NOVEL DESIGNS OF BROADBAND PATCH ANTENNA FOR WIRELESS COMMUNICATION APPLICATION (1800 MHZ AND 2400 MHZ)

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ABSTRACT

In this paper, three novel designs of broadband patch antenna are proposed. The first design propose broadband slotted equilateral triangular patch antenna (ETPA) operating on frequency around 1800 MHz. The second design propose broadband slotted right angle isosceles triangular patch antenna RAITPA operating on frequency around 2400 MHz. The third design proposes wideband V-Slotted and shorted edge ETPA antenna operating on frequency around 2400 MHz. The two powerful software HFSS and IE3D are used to simulate the proposed designs. Very good agreement between HFSS and IE3D software is obtained. The designs were chosen to fit modern wireless communication applications operate at Industrial Scientific Medical (ISM) bands such as Wireless local area networks (WLAN). Moreover, mounting the patch on thick substrate with loaded slot technique and loading the patch with a notch technique were used to enhance the bandwidth of those designs. Hence, large fractional bandwidth is obtained.

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KEYWORDS

Triangular microstrip antenna, slotted antenna, broadband antenna, notch antenna, wireless application, substrate

INTRODUCTION

Microstrip antennas consist of a patch of metallization on a grounded substrate. They are low-profile, lightweight antennas, most suitable for aerospace and mobile applications. Microstrip antennas have matured considerable during the past 35 years, and many of their limitations have been overcome [1]. Many of the antenna applications for satellite links, mobile communications, and wireless local-area networks impose constraints on compactness, dual-frequency operation, frequency agility, polarization control, and radiation pattern control. These functions can be achieved by microstrip antennas, and hence these antennas are becoming more commonly used [1]. Among the shapes that attracted much attention lately is the triangular shaped patch antenna [2]-[13]. This is due to their small size compared with other shapes like the rectangular and circular patch antennas. It is well-known that microstrip antennas are very narrow band, about several percent for a typical bandwidth. Therefore, bandwidth enhancement is usually demanded for practical applications [14]. Thus, bandwidth enhancement is becoming one of the major design considerations for practical applications of microstrip antennas. To meet bandwidth

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requirement, many bandwidth-enhancement or broadband techniques for microstrip antennas have been recently reported [14]. Decreasing the quality factor of the microstrip antenna is an effective way of increasing the antenna's impedance bandwidth. This kind of bandwidth-enhancement technique includes the use of a thick air or foam substrate. For feeding using a probe feed, a large reactance owing to the long probe pin in the thick substrate layer is usually a problem in achieving good impedance matching over a wide frequency range. To overcome this problem associated with probe-fed microstrip antennas, it was reported that by embedding a U-shaped slot in the patch, the impedance bandwidth of a probe-fed microstrip antenna with a thick air substrate can easily be enhanced [12]. In this paper, the designs are simulated using two powerful softwares. Wide range of frequencies is obtained. More enhancements obtained compared with previous designs. This paper can be divided into five sections. In Section II, broadband slotted equilateral triangular patch antenna (ETPA) is designed and simulated. This proposed design is used for Wireless Applications (around 1800 MHz). In Section III, broadband slotted right angle isosceles triangular patch antenna (RAITPA) is proposed. The proposed design will operate a round 2400 MHz which is used for Wireless applications. In Section IV, wideband V-slotted and shorted edge ETPA for wireless communication applications (around 2400 MHz) is proposed and simulated. Section V presents the comparison between all proposed design and pinch mark design in [13]. In Section VI present a conclusion of all results.

2. BROADBAND SLOTTED EQUILATERAL TRIANGULAR PATCH ANTENNA (ETPA) (AROUND 1800 MHZ)

It was demonstrated that, loading the patch with a U-shaped slot will enhance the bandwidth [13]. Figure 1 shows a proposed ETPA, loaded with slots. In this design, two techniques are exploited to obtain broadband operation. In the first technique the patch on thick substrate is mounted with loaded slot. In the second technique the patch is loaded with a notch which enhances the bandwidth. By combining both techniques, a broadband antenna that operates in frequencies ranging from 1530 MHz to 1870 MHz is obtained as shown in Figure 2. It can be seen from Figure 2 that the proposed design has a bandwidth of 340 MHz, and a center frequency of 1700 MHz, which implies that a fractional bandwidth of 20% can be obtained. Moreover, it can be noted that this design can fit wireless communication application.

