenna is designed to operate at 2.4 (GHz) with circular polarization, a U slot is inserted thereafter in the original patch to generate the second resonant at 5.2 (GHz). Another C-slot is inserted thereafter to generate the 3.5 (GHz) third band. The C-slot insertion effect on the original patch is examined, first arc length effect on the return loss and axial ration is examined in order to get the optimum length, and then the arc orientation effect also is examined to find out the best orientation to place the arc. The design is verified through both numerical simulations and measurement of a fabricated prototype as shown in figure 10. The results confirm good performance of the triple bands antenna design as shown in figure 11.

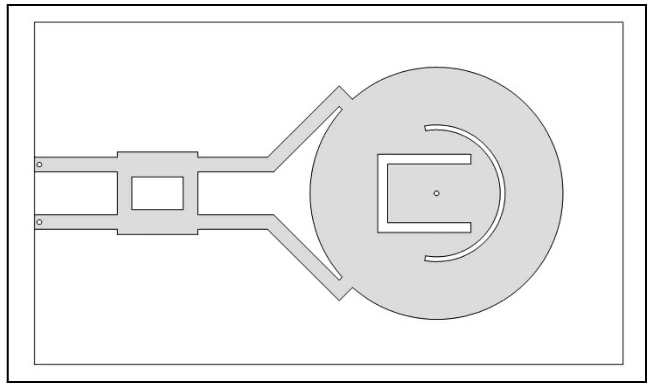

Figure.1 CMPA Configuration with integrated power divider, inserted U slot and C Slot.

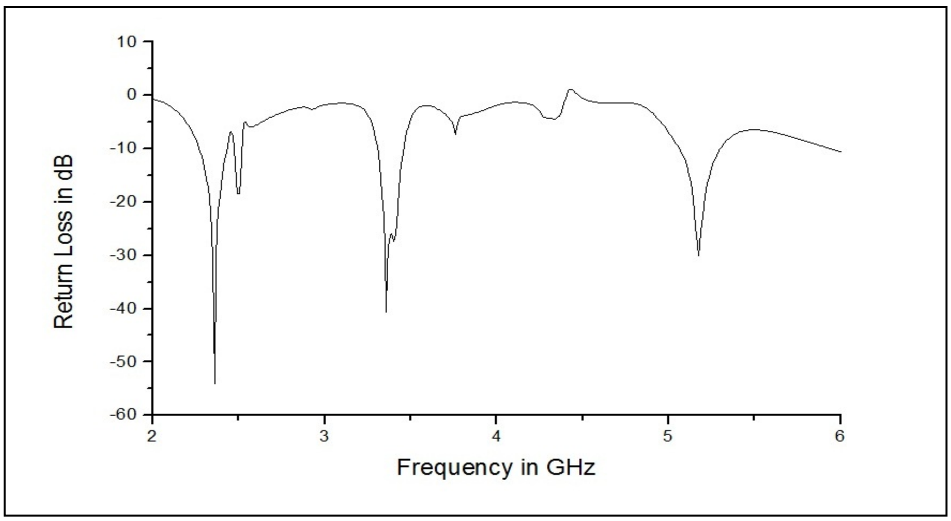

Figure.2 Simulated return loss of the triple band of CMPA configuration in figure 1

