Improving Band Width of Rectangular Microstrip Antenna for 5 GHz Application

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الخلاصة

الاتصالات اللاسلكية والاجهزة المحمولة قطعت شوطا طويلا منذ إنشائها وذلك من أجل التواصل. فنحن بحاجة إلى هوائيات مصغرة الحجم مثل الهوائيات الشريطية microstrip antennas. في هذا العمل، اقترح هوائي شريطي مستطيل الشكل Rectangular microstrip antenna. ويعد من التصاميم المستقبلية للاتصالات المتنقلة التي تعمل بالجيل الخامس (5) كيكاهرتز، يتركب الهوائي من مشع مستطيل الشكل على المادة العازلة (FR-4) والتي ثابت عزلها (4.4). وتم عمل قطع على شكل([]) في المشع المستطيل لغرض تحسين عرض النطاق الترددي، وقد اظهرت النتائج ان عرض الحزمة أصبح يساوي (20٪) وكذلك تحصيل الهوائي بلغ (7.41) ديسيبل عند التردد (5.1) كيكاهرتز. تم تنفيذ تصميم الهوائي والمحاكاة باستخدام طريقه العناصر المنتهية (FEM) باستخدام برنامج HFSS.

الكلمات المفتاحية

هوائي شريطي مستطيل الشكل، HFSS ، FR-4، عرض النطاق الترددي، طريقة العناصر المنتهية.

Abstract

The wireless communication has developed very fast since its creation. So for efficient communication we require miniature sized antennas such as microstrip antenna. In this paper, it proposes an efficient wide band rectangular microstrip antenna. In Equally important this design of future antenna for 5G mobile communication, a rectangular patch is mounted on FR-4 substrate material with dielectric constant (εr =4.4). A slot shape (] [) is etched on the rectangular patch to provide wideband operation, which provide a wider bandwidth of (20%) and high gain of (7.41) db. Antenna design and simulation were carried out in Finite Element Method (FEM) based High Frequency Structural Simulation (HFSS) tool. This antenna has good performance in terms of antenna Band width, return losses, VSWR, Characteristics impedance, and gain at the frequency (5.1) GHz.

Keywords

Rectangular Microstrip Antenna, FR-4 Substrate, HFSS, Bandwidth, FEM.

1. Introduction

The wireless communication system needs small antennas for mobile devices, and high band wide in multi-frequency bands for different applications [1].

In fact, the future wireless networks also require high band width systems with high mobility environments [2].

The principal advantages of microstrip antenna include, small size, light weight, low fabrication cost, low profile planar, and can be manufactured either as a separate component or part of array [3].

Some of disadvantages of microstrip antenna are: narrow bandwidth; low efficiency; low Gain; and thicker substrate results in excitation of surface waves [4].

The simplicity of Microstrip antennas and compatibility with printed circuit technology Led to great interest in them recently and its use on a widely in the microwave frequency spectrum. Microstrip antenna consists of dielectric substrate and conducting patch printed on in one side and in the other side printed a conducting ground plane [5].

Therefore, the radiating element can be take several shapes such as a rectangular, square, monopole, circular, triangular, circular ring, and elliptical, or other configuration. As a result, there are special features for each shape, but the rectangular, circular and square shapes are the most common configurations [6].

The used of different materials to design the dielectric substrate of microstrip antennas, where the range dielectric constant of this materials usually in ($2.2 \leq \varepsilon r \geq 12$). The thickness (h) is small fraction of a wavelength ($h << \lambda o$) [7]

Equally important, the ground plane of antenna is placed below dielectric substrate and represents the third part of the microstrip antenna. The ground plane is made of the same conductive material as the patch.

The dimension of ground plane effect on the edge fields (fringing fields) Which is very important to increases the radiation from the microstrip antenna [8].

There are different methods to feeding the patch of microstrip antenna such as the transmission line feed, coaxial probe feed, aperture coupling feed and proximity coupling feed.

