Design of T-Slot Loaded Circular Microstrip Patch Antenna to improved dual bandwidth

Zeki A. Ahmed Ranya M. Dawood; Raed M. Shaaban

Department of Physics, College of Science, University of Basra.
zeki_abduallah@yahoo.com

Abstract:

In this paper, a T-slot loaded circular disk microstrip patch antenna was designed using HFSS Microwave Studio at a resonant dual frequency of 4.37 GHz and 5.19 GHz. The antenna parameters are calculated such as a dual bandwidth was obtains as 105.8 and 137.6 MHz compared with 73.7 MHz for CMSA , return loss, VSWR values are 1.08 and 1.138 for corresponding two resonant frequencies and calculated 2D and 3D radiation pattern and a good agreement was obtained for this antenna after approximate the dimensions of the T-slot to zero.

Keywords: VSWR, Radiation Pattern, Bandwidth, Gain, return loss.

تصميم هوائي شريطي دائري بقطع حرف T من سطح المشع لتحسين عرض الحزمة المزدوجة

زكي عبد الله أحمد رانيا مسلم داوود رائد مسلم شعبان

قسم الفيزياء ، كلية العلوم ، جامعة البصرة

الخلاصة:

في الدراسة الحالية صمم هوائي شريطي دائري محمل بفتحة على شكل حرف T لغرض زيادة كفاءة الهوائي الشريطي الدائري وتحسين عرض الحزمة الترددية باستخدام برامج (Ansoft HFSS). من اهم النتائج التي حصلنا عليها في الدراسة الحالية هو عرض الحزمة المزدوجة 137.6 MHz و105.8 MHz عند التردد الرنيني المزدوج 4.37 و 5.19 GHzمقارنة مع ٧٣.٧ MHz عرض الحزمة الأحادية للهوائي الشريطي الدائري وكذلك تم حسام كمية الفقد ونسبة الموجة المنعكسة التي كانت بحدود و1.08و 1.138 للترددات الرنينية المزدوجة وتم حساب الهيكل الاشعاعي ثنائي وثلاثي الابعاد وعند للمقارنة مع الهوائي الشريطي الدائري كانت النتائج مقاربة بصورة مثالية عند تقريب ابعاد القطع الى الصفر.

الكلمات المفتاحية: نسبة الموجة المنعكسة ، الهيكل الاشعاعي،عرض الحزمة ،التحصيل ، كمية الفقد.

1. Introduction

A simple microstrip patch antenna consists of metallic patch and ground between them is a dielectric medium called the substrate. The microstrip antennas are one of the most promising technologies in the wireless communication due to their low profile, reduction in size, easy of fabrication, integrability with millimeter ,microwave circuits, communication

purposes especially in military and civilian applications [1, 2].

A number of theoretical and experimental researches have been done to improve the bandwidth of the antenna [3, 4]. Loading of shorting pins and stacking of patches are some techniques utilized to increase the bandwidth of microstrip antennas [5, 6]. Different shapes of slot loading in fed patch can also enhance the antenna bandwidth [7, 8].

In the present paper the multiresonator techniques was utilized by introducing the slots in the patch, which improves the antenna bandwidth. The antenna geometries are presented theoretically, this is a T- slot loaded disk. Both geometries are analyzed using finite element method [9].

Antenna Design

The geometry of single layer MSA, feed by coaxial probe, around in which T-shape slot is shown in Figures (1-a) and (1-b) .

The design of the antenna begins with a circular microstrip antenna with patch radius 15 mm. The substrate chosen for the proposed antenna is FR-4 epoxy with dielectric constant, $\varepsilon_r = 4.4$ and a thickness of 1.6 mm. Two rectangular slots with sizes of $(L_{VS} \times L_{HS} \times T)$ 18 mm × 18 mm × 2 mm were made on the circular patch antenna. The dimensions of the substrate are taken as $(L_S \times W_S \times h)$ 60 × 60 × 1.6 mm^3 and the dimensions of the ground plane is taken as $(L_S \times W_S)$ 60 × 60 mm^2. All dimensions of this proposed antenna are shown in Figure (1) and recorded in table (1).

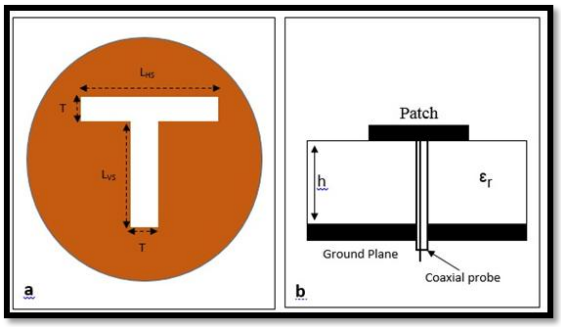

Fig.1. the dimensions of T-s lot loaded CMSA.

Table I: List of design parameters of Antenna.