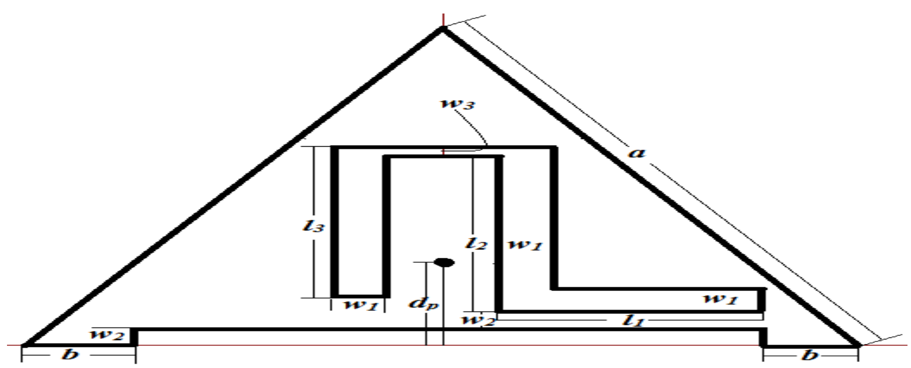

Figure 1: Geometry of our proposed broadband slotted ETPA; a=9.1 cm, h=1.43 cm, ϵ_r=1.07, d_p=2.125 cm, w_1=0.6 cm, w_2=0.4 cm, w_3=0.25 cm, l_1=2.85 cm, l_2=3.89 cm, l_3=3.72 cm, and b=1.05 cm.

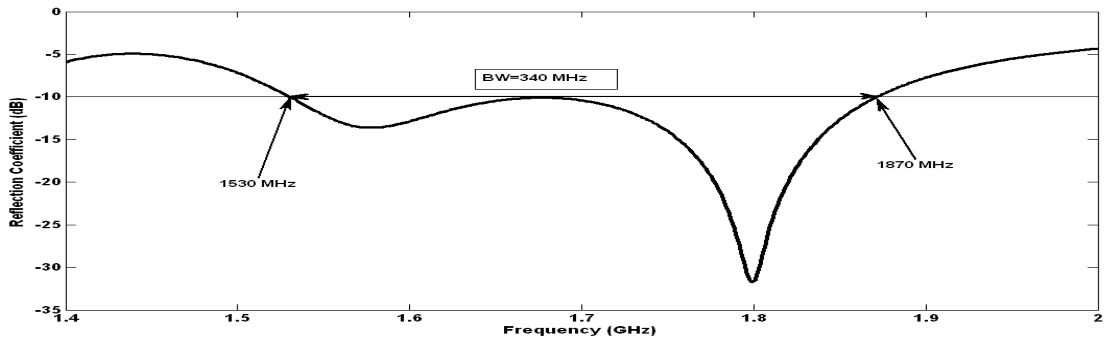

Figure 2: Simulated reflection coefficient of our proposed design shown in Figure 1 [IE3D].

For the sake of justification, this design is simulated again using HFSS simulator as shown in Figure 3. It can be noted from Figure 4 that a very good agreement between both simulators is obtained

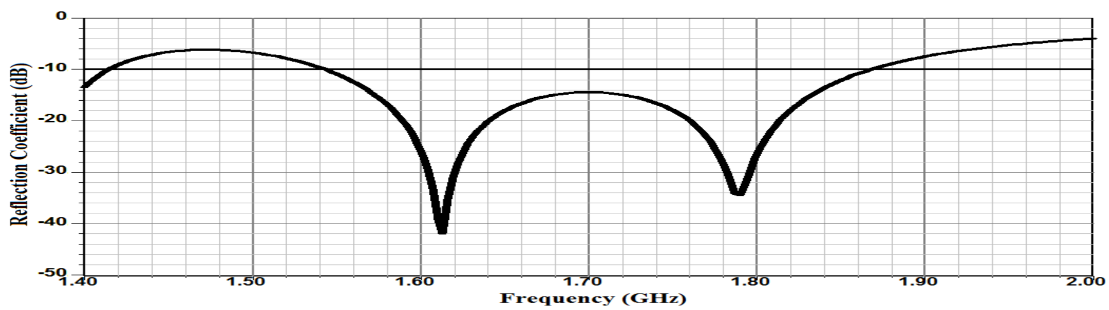

Figure 3: Simulated reflection coefficient of our proposed design shown in Figure 1 [HFSS].