Of these methods, connected or unconnected, connected methods include direct connection between the patch and transmission line. But in unconnected method used coupling electromagnetic field method to transfer energy to the patch [9].

The different techniqes have been used leately to increase the bandwidth of microstrip antennas [10], such as increasing the height of the substrate, microstrip slot antenna loaded approach on the patch and using different shapes of microstrip patch [11].

By increases thickness of substrate increases the gain, but may lead to surface wave excitation which decrease efficiency and perturb the radiation pattern [12].

Different shapes of slot loading in radiated patch to improving the antenna bandwidth [13].

In this study, a slot shape (] [) patch antenna were designed with coaxial -probe feed.

The software which is the industry standard for simulating high-frequency electromagnetic structure (HFSS).

2. Design of RMSPA in 5.2 GHz

To design an initial antenna in (5^{th}) generation (a future antenna for 5G mobile communication) and in the ultra-wide band UWB application for wireless communication. In this work, three parameters must be selected, there are: Resonance frequency is (5.2) GHz, the dielectric constant of the substrate is (4.4) (FR4-epoxy) , thickness (3.5)mm. The size of rectangular patch antenna are (46×33) mm^2, the size of ground plane is (67×54.8)mm^2. The co-axial feeding technique is used and the optimum location of feed is (0, -5) mm.

3. Design of RMSPA in 5.2 GHz with slot shape (] [)

The slot techniques etched in the rectangular patch is used here to improving the bandwidth of the antenna. The slot shape (] [) was to be etched in the rectangular patch of the proposed antenna, as shown in Fig. (1).

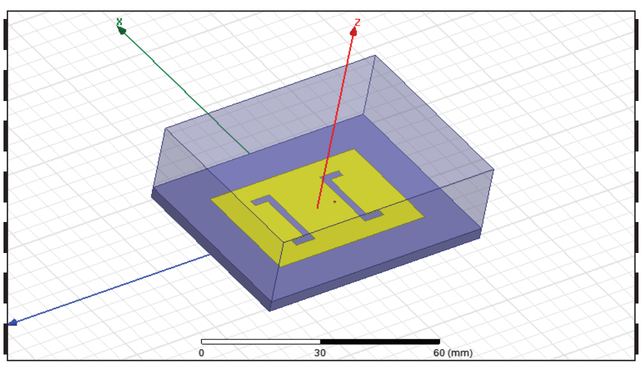

Fig. (1) rectangular antenna with ( ] [ )-slot

The dimensions of antenna with] [-slot as shown in Fig. (2), the total area of patch is (L x W) printed on a FR4 substrate having dielectric constant (4.4) with size (L_g x W_g), with thickness is (h). The antenna uses co-axial feeding technique, The position of feed point is (X_f, Y_f), where the feed location and the slots were tuning to give good impedance matching.

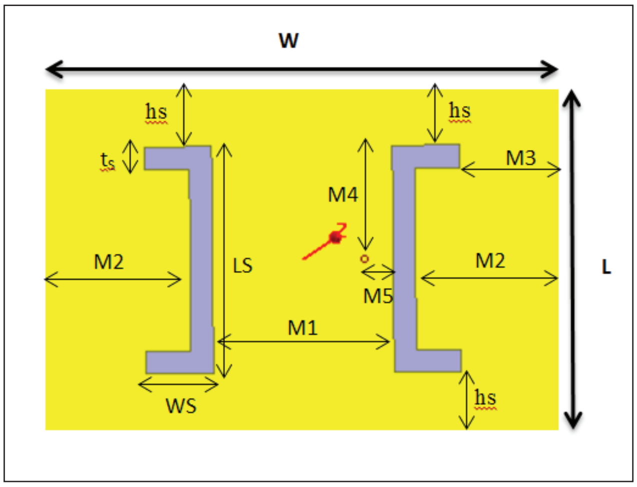

Fig. (2): Dimensions of Rectangular patch loaded by slot shape (] [)

4. simulation results of RMSPA in (5.2) GHz

Return loss versus frequency is shown in Fig. (3). While it is true that the bandwidth is(3.1%) at (4.5)GHz,(2.5%) at (5.2) GHz and (1.6%) at (6.26)GHz. The return loss value of these bands is (-18.06 dB,-18.9 dB and -13.39) dB respectively.

