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The Effect of Feeding Technique on the Parameter Analysis of 5G Applications Dual Bands Microstrip Patch Antenna

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Abstract

The rapid development of mobile technologies such as 4G and 5G and wireless networks lead to more research to employ a new range of frequencies, along with the necessity of reducing size and power consumption, moreover, it focuses on flexible antennas that can be used in a wide range of applications. This research investigates antenna design with three feeding methods (microstrip line feed, proximity coupled feed, and aperture coupled feed) and finds out the best feeding method. In the proposed design, a Rogers RT/duroid™ 5880 is used as a substrate, and all of the proposed designs were simulated via computer simulation technology (CST) software simulations. The antenna is supposed to operate at frequencies of 6 and 28 GHz. As a radiative element, a rectangular copper patch is used, and the ground is made of copper. The antenna main parameters like gain, directivity, radiation efficiency and VSWR were investigated.

Keywords: - Flexible, Wearable, WBAN, Antenna, Aperture Antenna

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Introduction

Wireless communication is an important technology recently. One of the important topics that attract attention is wireless body area networks (WBAN). WBAN used in many fields such as medical, military, and positioning systems (GPS) [1]. In these applications, flexible antennas are an essential component,. where the wearable antennas usually integrate into fabric[2] or within clothing details like buttons[3][4] and belts[5]. Additive manufacturing (AM) technology appeared to help manufacture wearable antennas and test them on bracelets[6] and shoes[7]. (AM) has many advantages such as reduced waste, lower cost of materials and work on designs that would be difficult to achieve through traditional methods. With the advent of 5G networks, these antennas have been developed to operate within the mm-wave range using AM [8]. Feeding methods are significant to match the characteristic impedance of the antenna patch and feed line, the impedance of the patch should be match with the impedance of the feeder line. If there is no matching impedance between antenna and the feeder line, the maximum power will not be transmitted[9]. There are many ways to feed the microstrip antenna, but there are four most common ways, a direct method (the microstrip line, coaxial probe) and indirect method (aperture coupling, and proximity coupling), and the method adopted in this research is aperture coupling, and each method will be explained in simplified [10] [11]. This paper presents the effect of using different feeding techniques that can be use with the propose design of wearable applications antenna in millimeter wave and microwave bands of frequencies. The proposed antenna resonates at 6 GHz - 28 GHz, which are used for 5G networks that design and simulated using CST Microwave Studios.

The Proposed Antenna Design

The proposed antenna model utilized in this investigation is intended to operate in two resonance frequencies, (6 GHz and 28 GHz). The model is a multi-band microstrip patch antenna that, among other things, can be customized to use in LTE and 5G services. The main design based on research, which operates at frequency 28 [12]that improves to resonate at two bands around 28 and 6 GHz, which makes it more appropriate for 5G applications. The proposed antenna was fed via three feeding methods, namely (microstrip line feed ,proximity coupled feed ,and aperture coupled feed), and the details of each method are explained below, and the results are compared for all methods. Rogers RT / duroid 5880 (tm) is the material of

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the substrate of the proposed model on which all of these feeding methods are used, where the material properties are (ε_r = 2.2 and tangent = 0.0009).

a) Microstrip Line Feed

This method represents a direct means to feed the patch using the feed line that is directly attached to the patch, Table1 proposed Antenna Dimensions in Microstrip Line Feed Method. The proposed model consists of T-shaped patch design Changing the dimensions of the patch feed line, the ground plane dimensions as well, which leads to the best impedance matching. Figure 1 shows the shape of the front side and back side for the propose design.

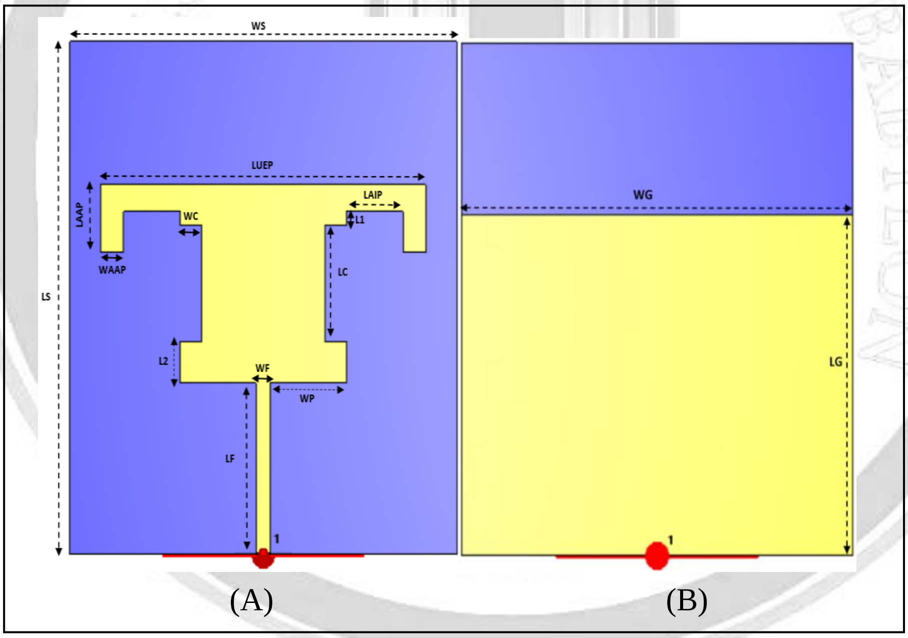

Figure 1: (A) Front Side for the Antenna (B) Back for the Antenna

In this feeding method, the return loss of (-35 dB and -24.9 dB at 6 GHz and 28GHz, respectively) were obtained, where the bandwidth are 2.7% (6.49-5.32) at 6 GHz and 1.23% (28.98 - 28.63) at 28 GHz as shown in Figure 4-1. The VSWR for this method are (1.03 dB and 1.12 dB at 6 GHz and 28 GHz, respectively) as shown in Figure 4-2. In the Microstrip Line Feed method, besides the gain and directivity of frequency 6, which consider not good enough for this method to be adopted, since the gain (1.75 dB and 2.7 dB at 6 GHz and 28 GHz, respectively) as shown in Figure 4-3 and directivity (7.81 dB and 8.27 dB at 6 GHz and

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28 GHz, respectively) as shown in Figure 4-4, in addition the efficiency of the model when using this feeding method are (80% on 6 GHz and 89% on 28 GHz).