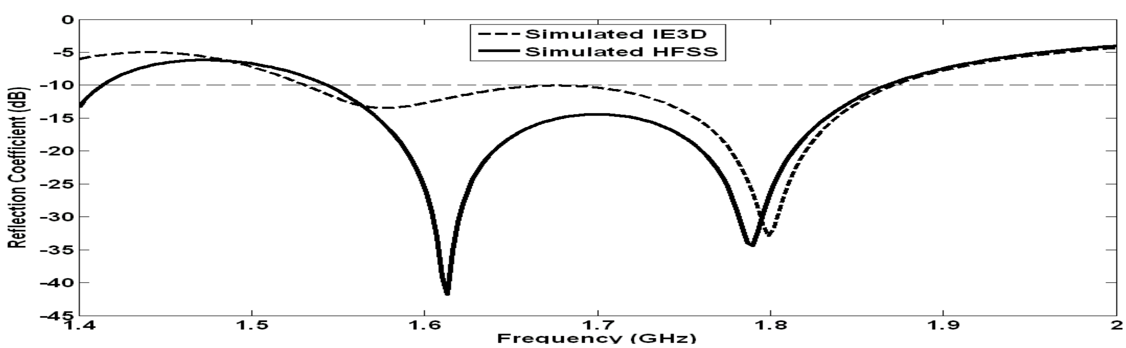

Figure 4: Comparison between HFSS and IE3D results for the design shown in Figure 1.

For the sake of justification, the radiation pattern of this design is studied at three different frequency values within the operating band. Specifically, Figures 5-7 show the radiation patterns at 1575 MHz, 1680 MHz, and 1800 MHz. It can be noted that the pattern is almost the same at the three frequencies. In these figures, the beam in the Φ=90o plane gets a bit tilted from broadside as the frequency increases.

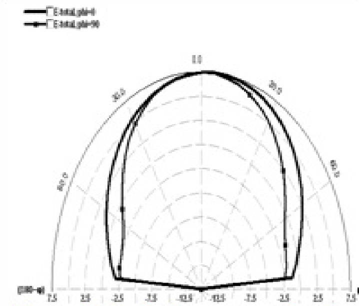

Figure 5: Radiation pattern for the design in Figure 1 at 1575 MHz

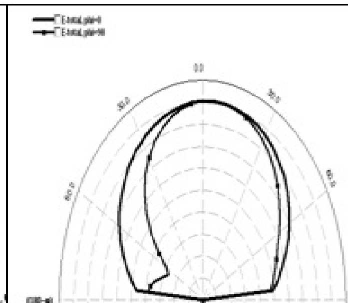

Figure 6: Radiation pattern for the design in Figure 1 at 1680 MHz.

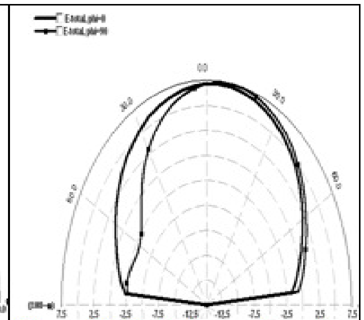

Figure 7: Radiation pattern for the design in Figure 1 at 1800 MHz.

3. Broadband Slotted Right Angle Isosceles Triangular Patch Antenna RAITPA for Wireless Applications (around 2400 MHz)

Another broadband patch antenna is proposed to fit with the bands of wireless communication applications. The proposed antenna is a RAITPA loaded with slots, mounted on a thick foam substrate (Єr =1.07), and fed, using probe-feed at dp as shown in Figure 8.