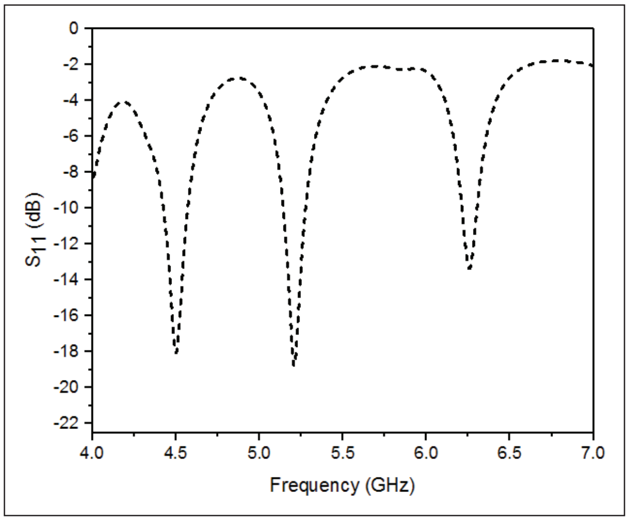

Fig. (3): Return loss of RMSPA at 5.2GHz

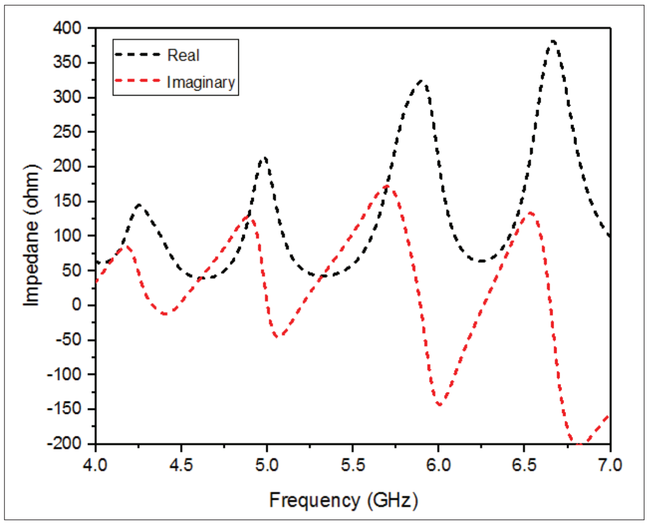

Fig. (5): Real and imaginary parts of the input impedance of RMSPA at (5.2) GHz

VSWR (Voltage Standing Wave Ratio) versus frequency is shown in Fig. (4). The values of VSWR for rectangular microstrip patch antenna is (1.10, 1.03 and 1.15) at (4.5) GHz, (5.2)GHz and)6.26(GHz respectively.

2-D radiation pattern antenna at (5.2)GHz as shown in Fig. (6). The Fig. shown as E and H-Plane radiation pattern of rectangular microstrip antenna,

