JOURNAL OF KUFA−PHYSICS
www.uokufa.edu.iq/journals/index.php/jkp | ISSN: 2077−5830

Design and simulation of a 2-shaped Slotloaded Rectangular Microstrip Patch Antenna

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KEYWORDS:

- 2-slot
- HFSS
- VSWR
- FR4-epoxy
- band width

ABSTRACT

A design of 2-slot loaded rectangular microstrip patch antenna was worked out. The aim of this design is to improve the parameters of microstip antenna .This design shows that there is an increase in the bandwidth, which may distinguish it for the use in communication purposes especially in military and civil applications .The antenna has been designed selecting FR4-epoxy substrate with dielectric constant of 4.4.andoptimum dimensions of 60 × 60 × 1.66 mm^3. The design requirements for this antenna should include a VSWR less than 2 for 50 Ω reference impedance and return loss is less than to -10 dB. The simulation of this design is carried out using a high frequency simulation structure (HFSS). The 2-slot microstrip patch antenna was then fabricated using microstrip coaxial probe feed technical .was calculated the return loss VSWR, real and imaginary impedance, radiation patter and gain results . The -10 dB impedance bandwidth of the proposed antenna is 9.06 -13.86GHz , which is about 51.06% broader . The proposed antenna has an average gain of 6.3 dB and the peak is 8.239 dB at resonance frequency 9.42GHz. Compared with the original one , the average gain of the proposed antenna improve about 1.7 dB.

http://dx.doi.org/10.31257/2018/JKP/100204

تصميم ونمذجة هوائي شريطي بقطع على شكل ٢ من سطح المشع المستطيل

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الكلمات المفتاحية

- قطع شكل ٢
- نسبة الموجة المنعكسة
- عرض الحزمة
- الهيكل الاشعاعي
- الممانعة

الـــخُـــلاصـــة

تم العمل على تصميم ودراسة الهوائي المستطيل المحمل بقطع على شكل رقم ٢ . الغرض من التصميم هو لتحسين اداء الهوائي ، هذا التصميم اعطى زيادة في عرض الحزمه مما يعطي اهميه ومؤشرات ايجابيه لهذا التصميم المقترح لاستخدامة في مجال الاتصالات فيما يخص التطبيقات العسكريه والمدنيه . اختيرت مادةFR4-epoxy(ثابت العزل 4.4) في الطبقه العازلة لهذا الهوائي ذو الابعاد $60 \times 60 \times 1.66$ mm^3 . تصميم الهوائي يتطلب ان تكون نسبه الموجه المنعكسه اقل من ٢ عند الممانعة البالغه ٥٠ اوم . تم تصميم وحساب النتائج باستخدام برامج HFSS وكانت تغذية الهوائي عبارة عن مغذي محوري . تم قياس كمية الفقد فكان من خلال S_{11} ومعرفة مدى الانعكاسية في القدرة المرسلة فكان من خلال حساب $VSWR$ التي كانت 1.008ضمن مدى التردد الرنيني ، اما عرض الحزمة فكانت ضمن المدى الترددي (9.06 – 13.86) كيكا هيرتز ، وتم حساب عرض الحزمه كنسبه مئويه وبلغت 51% عند التردد 9.42 كيكاهرتز . اما معدل التحصيل كان 6.3 dB ، حيث بلغت القمة dB8.23 عند التردد 9.4 كيكاهرتز ، مقارنه بالهوائي الابتدائي فان الزيادة في التحصيل بلغت 1.7 dB.

1. Introduction

The microstrip antennas are characterized by having small size, low profile, and light weight , conformable to planar and non-planar surfaces. It demands a very little volume due to it structure, when mounted . They are simple and cheap to manufacture using modern printed circuit technology [1].

However,The main disadvantages of the microstrip antennas are: low efficiency, narrow bandwidth of less than 5%, and low RF power due to the small separation between the radiation patch and the ground plane(not suitable for high-power applications) [٢]

Microstrip antennas are used in a wide range of applications from communication systems (radars, telemetry, and navigation) to biomedical systems [3].Basic microstrip antenna consist of two thin metallic layers ($t \ll \lambda_0$) separated bydielectric substrate of thickness ($h \ll \lambda_0$) usually $0.003\ \lambda_0 \leq h \leq 0.05\ \lambda_0$[4-5] **.**microstrip patches have several shapes such as rectangular, circular, triangular, semi-circular, sectoral and annular [6-7].An antenna ischaracterized by its center frequency, bandwidth (B.W), polarization , radiation pattern, gain, and impedance [8]. The bandwidth of the antenna depends on the patch shape, resonant frequency, dielectric constant, and the thickness of the substrate. The bandwidth improvement of a microstrip antenna has been directed towards improving the impedance bandwidth of the antenna element[9].