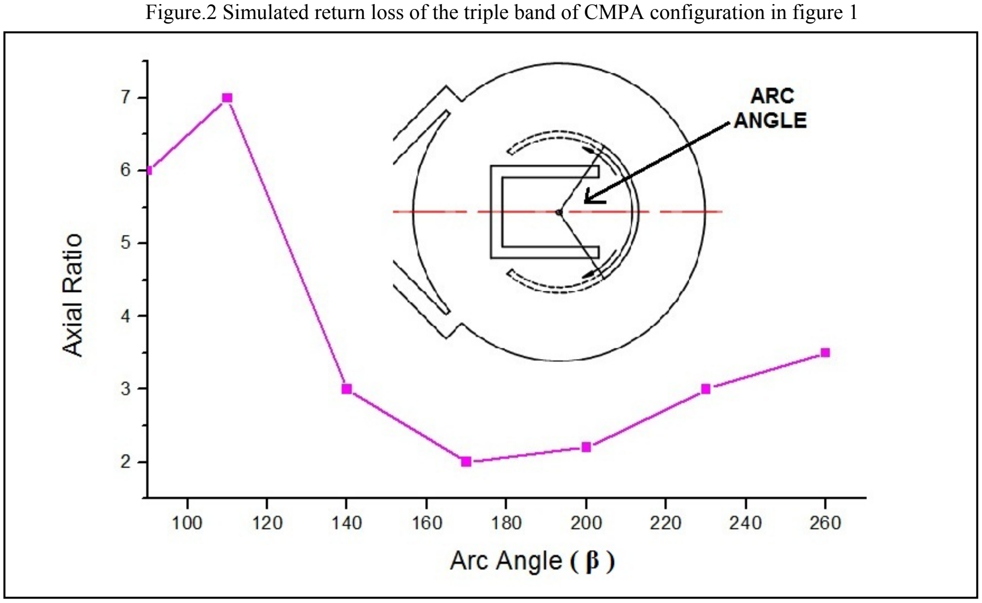

Figure.3 Effect of different C-slot lengths on axial ratio of first frequency 2.4 GHz

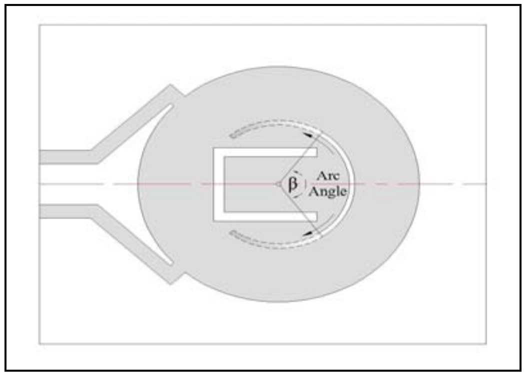

Figure.4 CMPA Configuration with different C-Slot lengths

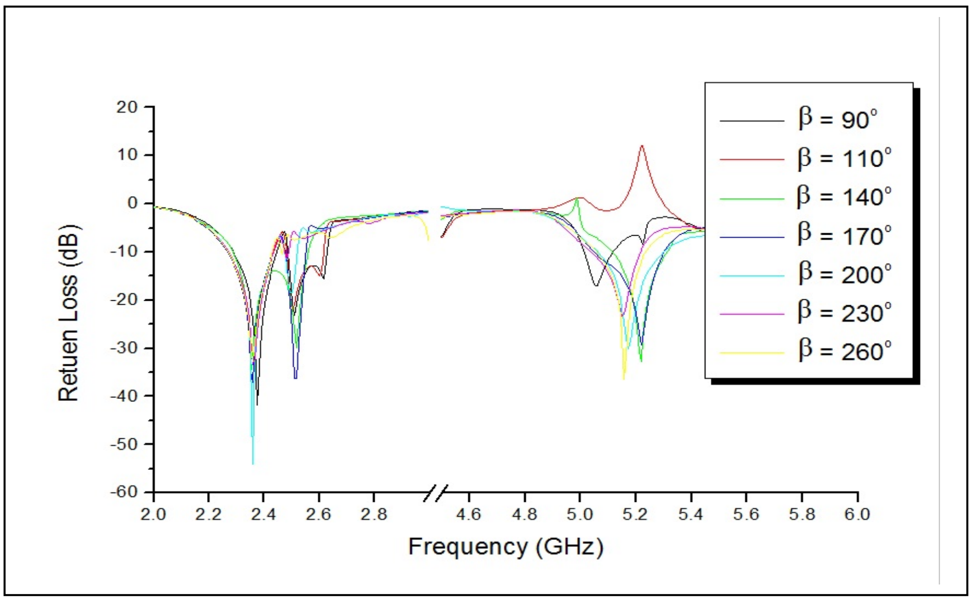

Figure.5 Effect of different C-Slot lengths on return loss of the first and third frequency