Table1: Proposed Antenna Dimensions in Microstrip Line Feed Method

The Sample	**mm**	**The Sample**	**mm**
LS	22	LUEP	16.62
WS	19.8	LAAP	2.9
L1	0.59	WAAP	1.16
L2	1.75	LAIP	2.9
WF	0.C	WC	1.1
LF	7.3	LC	5
WG	19.8	copper thickness	0.035
LG	14.63	substrate thickness	0.22
WP	3.9		

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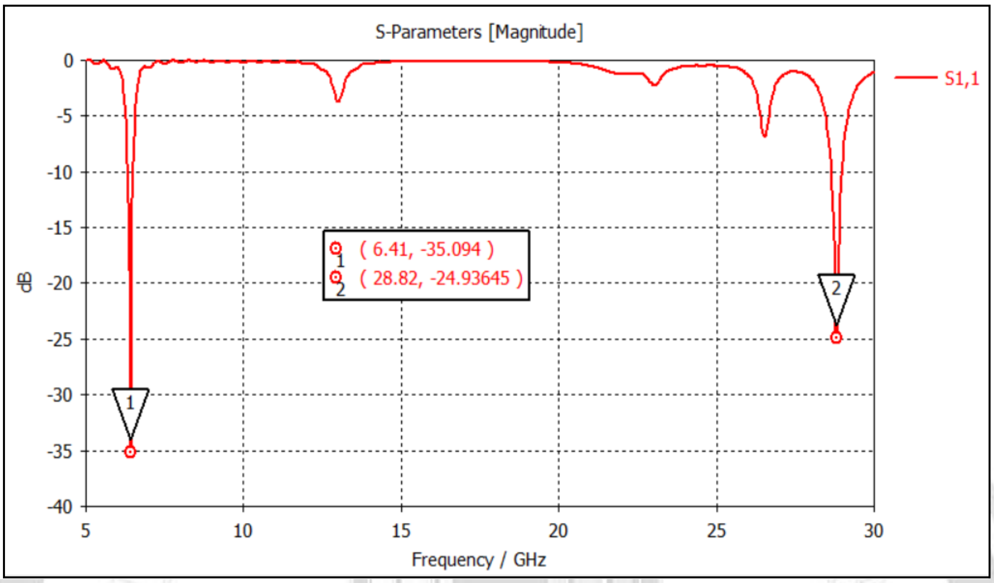

Figure 2: S11 For The Antenna with Microstrip Line Feed Method

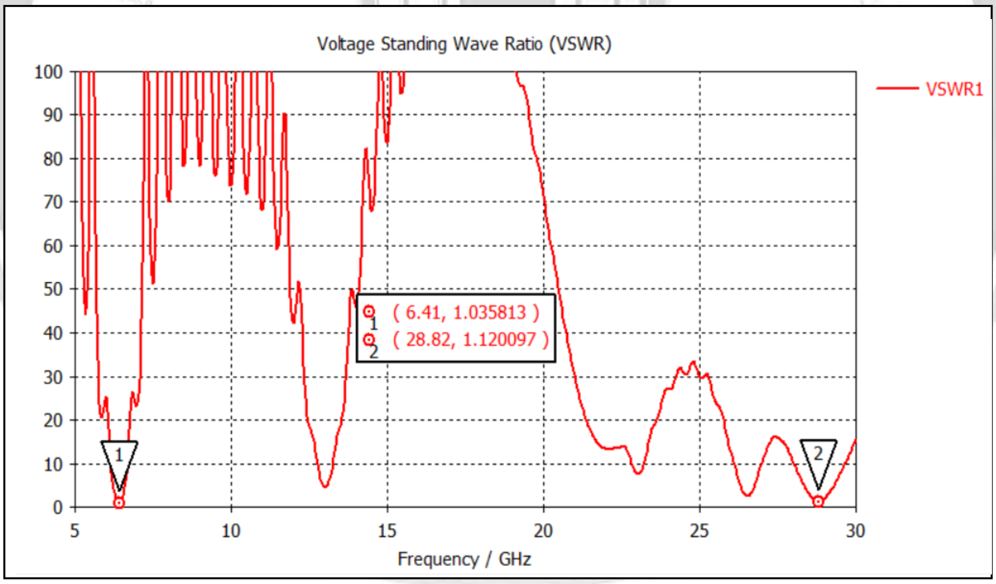

Figure 3: VSWR For The Antenna with Microstrip Line Feed Method

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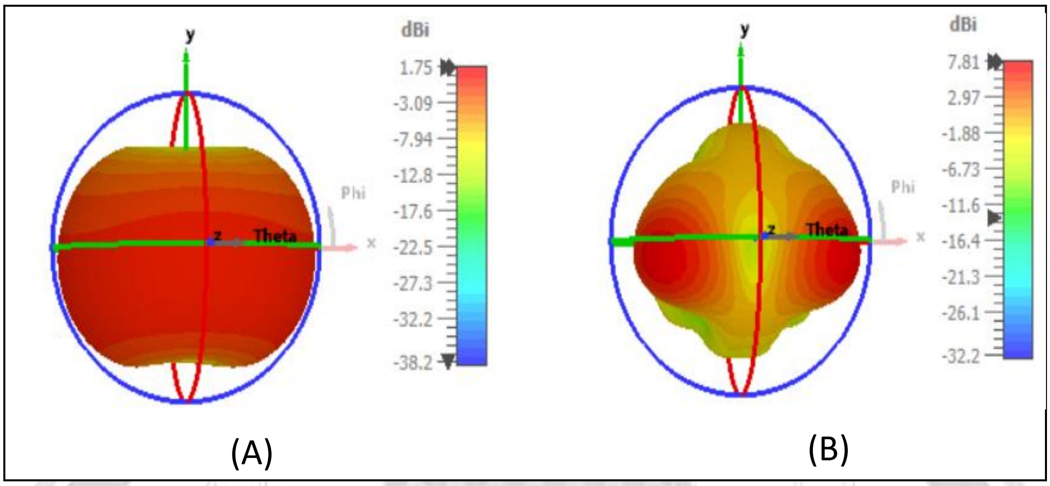

Figure 4: The Gain for the Antenna with Microstrip Line Feed Method

a) Proximity Coupled Feed

This method feeds the patch indirectly using a feed line buried between the two substrates, where the patch is indirectly stimulated. This method is distinguished by the fact that the antenna has two substrates with T-shaped patch design. To get the best matching, the change of the dimensions for the feed line and ground.