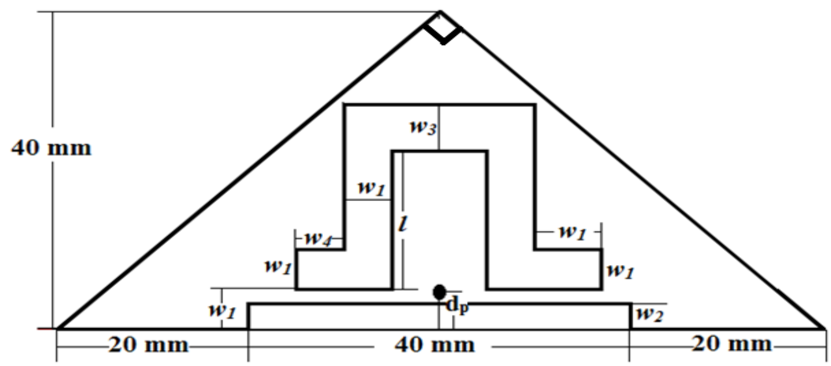

Figure 8: Geometry of the proposed broadband slotted RAITPA; h=14.3 mm, ϵ_r =1.07, w_1=5 mm, w_2=3 mm, w_3=6 mm, $w4$=4 mm, l=17.5 mm, and d_p=5 mm.

From Figure 9, it can be seen that this patch operates at frequencies ranging from 2463 MHz to 2948 MHz, with bandwidth equal to 485 MHz. Again, this design is simulated using HFSS simulator for the sake of justification.

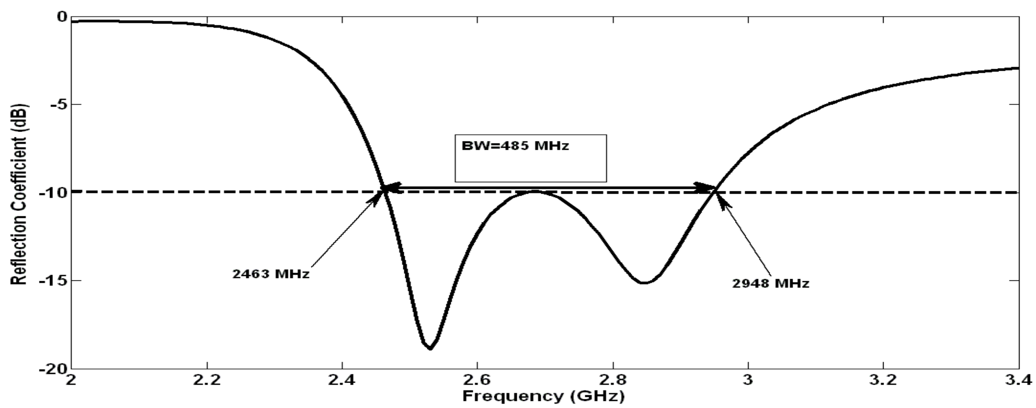

Figure 9: Simulated reflection coefficient of our proposed design shown in Figure 8 [IE3D].

Figure 10 shows the simulated reflection coefficient using HFSS. The obtained results, using both simulators, are close to each other as shown in Figure 11.

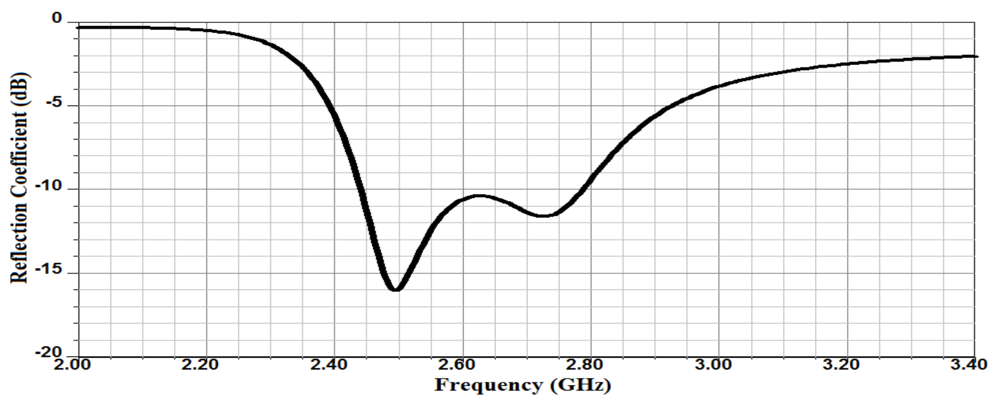

Figure 10: Simulated reflection coefficient of our proposed design shown in Figure 8 [HFSS].