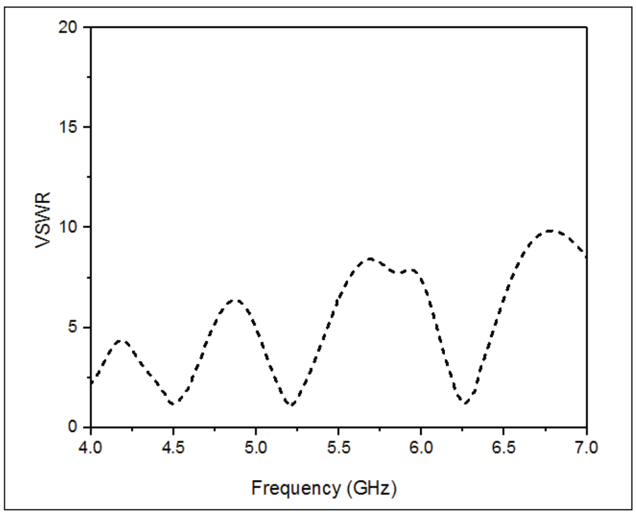

Fig. (4): VSWR of RMSPA at)5.2(GHz

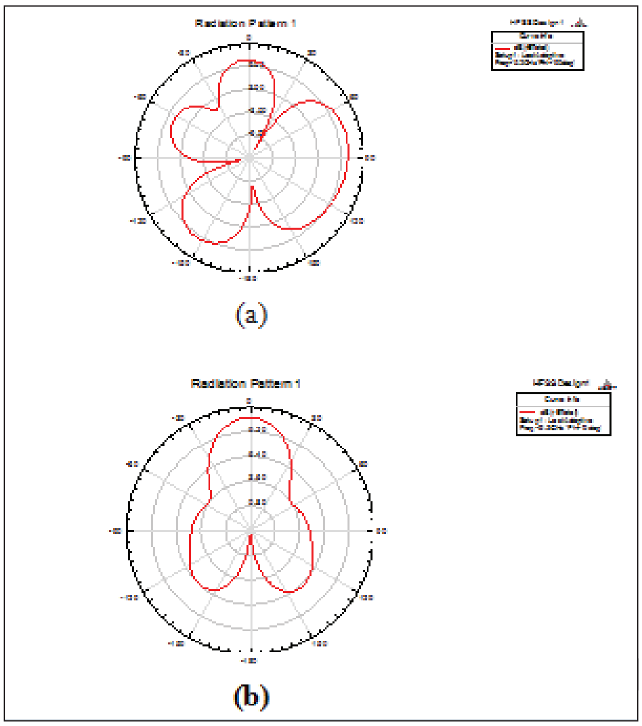

Fig. (6): E and H -Plane radiation pattern of RMSPA at (5.2) GHz

The input impedance of rectangular microstrip antenna is shown in Fig. (5). The figure shows, at frequency (5.2) GHz, the real part of impedance approximately (50) Ω while the imaginary part equal to zero.

The gain of the proposed antenna is shown in Fig. (7). The maximum gain is (6.24)dB at (5.2)GHz, and the average gain is (5.12)dB.

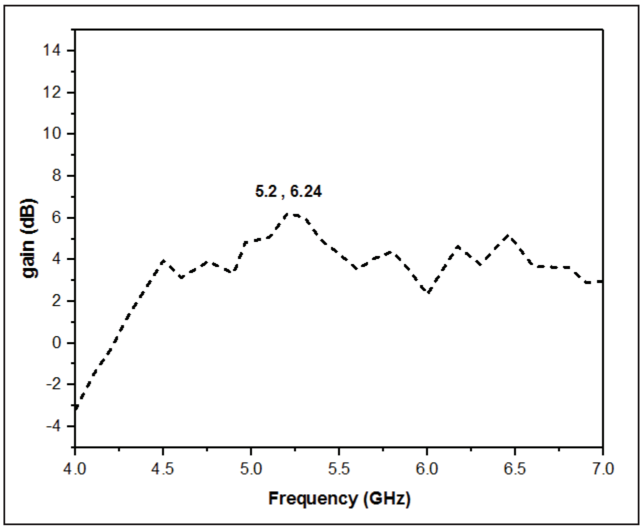

Fig. (7): gain of RMSPA at)5.2(GHz

As shown above the performance parameter of a rectangular patch is shown in Table (1).

Table (1): RMSPA performance parameters at (5.2) GHz

S11	-18.9 dB
Bandwidth	2.5%
VSWR	1.03
Average Gain	5.12 dB

5. simulation results of RMSPA with slot shape (] [)

Parametric study done to get the optimum dimension for the slot, to get the best value of band width. For different values of (ts), when (Ws = 6mm), the results show the best value of a bandwidth for the thickness of the slot equal to (2) mm , as in Fig.(8).