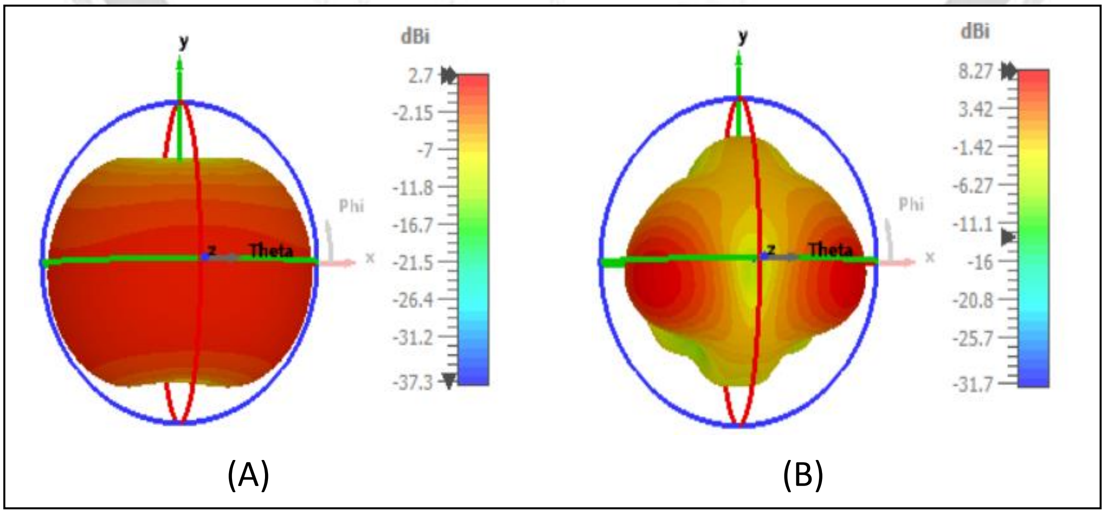

Figure 5: The Directivity for the Antenna with Microstrip Line Feed Method

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Table 2: Proposed Antenna Dimensions in Proximity Coupled feed Method

The Sample	mm	The Sample	mm
LG	19.70	LAAP	4.04
WG	20	WAAP	0.34
LS	22	LAIP	4.04
L	1.76	WC1=WC2	1.35
WF	0.72	LC1=LC2	5
LF	17.8	LLEP	9.20
HL1	1.1	copper thickness	0.035
HL2	0.6	LUEP	17.96

Figure 6 shows the antenna's shape and the position of the feed line, while Table2 shows the antenna dimensions suggested for this method of feeding.

In this feeding method, the return loss are (-45.33 dB and -25.7 dB at 6 GHz and 28GHz, respectively), where the bandwidth are 3.2% (6-6.2) at 6 GHz and 2.76% (28.5 - 29.3) at 28 GHz as shown in Figure 7. The VSWR for this method are (1.01 dB and 1.1 dB at 6 GHz and 28 GHz, respectively) as shown in Figure 9. In the Microstrip Line Feed method, the gain at the frequency 6 GHz is not good enough for this method to be adopted ,since the gain (2.77 dB and 7.02 dB at 6 GHz and 28 GHz, respectively) as shown in Figure 8, besides the directivity are (5.1 dB and 7.17 dB at 6 GHz and 28 GHz, respectively) as shown in Figure 10, as well as the efficiency are (58% on 6 GHz and 96% on 28 GHz).