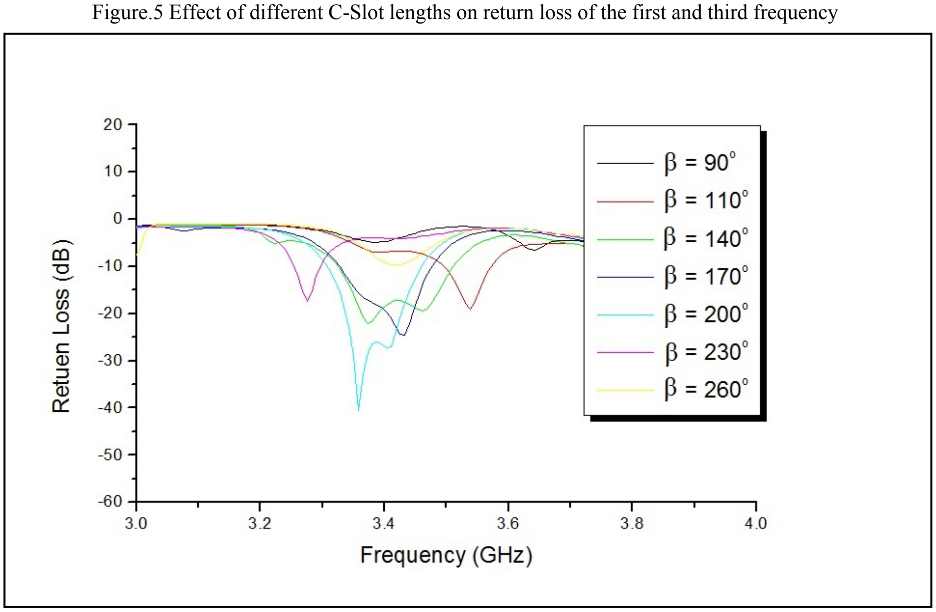

Figure.6 Effect of different C-Slot lengths on return loss of the second frequency 3.5 GHz

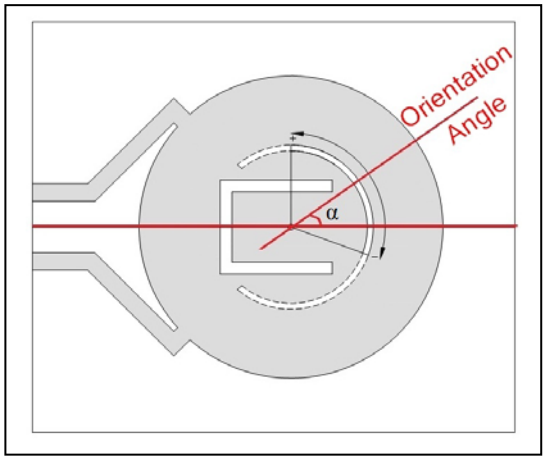

Figure.7 CMPA Configuration with different C-Slot orientation angle α

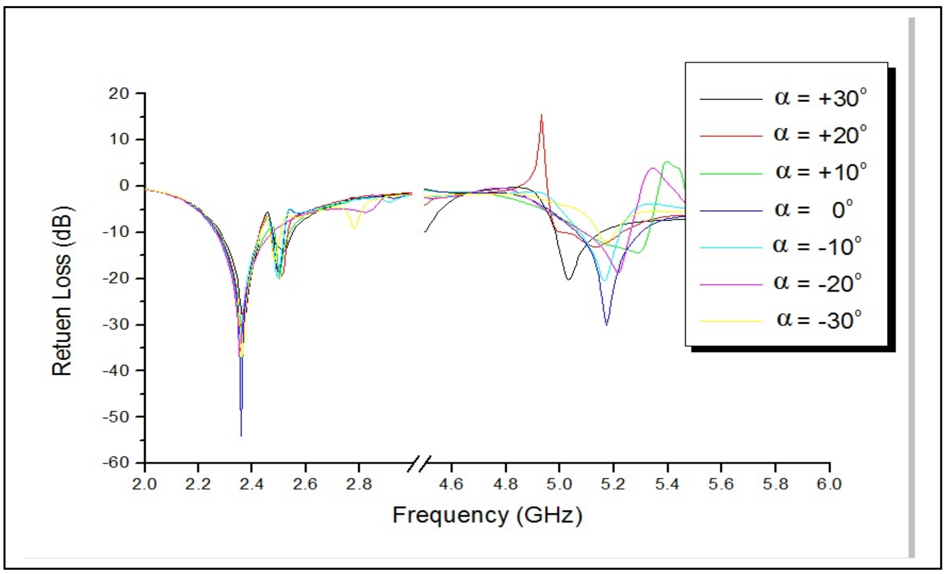

Figure.8 Effect of different C-Slot orientation angle α on return loss of the first and third frequency