Due to the widely used in different application ofmicrostrip antennas,this causes a demandto improve antennasefficiency. A number of theoretical and experimental researches have been done to improve the bandwidth of this antenna [10]. Loading of shorting pins and stacking of patches are some techniques to increase the bandwidth of microstrip antennas [11].

Different shapes of slot loading in feed patch can also enhance the antenna bandwidth [12].

In this study, a2-slot patch antenna was designed with coaxial -probe feed,to improve antenna efficiency, using , software which is the industry standard for simulating high-frequency electromagnetic fields (HFSS).

In this paper , a microstrip antenna with higher gain and wider band is proposed .The configuration of the initial antenna at Resonance frequency is 2.3 GHz ,FR4-epoxy material has been used as substrate having thickness 1.6mm ,and the dielectric constant of substrate is 4.4 .with dimension ofpatch $30*37mm^2$. The band width of that antenna is from 2.26to 2.4 GHz at 2.3 GHz where S_{11} is -24.40 dB , and from 9.0 to 9.25 at 9.13 GHz where S11 is -28.21dB the VSWR is 1.11 at 2.32 GHz, and the average gain is 4.6 dB with the peak is 6.21 dB .

2. Antenna design

The configuration of the proposed antenna is shown in Fig. (1)

the antenna is of single layer configuration along with its current distribution, in which 2-shape slot is incorporated in feed rectangular patch. The design ofthe antenna is a rectangular microstrip antenna with patch size of $29.44*38.04\ mm^2$. The substrate chosen for the proposedantenna is FR4-epoxy with dielectric constant of 4.4 and a thickness of 1.66 mm.

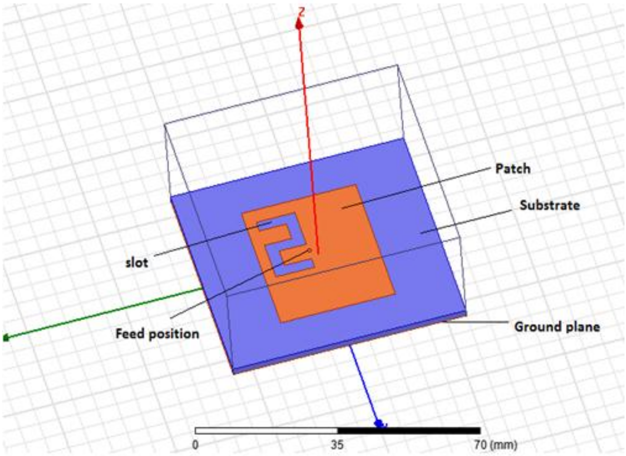
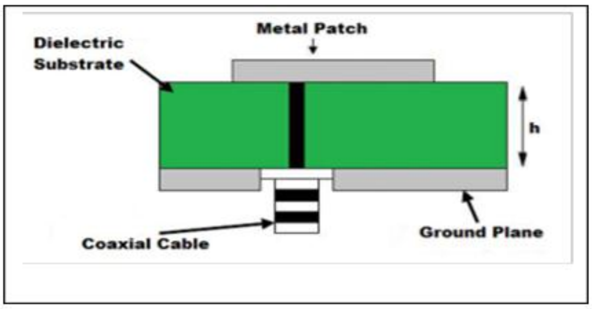


Fig (1): a) The rectangular microstrip antenna loaded by 2- slot



b) Side view of microstrip antenna.

The dimensions of slot, are shown in Fig(٢), were L_S represents the length of the slot , the width is W_S , and T_S is the thickness of the slot .

B_1 represent the height of the lower edge of the slot from lower edge of the patch.

B_2 represents the distance between right side of the slot from the right side of the patch, B_3 represent the distance between left side of the slot from the left side of the patch.

B_4 represents the distance between the upper edge of the slot to the upperedge of the patch at y-plane direction , B_5represents the distance between the feed position and the slot in x direction and B_6 represent the distance between the position of feed and thelower edge of the slot in y direction.