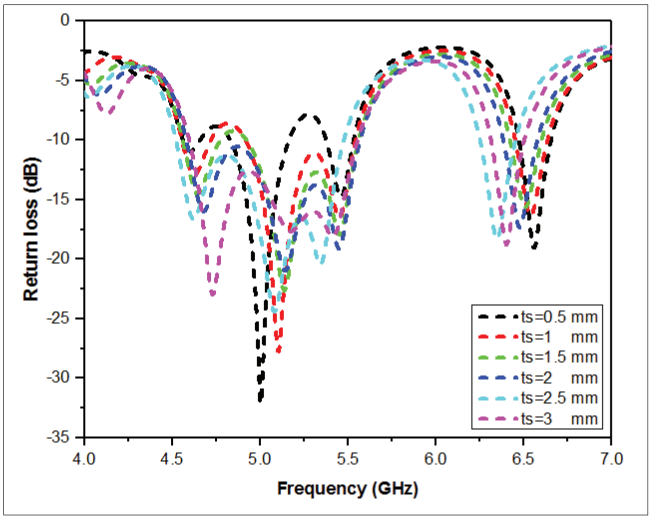

Fig. (8): Return loss of proposed antenna with different ts value>

Now, for the thickness of the slot (ts = 2) mm, the results show that, the best value of a bandwidth was obtained at the width of slot equal to (6) mm, as in Fig. (9).

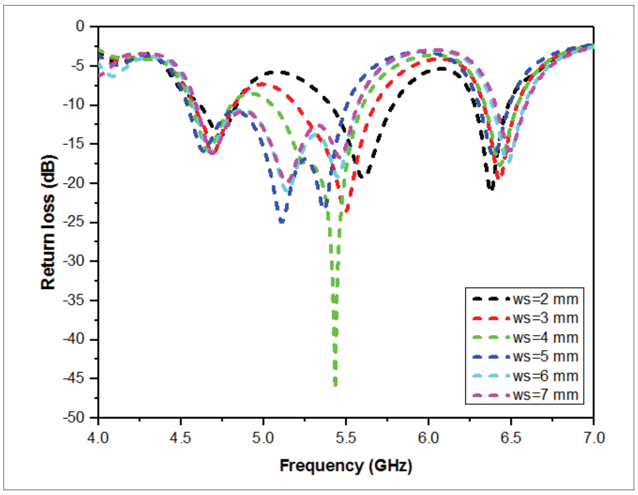

Fig. (9): Return loss of proposed antenna with different Ws of slot.

The optimum dimensions of the patch and slots of the proposed antenna, with the best value of the band width listed in Table (2).

Parameters	Value
Size the ground plane (Lg × Wg)	52 mm * 67 mm
Dielectric constant (ε_r)	4.4 (FR4-epoxy)
Thickness of substrate (h)	3.5 mm
Size of the patch (L × W)	31mm x 46 mm
Feed position (X_f , Y_f)	(0 mm , -5.5 mm)
Frequency	5.1 GHz
Size of the slot Ls × Ws	20 mm * 6 mm
thickness of the slot t_s	2 mm
hs	5.5 mm
M1	16 mm
M2	13 mm
M3	9 mm
M4	10 mm
M5	2.5 mm

Vol. 10, No. 19 and 20 P. (67-76), Sept., 2019

According to the dimensions listed in the Table (2), the return loss of (] [) -slot antenna shown as in Fig. (10). The bandwidths for (-10) dB return loss ranging from (4.5 to 5.54) GHz or (% 20.4) especially at (5.11) GHz, and ranging from (6.35 to 6.540) or)3%(at (6.44) GHz.