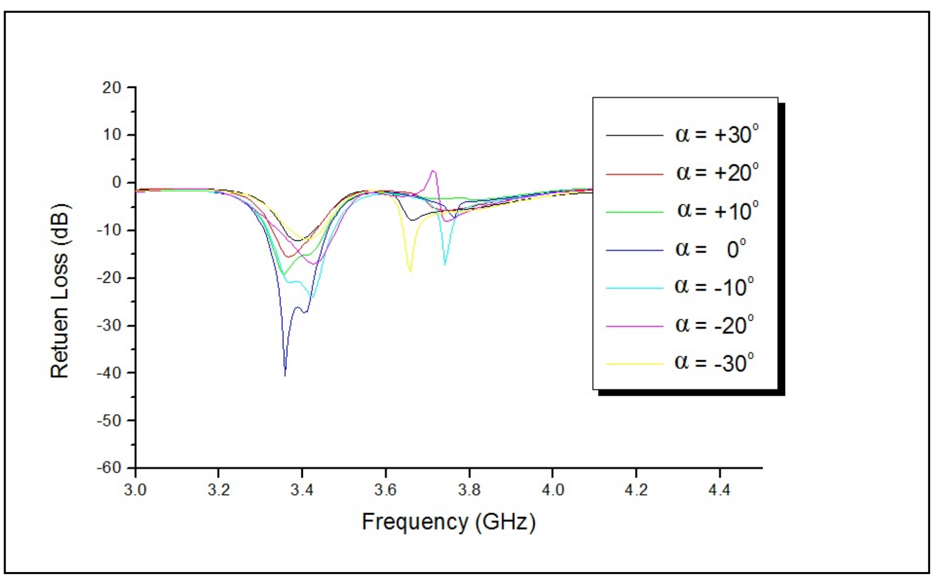

Figure.9 Effect of different C-slot orientation angle α on return loss of the second frequency 3.5 GHz

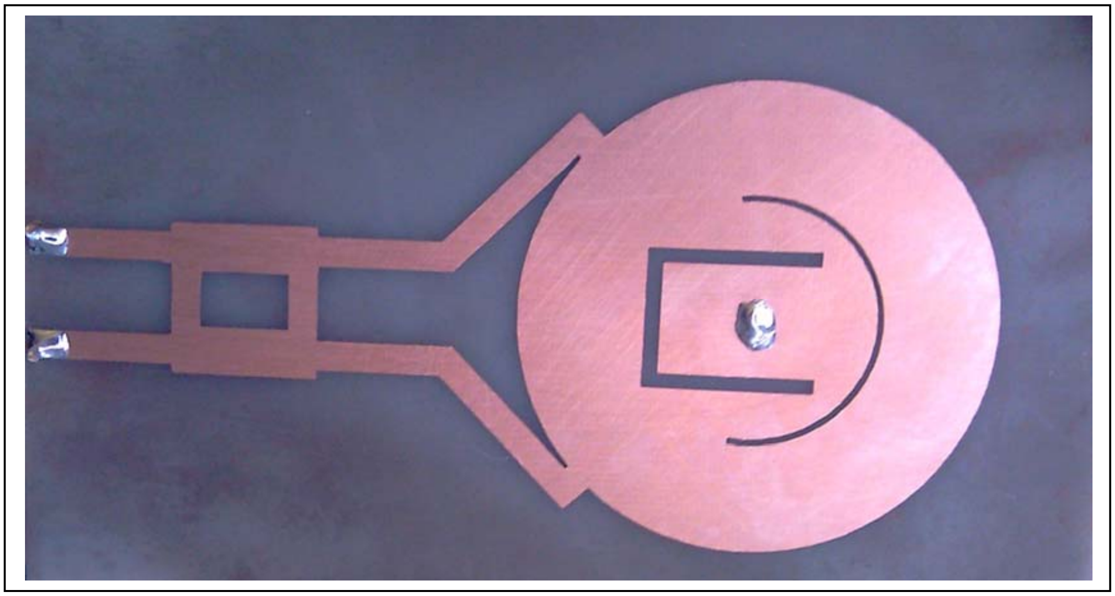

Figure.10 CMPA Configuration with integrated power divider and inserted U slot and C slot