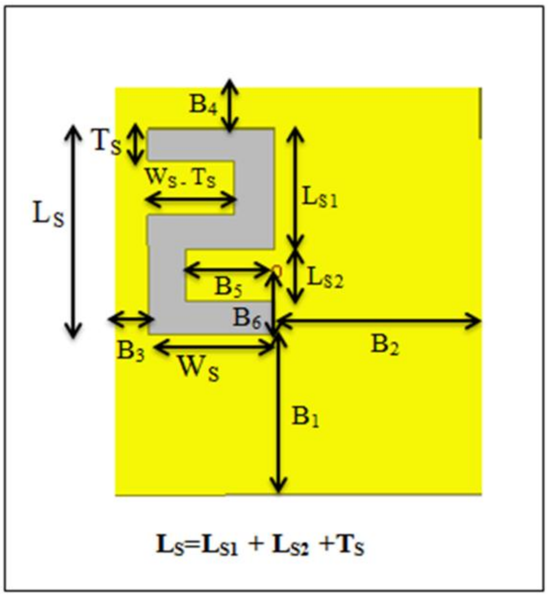


Fig (2): Slot dimension of proposed antenna

Thevalue of these dimensions of the proposed antenna are presented in table (1)

Table 1: Dimensions of proposed antenna

Parameters	Values
Size the substrate (L x W)	60 mm * 60 mm
Dielectric constant (ε_r)	4.4 (FR4-epoxy)
Thickness of substrate (h)	1.66 mm
Size of the patch (L_P x W_P)	29.44 mm x 38.04 mm
Feed position (X_f , Y_f)	(1.8 mm , -1.8 mm)
Frequency	9.4 GHz
Dimension of the slot L_S * W_S	19 mm * 10 mm
thickness of the slot T_S	3 mm
B_1 , B_2	15.02 mm , 16.72 mm
B_3 , B_4	2.6 mm , 4.02 mm
B_5 , B_6	7.2 mm , 5.8 mm
L_{S1} , L_{S2}	11 mm , 5 mm

3. Results and Discussion

Fig.(3)shows the simulated and measured return loss of the 2-slot antenna. The measured impedance bandwidths for -10 dB return loss ranging from 9.06 to 13.86 GHz or 51% forthe 2-slotmicrostrip antenna. The VSWR value is 1.008 for the antenna at resonant frequencies 9.42 GHz as shown in Fig. (4), The resonant frequency was determined from Fig(5) that shows that the real part of impedance which is approximately equal to 50 Ω , and the imaginary part is approximately equal to zero .

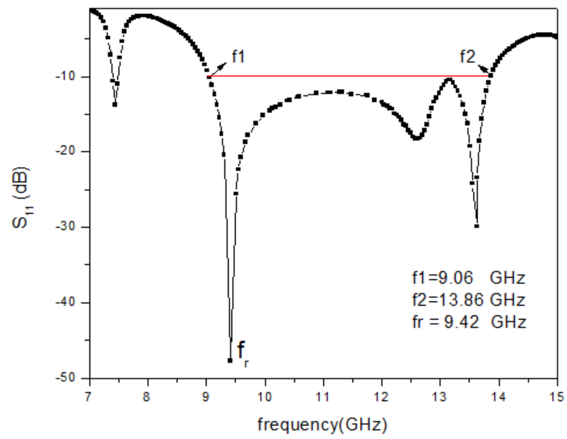


Figure (3): Return loss of the proposed antenna.

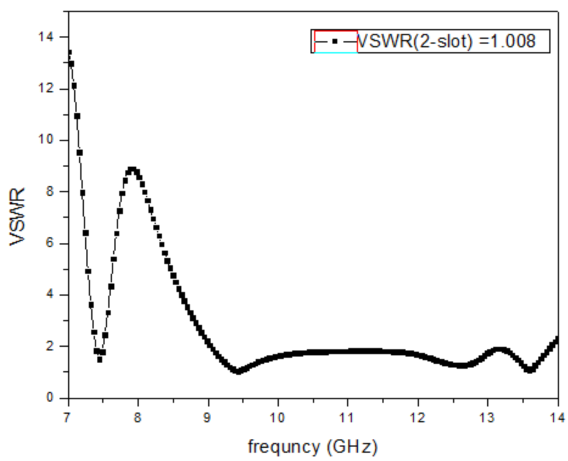


Figure (4): VSWR of the proposed antenna.