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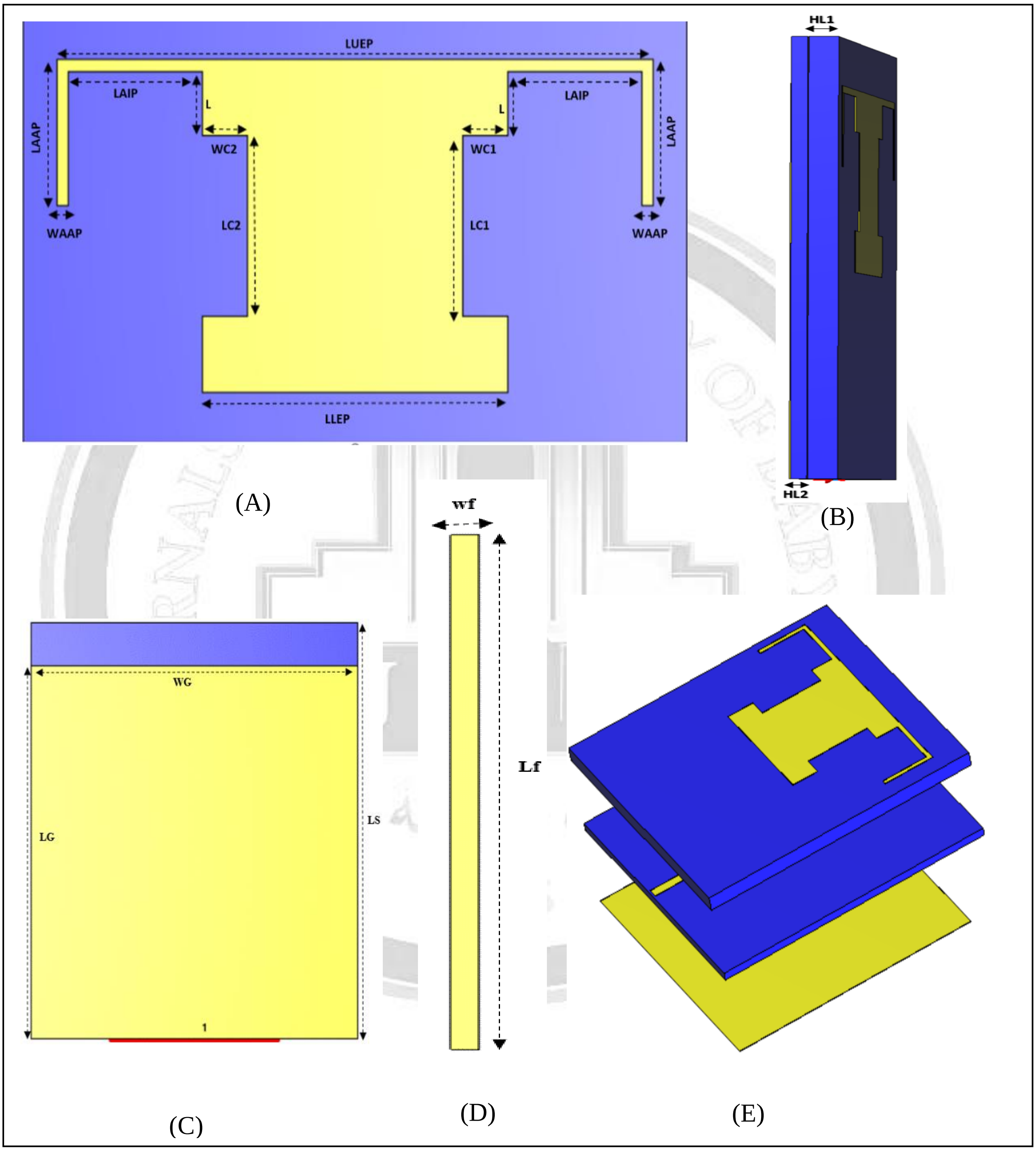

Figure 6: The Antenna Shape in the Proximity Coupled Feed method ((A) Front (B) Side Image (C) Back (D) Feed Line (E) Illustration of the Layers)

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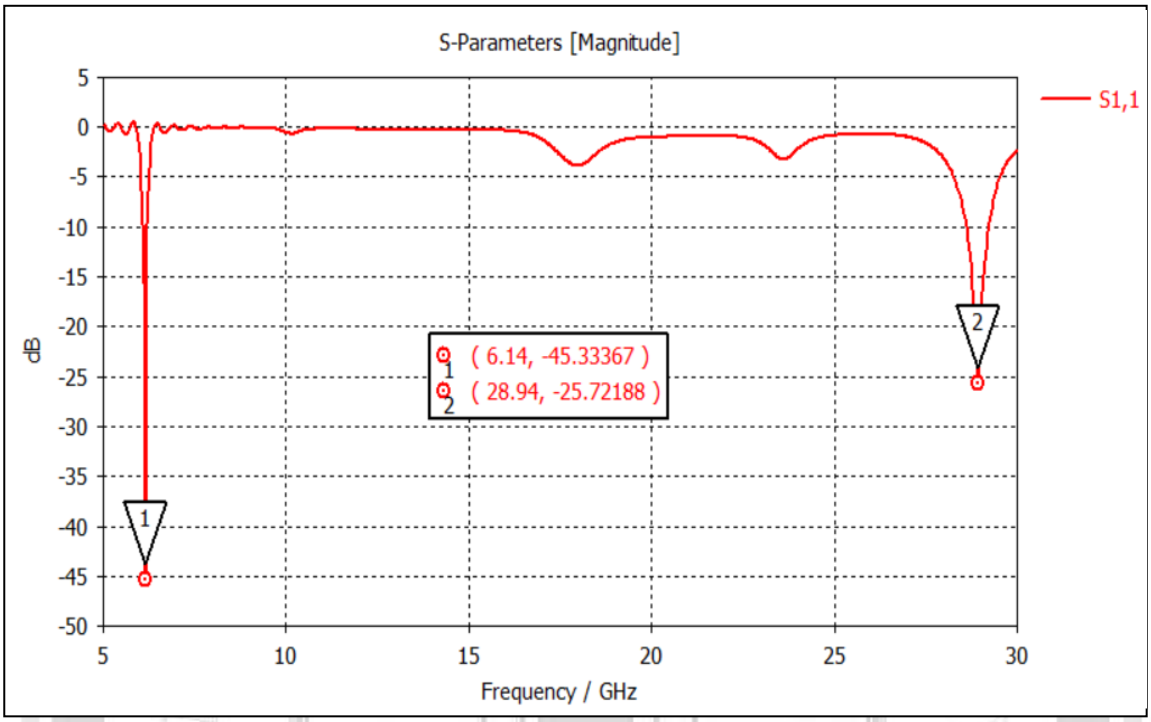