Parameters	Values
Substrate material	FR4 -epoxy
substrate thickness h	1.6mm
dielectric constant ε_r	4.4
Radius of the disk patch a	15.0mm
substrate size $(L_S \times W_S \times h)$	60×60×1.6 mm^3
Length of the vertical slot L_{VS}	18.0 mm
Length of the horizontal slot L_{HS}	18.0 mm
Thickness of the slots T	2.0 mm
Feed location (x_f, y_f)	(1.55,-6.825) mm

2. Result and Discussion:

Fig. 2 shows the simulated and measured return loss of the T-slot antenna. The measured impedance bandwidth at -10 dB return loss was 105.8 MHz, ranging from 4.328 to 4.4339 GHz, and 137.6 MHz, ranging from 5.12173 to 5.2593 GHz, with a return loss of -28.30 dB, -23.80 dB respectively.

The VSWR values are 1.08 and 1.138 for the corresponding two resonant frequencies indicating a good matching conditions with dual band frequencies shown in Fig (3). Fig. 4 show that the real part of input impedance Zin at resonant frequency (4.37 GHz and 5.19 GHz) is approximately equal to 62 Ω and 68 Ω respectively, while the imaginary part equal to 0.5 and 0.3 which is approximately equal to zero .

Figure (5) and (6) represent 2D and 3D radiation patterns at 4.38 GHz and 5.19 GHz when $\varphi = 0$ & 90 respectively, and

Fig. (7) shown the electric and magnatic current distribution on the circular patch with loaded T-slot.

3. Conclusions

The simulation design T-slot loaded circular disk microstrip patch antenna using Ansoft HFSS Microsoft, at a resonant dual frequency of 4.37 GHz and 5.19 GHz. A dual bandwidth was obtained as 105.8 and 137.6 MHz compared with 73.7 MHz for CMSA and the VSWR values are 1.08 and 1.138 for corresponding two resonant frequencies indicating a good matching conditions with dual band frequencies.

4. Reference

[1] K. R. Carver, "Microstrip Antenna Technology", IEEE Transaction on Antenna and Propagation, vol. 29, pp. 2-24, 1981.

[2] B. K. Kanaujia, and B. R. Vishvakarma, "Design considerations for the development of the annular ring microstrip antenna", International Journal of Electronics, vol. 89- 8, pp. 665-667, 2002.

[3] J.R. Costa, et. al., "Evaluation of a new wideband slot array for MIMO performance enhancement in indoor WLANs," IEEE Trans. Antennas Propag.,vol.59, no.4, pp.1200-1206, April 2011.

[4] M.K.T. Al-Nuaimi, "Mutual coupling evaluation of dual-miniaturized PIFA antenna array for MIMO terminals," European Wireless Conf., pp.1-4, 2011.

[5] J.A Ansari, P. Singh, and N.P. Yadav, "Analysis of shorting pin loaded half disk patch antenna for wideband operation," Progress in Electromagnetics Research C Vol.6, 179-192, Feb 2009.

[6] J.A Ansari, R.B. Ram and P. Singh, "Analysis of a gap-coupled stacked annular ring microstrip antenna," Progress in Electromagnetics Research B Vol.4, pp.147-158, November, 2008.

[7] J.A Ansari, and R.B. Ram, " Broadband stacked U-slot microstrip patch antenna," Progress in Electromagnetics wave Research letters Vol.4, pp.17-24, Sep, 2008.

[8] E. Shigeru, and E. Nishiyama, "Stacked microstrip antenna with wide bandwidth and high gain," IEEE. Trans. Antennas and Propagat .Vol.44, pp.1533-1534, 1996.

[9] Volakis, J. L., Chatterjee, A. and Kempel, L. C., Finite Element Method for Electromagnetics, IEEE Press & Oxford University Press; New York, 1998.

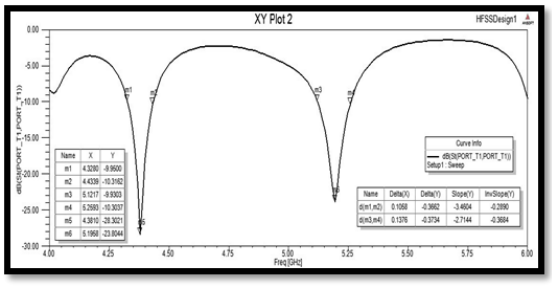

Fig. 2. Return loss for the T-slot loaded CMSA.

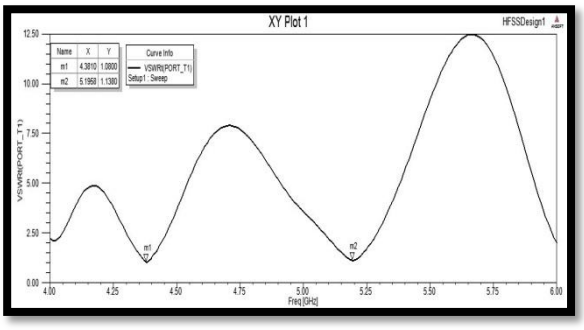

Fig. 3.VSWR of the T-slot loaded patch antenna at the frequency 5.19GHz.