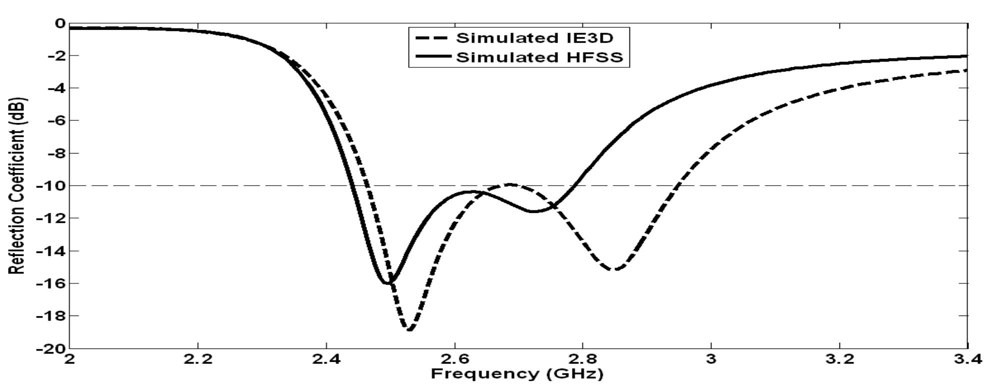

Figure 11: Comparison between HFSS and IE3D results for design shown in Figure 8.

The radiation pattern of this design is studied at three different frequencies. From Figures 12-14, it can be noted that the pattern is almost the same at the three frequencies. In these figures, the beam in the Φ=90o plane gets a bit tilted from broadside as the frequency increases.

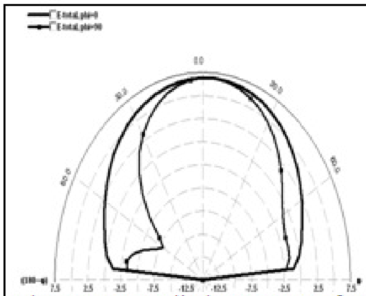

Figure 12: Radiation pattern for the design in Figure 8 at 2527 MHz.

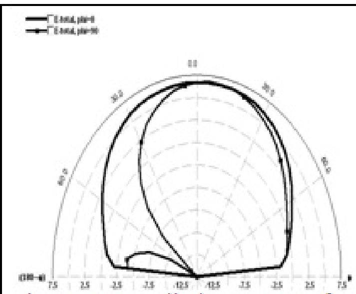

Figure 13: Radiation pattern for the design in Figure 8 at 2682 MHz.

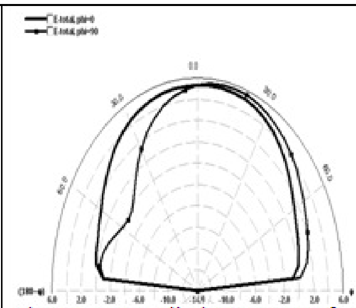

Figure 14: Radiation pattern for the design in Figure 8 at 2848 MHz.

4. PROPOSED WIDEBAND V-SLOTTED AND SHORTED EDGE ETPA ANTENNA FOR WIRELESS COMMUNICATION APPLICATIONS (AROUND 2400 MHZ)

A new design of Wideband V-Slotted and Shorted Edge ETPA Antenna is proposed for Wireless Communication Applications. Figure 15 shows the geometry of the design. In this design, two techniques are combined. Namely, shorting the edge and loading V-slots on the patch. This combination allows obtaining a wideband antenna that operates at frequencies ranging from 2070 MHz to 2714 MHz, with bandwidth equal to 644 MHz, and center frequency equal to 2392 MHz, as shown in Figure 16. So, a fractional bandwidth of approximately 27% can be achieved. It can be noted that this design can be used for wireless communication applications, especially, WLANs and ISM, which operate at frequencies ranging from 2400 MHz to 2484 MHz.