Figure 7: S11 for the Antenna with Proximity Coupled Feed Method

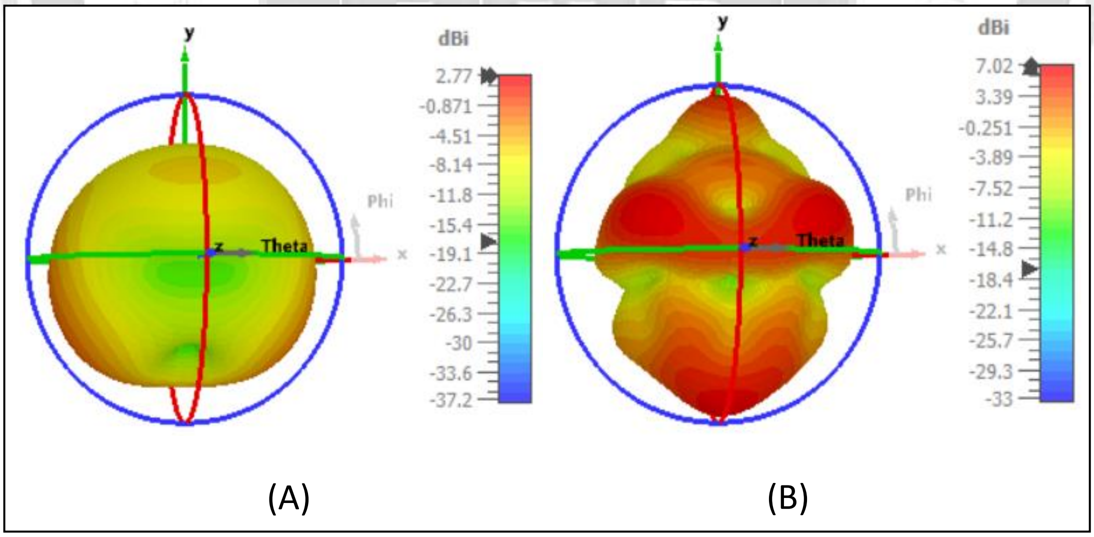

Figure 8: The Gain for the Antenna with Proximity Coupled Feed Method

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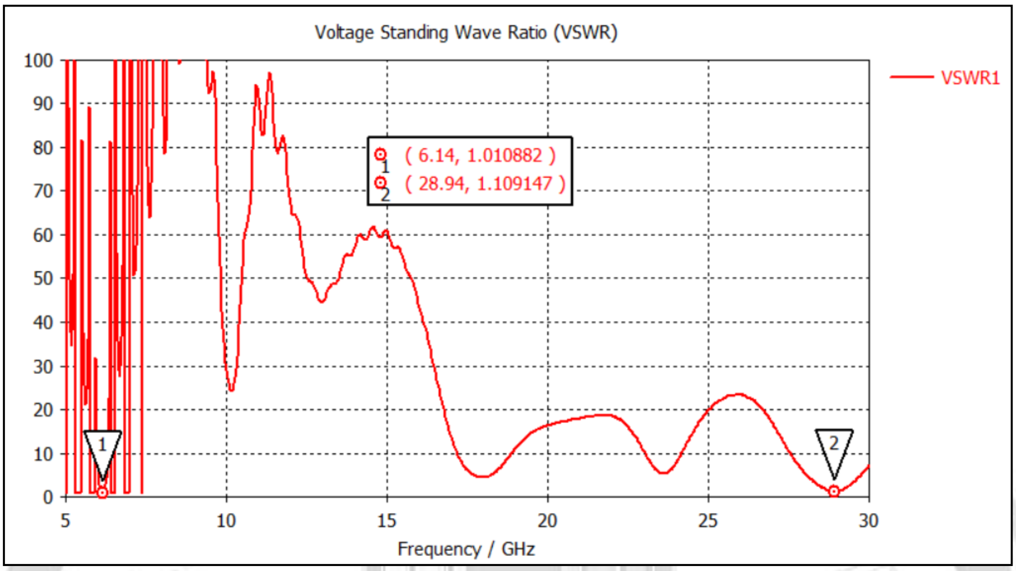

Figure 9: VSWR for the Antenna with Proximity Coupled Feed Method

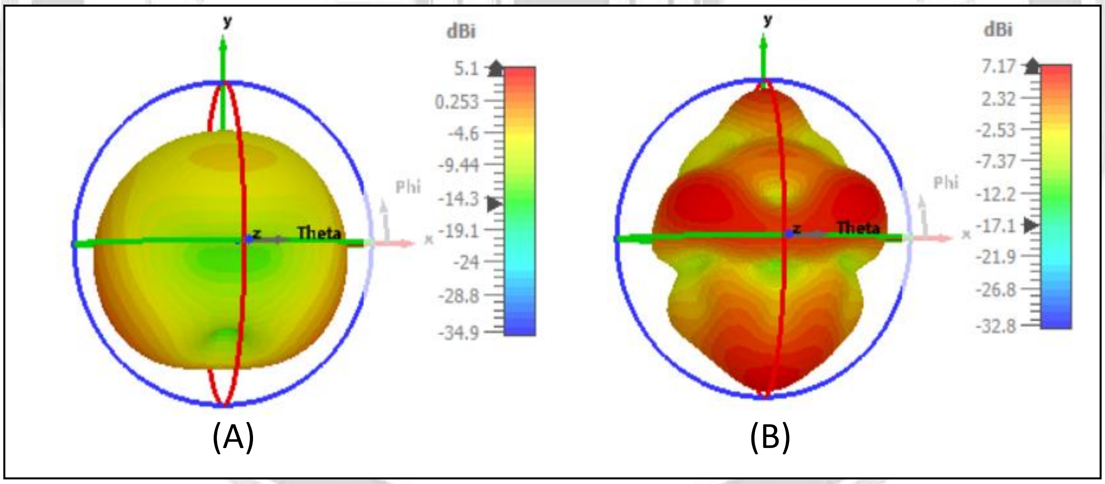

Figure 10: The Directivity for the Antenna with Proximity Coupled Feed Method

b) Aperture Coupled Feed

The proposed model consists of a T-shaped patch design with two substrates, which are excited by drilling a rectangular-shaped hole at ground level through a microstrip line printed below the bottom substrate as show in figure 11, which shows the antenna design proposed to operate in the double-slot feed-through method designed to operate in the 6 GHz and 28 GHz bands.