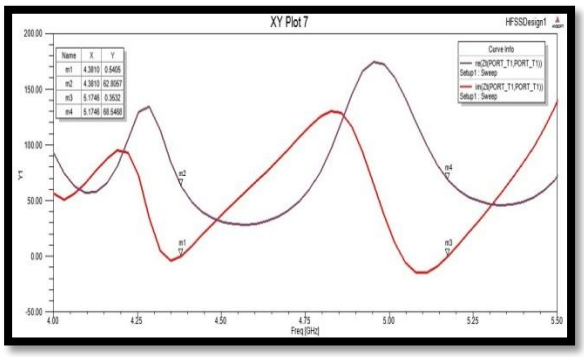

Fig. 4. Real and imaginary part of the input impedance of the proposed antenna.

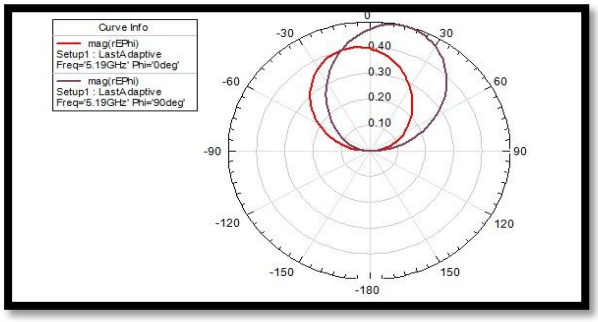

Fig. 5: Radiation pattern of the T-slot loaded patch antenna at 5.19 GHz

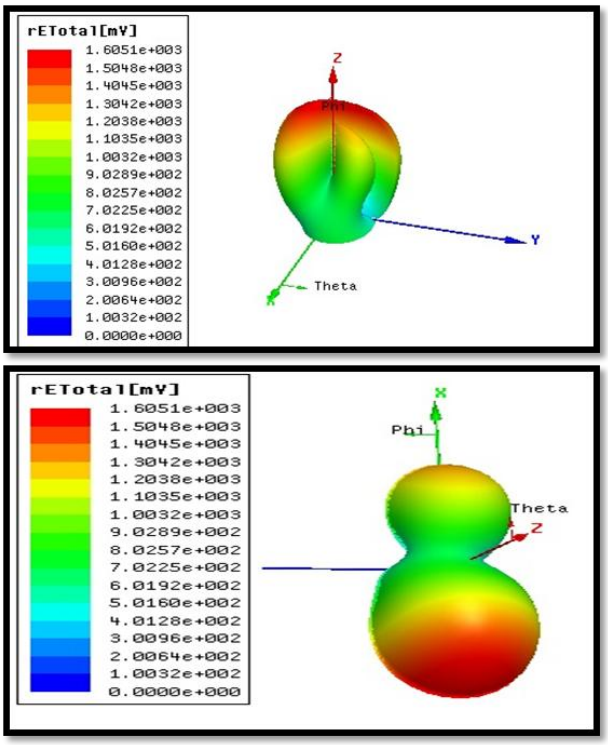

Fig. 6. 3D Radiation Patterns of T-slot loaded patch antenna

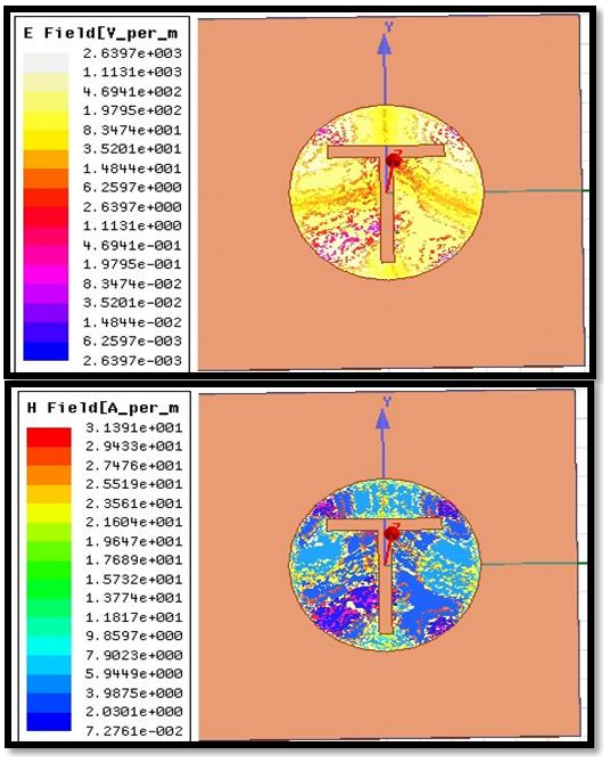

Fig.7. Simulated E&H field distribution for the proposed antenna at 5.19 GHz