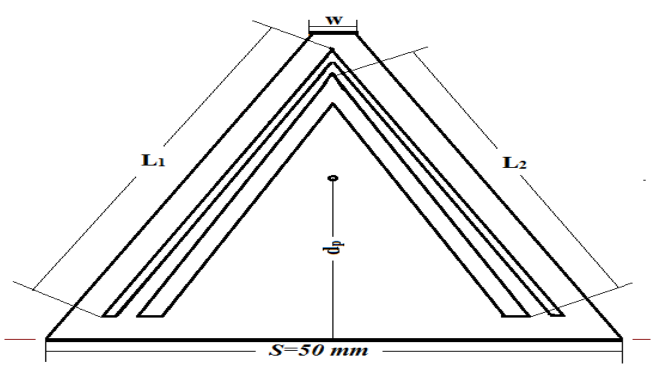

Figure 15: Geometry of our proposed wideband V-slotted ETPA; h=6 mm, ϵ_r =4.6, *w*=3.8

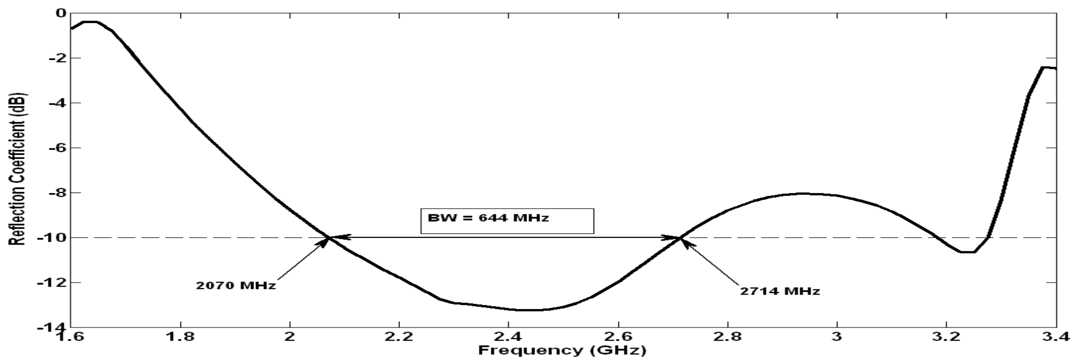

Figure 16: Simulated reflection coefficient of the design shown in Figure 15 [IE3D].

The radiation pattern of this design is studied at three different frequencies. From Figures 17-19, it can be noted that the pattern is almost the same at the three frequencies. The radiation is in the broadside direction in the Φ=0o plane, while it is titled approximately 45o in the Φ=90o plane.

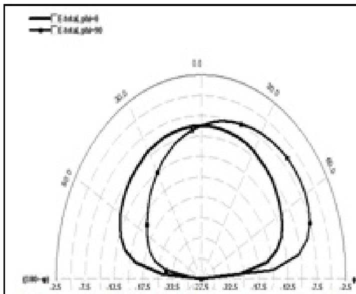

Figure 17: Radiation pattern for the design in Figure 15 at 2200 MHz.

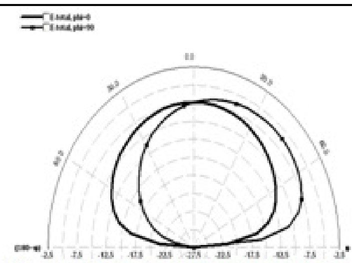

Figure 18: Radiation pattern for the design in Figure 15 at 2400 MHz.

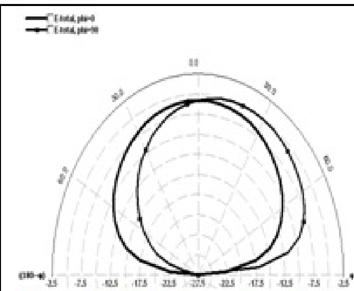

Figure 19: Radiation pattern for the design in Figure 15 at 2600 MHz.

5. COMPARISON

Figure 20 shows a comparison between result obtained from reference [13] and result obtained from proposed design in figure 1. As shown in the figure more bandwidth can be obtained in the proposed design. It can be seen that the proposed design has a bandwidth of 340 MHz, and a center frequency of 1700 MHz, which implies that a fractional bandwidth of 20% can be obtained, whereas the obtained bandwidth in [13] is 308 MHz and a center frequency of 1677 MHz, which implies that a fractional bandwidth of 18.3%. It can be noted, first proposed design is better than the design proposed in [13] in terms of bandwidth and fractional bandwidth.