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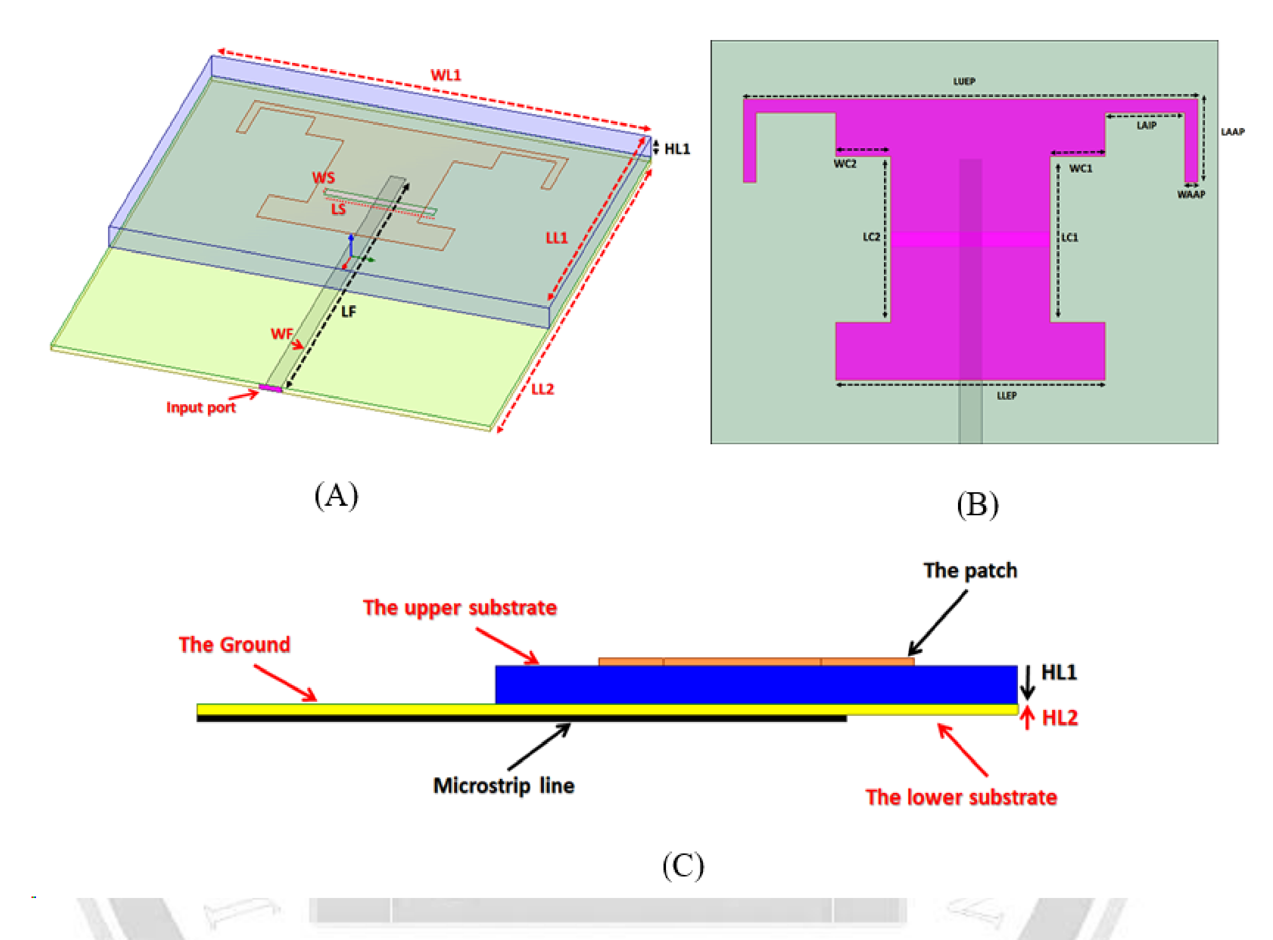

Figure 11: (A) 3D View for the Antenna (B) Top View (C) Side View

The radiator has two parts of a conductive layer made of metal (one layer acts as a radiator which is installed above the face of the substrate and the other layer is used as a ground layer below the substrate) placed on a lower of substrate, this layer of substrate is placed in a floor containing an opening which is induced by a line microstrip, which is printed below the slot under another layer of electrical insulator made of the same substrate material for the first layer. Table3 shows the antenna dimensions suggested in this method.

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Table 3: The Dimensions of the Antenna In The Aperture Feed Method

The Sample	mm	The Sample	mm
LL1	14	LUEP	14.26
HL1	1.075	LAAP	2.5
WL1	20	WAAP	0.4
LL2	22.02	LAIP	2.5
WF	0.7	WC1=WC2	1.73
LF	17.42	LC1=LC2	5.01
WS	0.32	LLEP	8.46
LS	5.2	copper thickness	0.035
HL2	0.238		

Table 4: Shows a Comparison of Parameters between All Feeding Methods Used

feeding method	Microstrip Line	Proximity Coupled	Aperture Coupled
Frequency (GHz)	6/28	6/28	6/28
VSWR	1.03/1.12	1.01/1.1	1.01/1.1
Bandwidth (%)	2.7/1.23	3.2/2.76	3.2/2.76
Gain (dB)	1.75/7.81	2.77/7.02	7.02/ 2.77
directivity	2.7/8.27	5.1/7.17	5.1/7.17
Efficiency (%)	80/89	58/96	63/98

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Where the bandwidth are 4.3 percentage (6.96-6.8 at 6 GHz and 14.18% (32.38 – 28.1) at 28 GHz as shown in Figure 12. Figure 13 shows that the VSWR of the proposed antenna model are 1.08 and 1.00003 dB respectively, which also have gain (3.74 dB and 8.33 dB at 6 GHz and 28 GHz, respectively) as show in Figure 14, as well as the directivity (5.9 dB an 8.4 dB at 6 GHz and 28 GHz, respectively) as shown in Figure 15, From the result of the gain and directivity the radiation efficiency was obtained (63% on 6 GHz and 98% on 28 GHz).

Table 4 shows a parameter comparison between all the feeding methods used and shows the best method used.