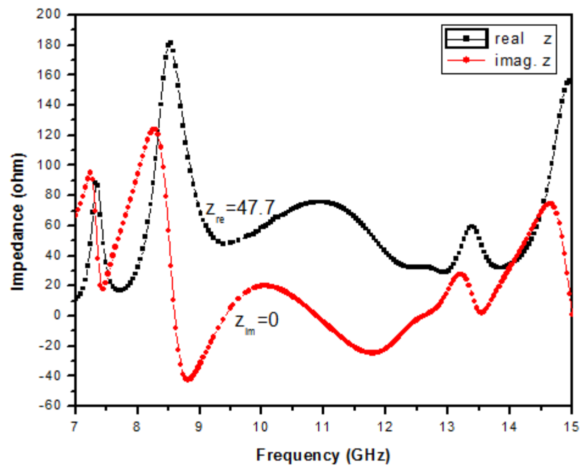


Figure (5): The real and imaginary part of input impedance with the Frequency.

The radiation patterns of proposed antenna shown in Figs (6)and (7) it was shown that the E-plane and H-plane at 9.42GHz ,by the polar coordinates fig (8) show the evaluation pattern for proposed antenna at 9.42GHz .

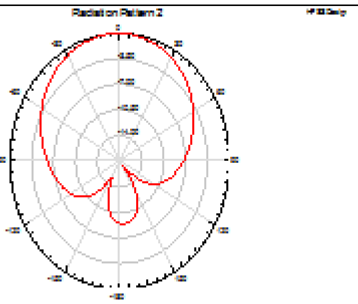


Figure: (6): E-Plane of proposed antenna at 9.42GHz.

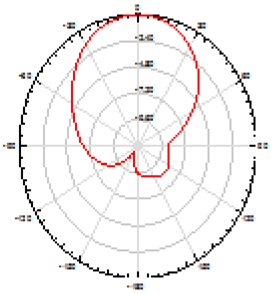


Figure (7): H-Plane of proposed antenna at 9.42GHz.

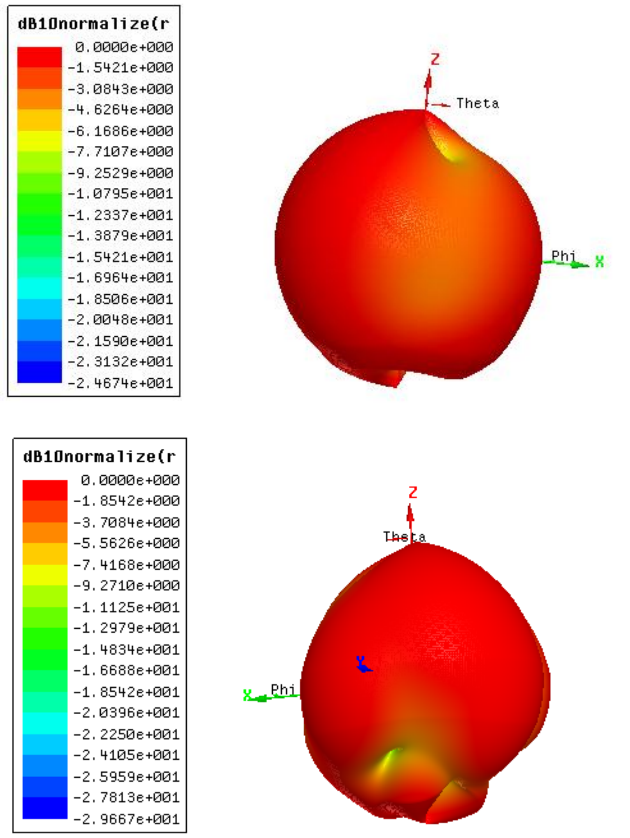


Figure (7a,b): 3-D radiation pattern of the proposed antenna at 9.42 GHz.

4. Conclusions

The simulation design of 2-slot loaded rectangular microstrip patch antenna using Ansoft HFSS Microsoft was presented. The design requirements for the antennas include a VSWR < 2 for 50 Ω reference impedance and return loss is less than to -10 dB . The shape of the proposed microstrip patch antenna was then fabricated using coaxialprobe feed arrangement with VSWR values of 1.008 which is corresponding to the resonance frequency 9.42 GHz . The slot in proposed antenna ,in the patch areasoflow fields, led to increasing fringing fields , this will be resulting in a clear increase in bandwidth and gain compare to initial antenna.

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