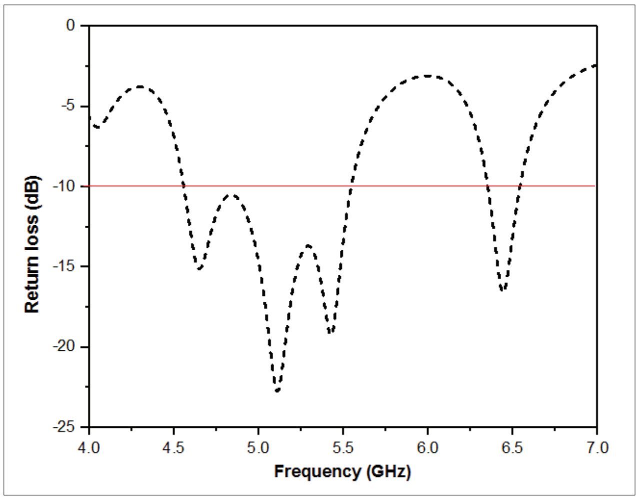

Figure (10): Return loss of proposed antenna

The values of VSWR are (1.09 and 1.26) for the antenna at resonant frequencies at (5.11) GHz and (6.44) GHz as shown in Fig (11).

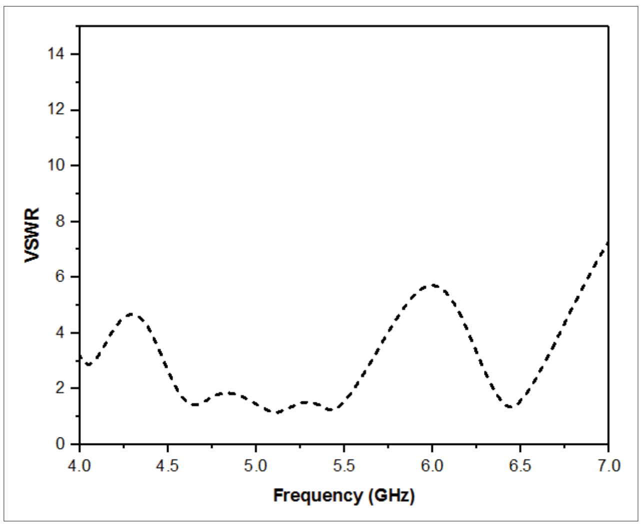

Fig. (11): VSWR of the proposed antenna.

The input impedance as shown in Fig. (12), at resonant frequency (5.1) GHz the real part of impedance is approximately (50) Ω and the imaginary part is zero

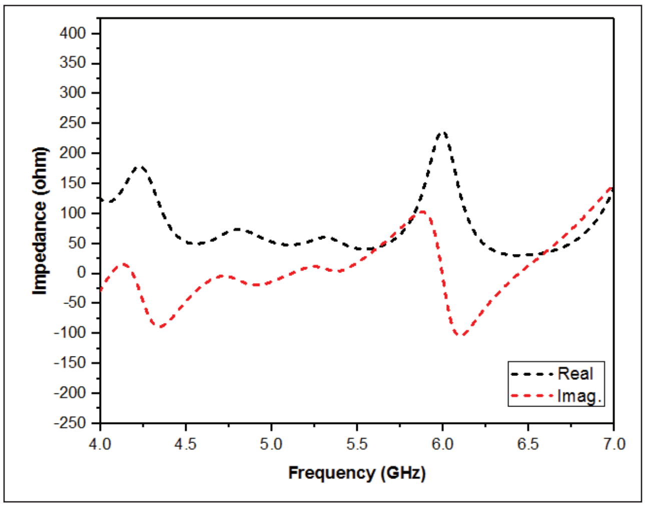

Fig. (12): The real and imaginary part of input impedance vis. Frequency.

The proposed antenna's radiation patterns are shown in Fig. (13).