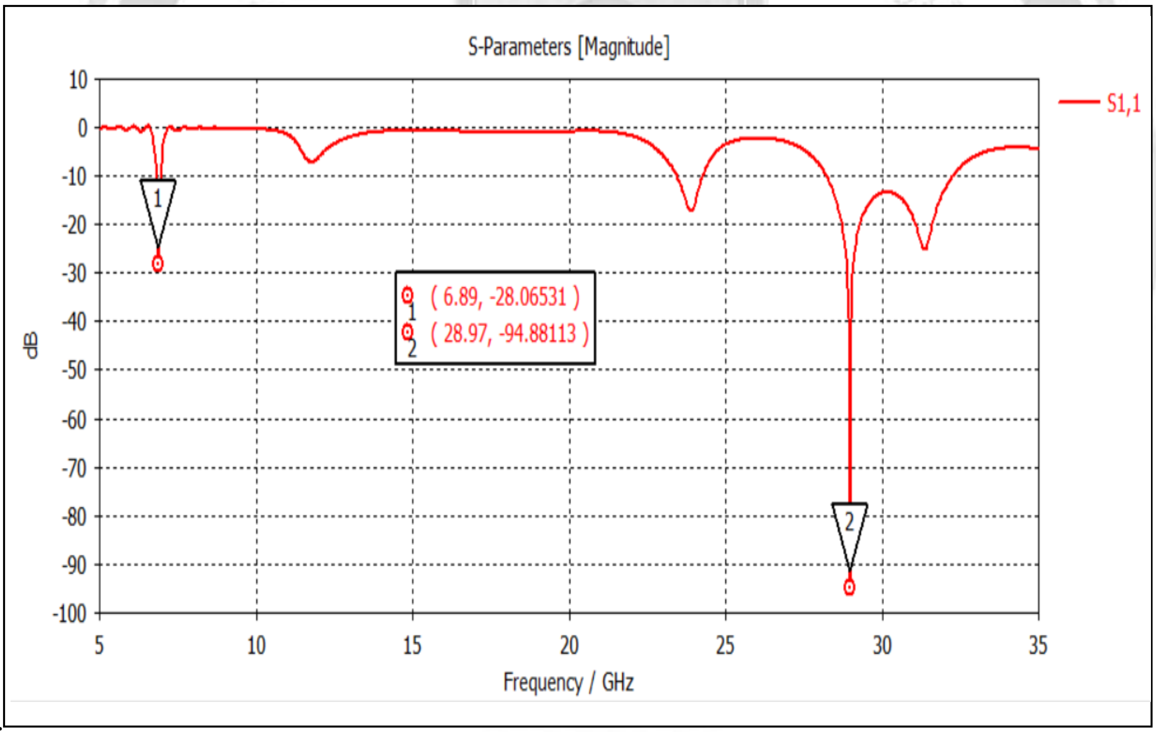

Figure 12:S11 for the Antenna with Aperture Coupled Feed Method

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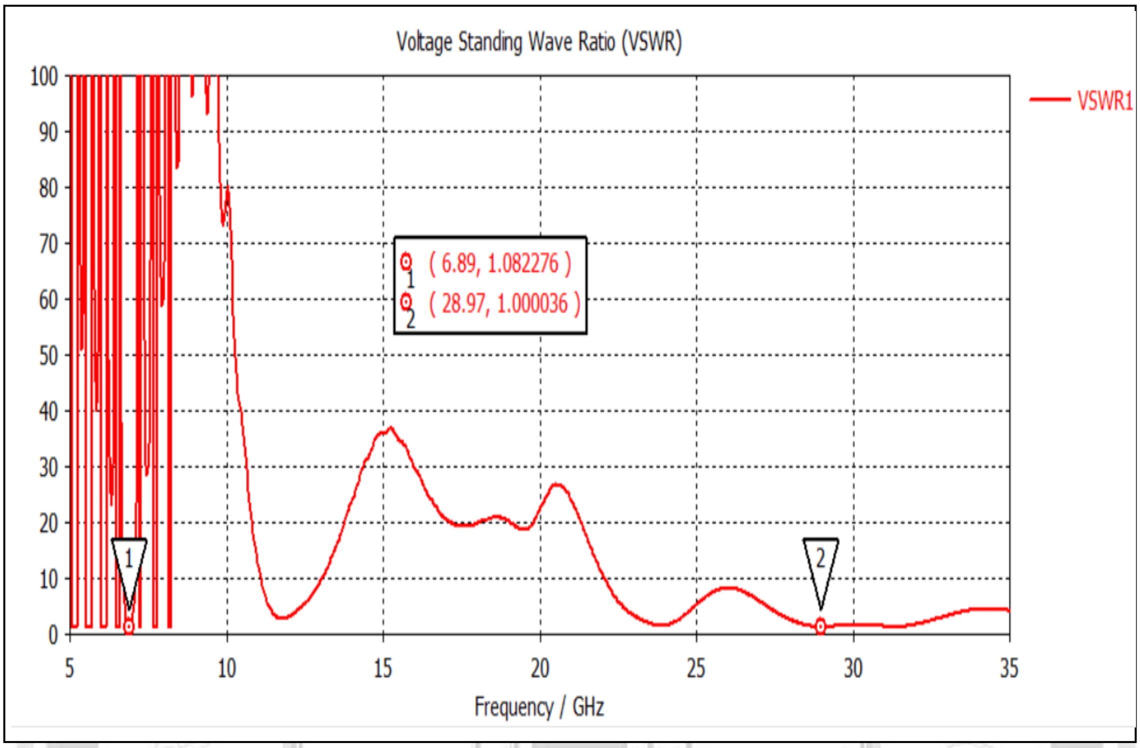