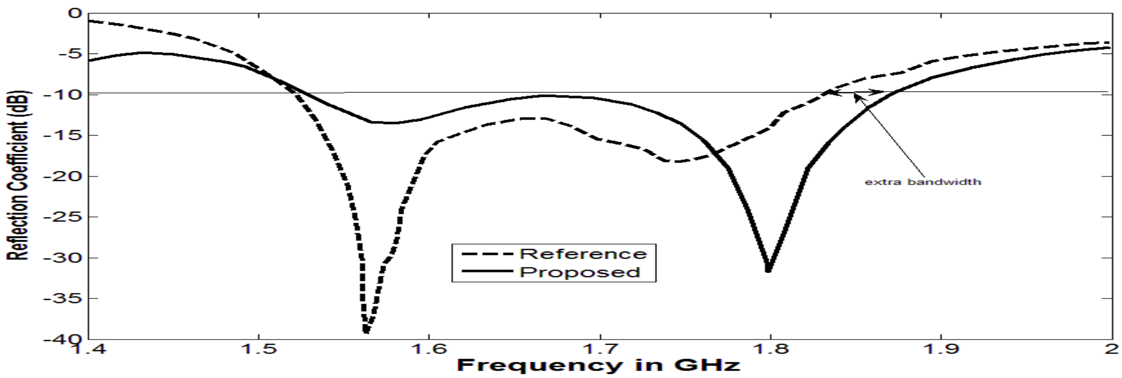

Figure 20: Comparison between result obtained from reference [13] and result obtained from proposed design in figure 1.

Figure 21 shows a comparison between results obtained from second and third proposed designs. It can be depicted that both designs are operated around 2400 MHz. Moreover, by using ETPA, more bandwidth can be obtained.

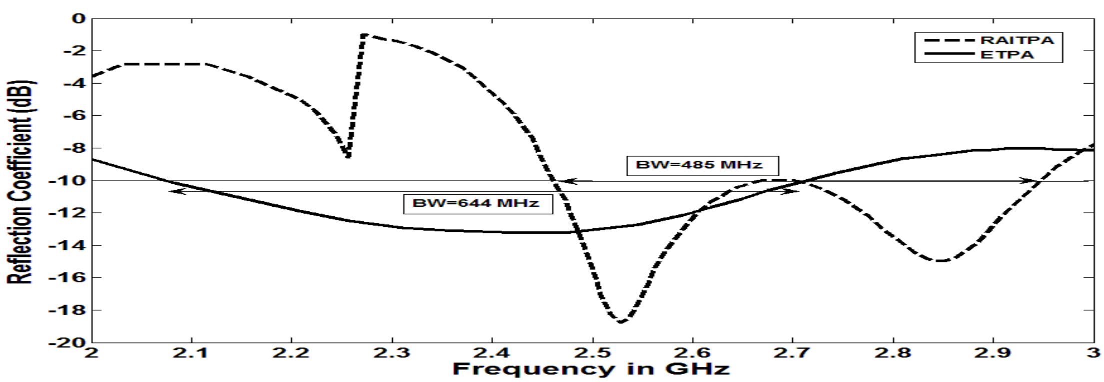

Figure 21: Comparison between results obtained from second and third proposed designs.

Table 1 shows a center frequency, bandwidth and fractional bandwidth for all designs which summarize all the results mentioned above.

Table 1: Comparison of Center frequency, bandwidth and fractional bandwidth for all designs.

Design	**Center Frequency (f_c) (MHz)**	**Bandwidth (BW) (MHz)**	**Fractional Bandwidth (BW/f_c)*100%**
Reference [13]	1677	308	18.3%
1st Design	1700	340	20%
2nd Design	2705.5	480	17.9%
3rd Design	2392	644	27%

6. CONCLUSION

In this paper, three new designs that fit modern wireless communication application, which operate at 1800MHz and 2400 MHz, are suggested and simulated using powerful software. The design is justified by comparing between two software tools (HFSS and IE3d) results and great agreement is obtained. Good result obtained compared with those obtained in [13]. Wider bandwidth is obtained which can be fit for new generations of wireless communication that require wider bandwidth.

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