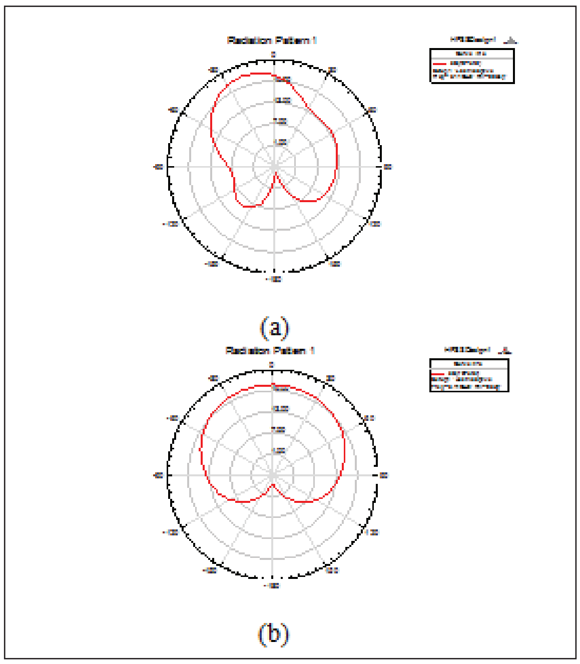

Fig. (13): (a) E-plane and (b) H-Plane pattern of proposed antenna at)5.11(GHz

The gain of proposed antenna shown in Fig. (14). The maximum gain is (7.41) dB at (5.11) GHz and the average gain is (6.5) dB.

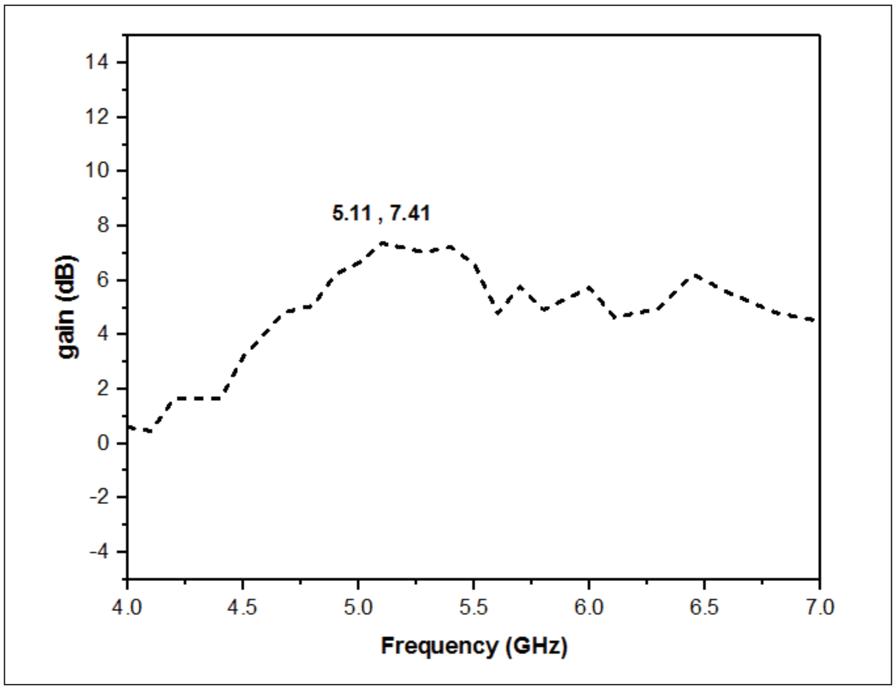

Fig. (14): The gain of the proposed antenna at (5.11)GHz.

As shown previously above the performance parameter of the proposed antenna is shown in Table (3).

Table (3): Proposed antenna performance parameter

f_r	5.11 GHz
S_{11}	-22.735 dB at 5.11GHz and -16.6 dB at 6.44 GHz
B.W	20% at 5.11GHz and 3% GHz at 6.44 GHz
VSWR	1.09 at 5.11GHz and 1.26 at 6.44 GHz
average gain	6.5 dB

6. Conclusion

In this work we proposed a rectangular micro strip patch antenna with (] [)-shaped slot to improving the band width of micro strip antenna. The proposed antenna was designed at (5.1)GHz with wider bandwidth and high gain. Hence this antenna used widely in different applications of communication system.

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