Figure 13: VSWR for the Antenna with Aperture Coupled Feed Method

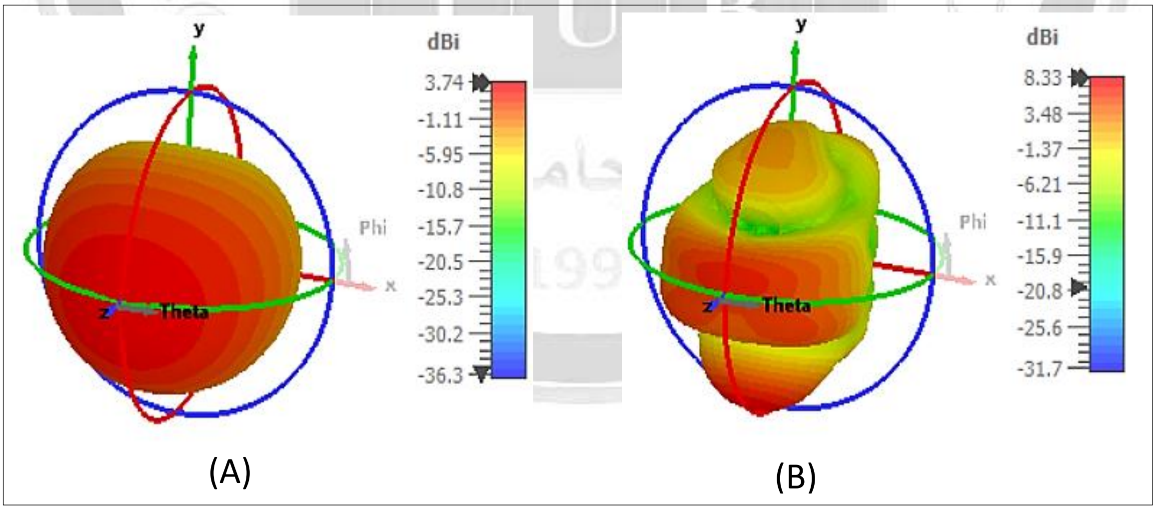

Figure 14: (A) The Gain at Frequency 6 GHZ, (B) the Gain at Frequency 28 GHZ, for the Antenna with Aperture Coupled Feed Method

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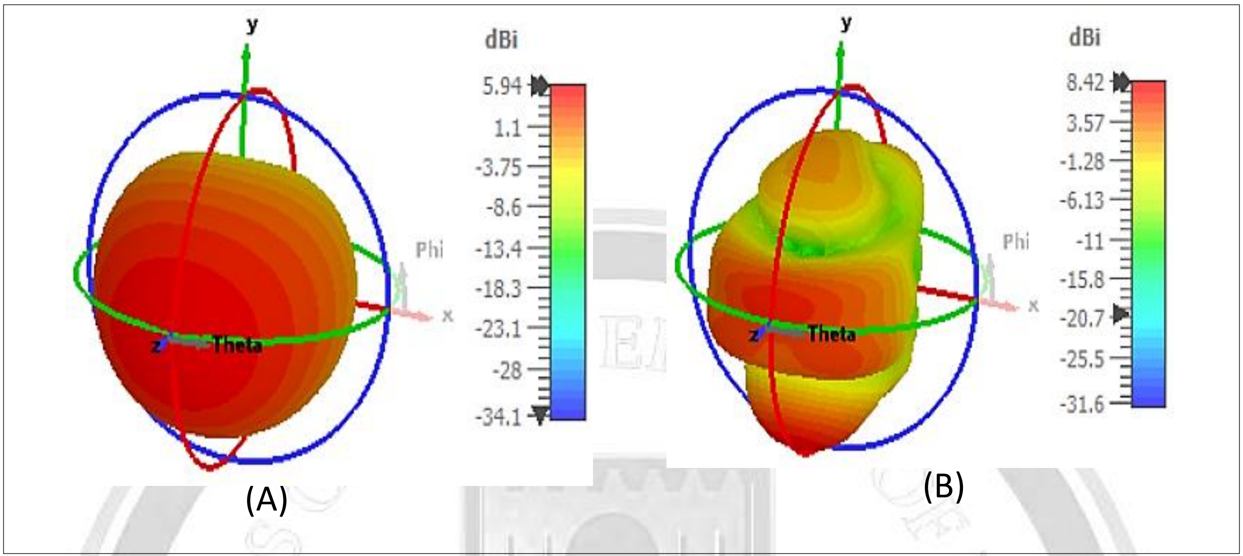

Figure 15: (A) The Directivity at Frequency 6 Ghz, (B) The Directivity at Frequency 28 Ghz, for the Antenna with Aperture Coupled Feed Method

Conclusion

The proposed antenna design is studied for the dual bands of 5G applications, which is suitable for wireless body area network applications. Four antenna-feeding methods were used , the best method for this design and frequencies is the aperture coupled feed method, in which all antenna parameters are better than the other methods. The antenna model is small compared to pre-designed antennas. The dimensions of the antenna are approximately 20 * 22 * 1.25 mm. The antenna model works as a multi-band antenna and is at 28 GHz and 6 GHz. It provides a wide bandwidth in the aperture coupled feed mode, from 6.8 to 6.96 GHz at 6GHz and from 28.1 GHz to 32.38 GHz at 28GHz. The antenna efficiency of this method is 63% on 6 GHz and 99% on 28 GHz, and this antenna model is suitable for wearable applications.

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تأثير تقنية التغذية على تحليل المعلمات لتطبيقات G5 هوائي تصحيح شريط دقيق ثنائي النطاق

شهلاء ياسين يونس **محمد تايه كاطع**

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الخلاصة

أدى التطور السريع لتقنيات المحمول مثل *4G* و *5G* والشبكات اللاسلكية إلى مزيد من البحث لتوظيف نطاق جديد من الترددات ، إلى جانب ضرورة تقليل الحجم واستهلاك الطاقة ، علاوة على ذلك ، فإنه يركز على الهوائيات المرنة التي يمكن استخدامها في مجموعة واسعة من التطبيقات. يبحث هذا البحث في تصميم الهوائي بثلاث طرق تغذية (تغذية خط ميكروستريب ، تغذية متقاربة متقاربة ، تغذية مقترنة بفتحة عدسة) ويكتشف أفضل طريقة تغذية. في التصميم المقترح، تم استخدام *5880 ™ Rogers RT / duroid* كركيزة ، وتمت محاكاة جميع التصميمات المقترحة عبر محاكاة برامج تقنية محاكاة الكمبيوتر *(CST)*. من المفترض أن يعمل الهوائي بترددات 6 و 28 جيجاهرتز. كعنصر إشعاعي ، يتم استخدام رقعة نحاسية مستطيلة ، والأرض مصنوعة من النحاس. تم فحص المعلمات الرئيسية للهوائي مثل الكسب والاتجاهية وكفاءة الإشعاع و*VSWR* .

الكلمات الدالة: مرن ، يمكن ارتداؤها ، *WBAN*، هوائي ، هوائي فتحة.