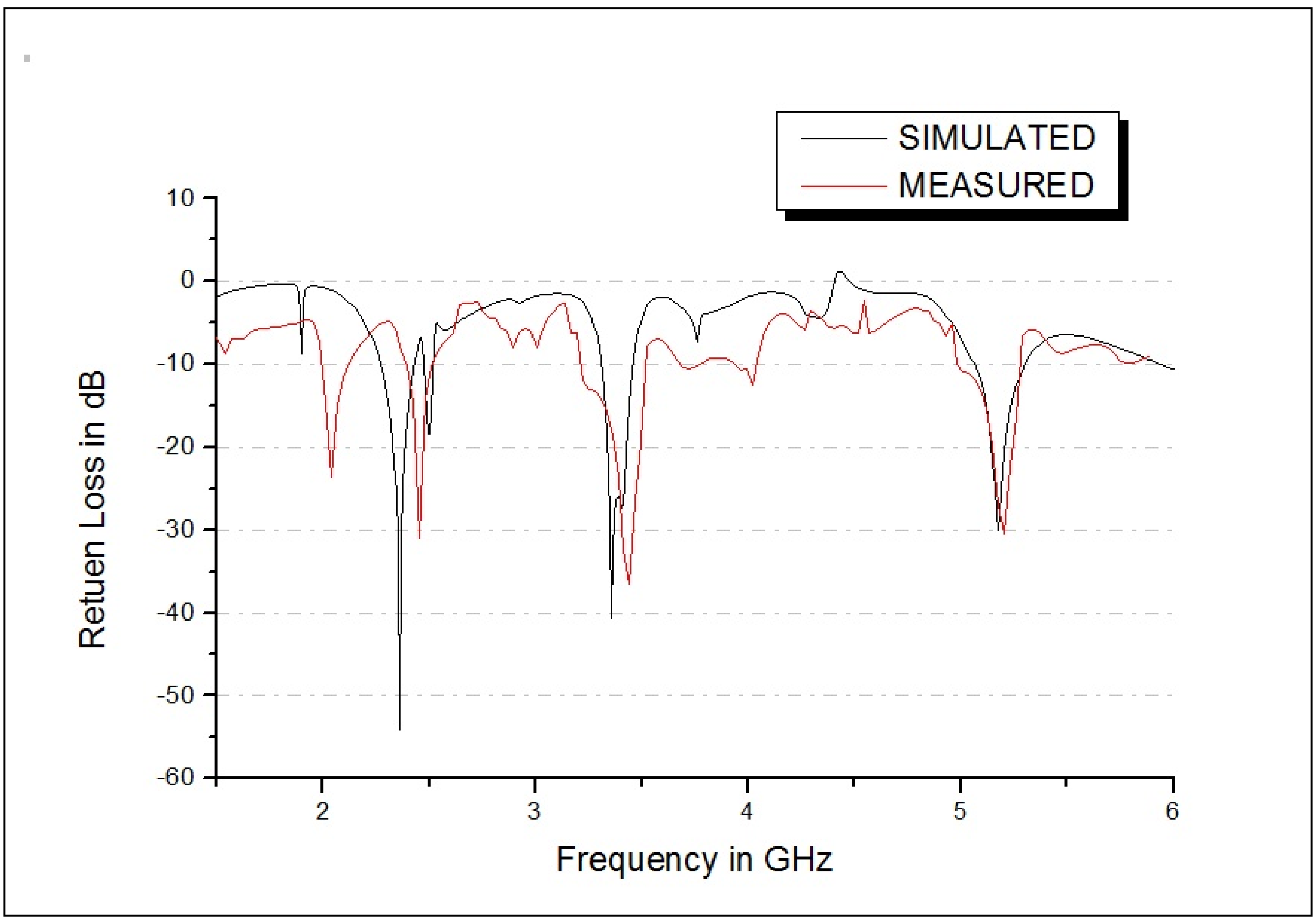

Figure.11 Simulated and measured result of return loss for the triple band antenna configuration given in figure 10

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