Expanding the Bandwidth of Rectangular Microstrip Antenna by Inserting a Slot

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Abstract*— *In this work we were able to improve the reflection coefficient S_{11} and bandwidth BW of a rectangular microstrip antenna fed by a coaxial cable firstly by adjusting a the feed point and secondly by inserting a rectangular slot in the radiating element

The results obtained using the HFSS software, have been compared by those published. These results are very satisfying.

Keywords*— Rectangular *microstrip antenna,* S_{11}, *bandwidth slot.

I. INTRODUCTION

The patch antennas are largely used for wireless telecommunications seen their many advantages as their low profile, light weight, low cost and ease of manufacture. They are extremely compatible to be incorporated in portable wireless devices such as cell phones [1]. But these types of antennas have some disadvantages such us low efficiency [2], a narrow bandwidth, since its width is limited to a few percent (3-6%) [3] which is insufficient for most systems wireless communication.

Several techniques have been proposed to increase the bandwidth of these types antennae, which may be mentioned the use of substrates with higher dielectric constants [4], the increase in thickness of the dielectric substrate [5], the introduction of the slots on the patch antenna [6], the location, size and shape of this slot are parameters that have a significant effect on the operation of the antenna.

One of the most methods used to improve the bandwidth of microstrip patch antennas is introducing a slot at the patch [7].

In this work, we present a planar antenna patch size (61.23x72.8x5,8) mm^3 with a rectangular slot (5x15)mm^2 introduced on its patch deposited by the photoetching method on a substrate of FR4-epoxy whose relative permittivity is: $\varepsilon_r = 4.4$.

The antenna is fed by a coaxial cable, whose resonance frequency is 2.4GHz.

The results for the reflection coefficient S_{11} and the bandwidth BW are very encouraging compared with those published in the literature

II. THEORY AND MODEL

In figure (1) presents the studied antenna diagram, the patch, initially without slot, is deposited on a substrate FR4-epoxy, its relative dielectric constant is 4.4, is fed by a coaxial cable in order to eliminate surface waves and have a good adaptation of the [8] impedance.

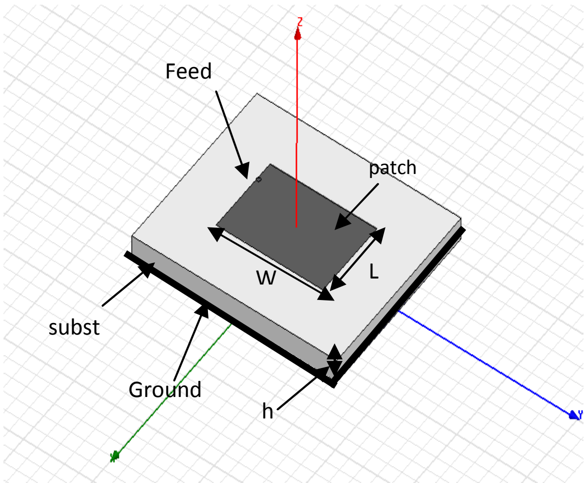

Fig.1 : The studied antenna diagram (h=5.8 mm, ε_r=4.4)

The simplest model to express the operation of a microstrip antenna is that of the transmission line, this model gives a good physical preview, but it is less precise [8]. In this model, the antenna can be represented by two slots dimensional (W x L) and height (h). The dimension W may be calculated from the following equation (1) [9]:

$$w = \frac{c}{2f_r\sqrt{\frac{\varepsilon_r+1}{2}}} \quad (1)$$

This formula can be improved by replacing (ε_r) by (ε_{reff}) [10] which is given by:

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1+12\frac{h}{w}\right) \quad (2)$$

Where h is the height of the substrate,

The actual physical size of patch is given by [9]

$$L = L_{eff} - 2\Delta L \quad (3)$$

Where

$$L_{eff} = \frac{C}{2f_r\sqrt{\varepsilon_{eff}}} \quad (4)$$

and

$$\Delta L = \frac{0{,}412h(\varepsilon_{reff} + 0{,}3)(\frac{w}{h} + 0{,}26)}{(\varepsilon_{reff} - 0{,}258)(\frac{w}{h} + 0{,}8)} \quad (5)$$

For an input impedance in the neighborhood of 50 Ω, a good approximation to the coordinates of the feed point are written: [11]

$$x_f = \frac{L}{2\sqrt{\varepsilon_{eff}}} \quad (6)$$

$$y_f = \frac{W}{2} \quad (7)$$

III. RESULTS AND DISCUSSION

Wi-Fi use by telecommunications a frequency range between 2 GHz and 3 GHz [8], in this work we chose an antenna that works around a central frequency of 2.4 GHz. Based on the values calculated from the theoretical formulas (1-4), we obtain the following parameters of the antenna (Table 1).

Table.1: Theoretically calculated characteristics of the antenna.

W	L	xf	yf
38mm	26.43mm	6.86mm	18.5mm

Figure 2 shows the variation of reflection coefficient S_{11} as a function of frequency, using the parameters listed in Table 1. This curve shows that the resonance frequency f_r is equal to 2.3 GHz with a reflection coefficient S11 = -32.92dB and a bandwidth BW = 275MHz.

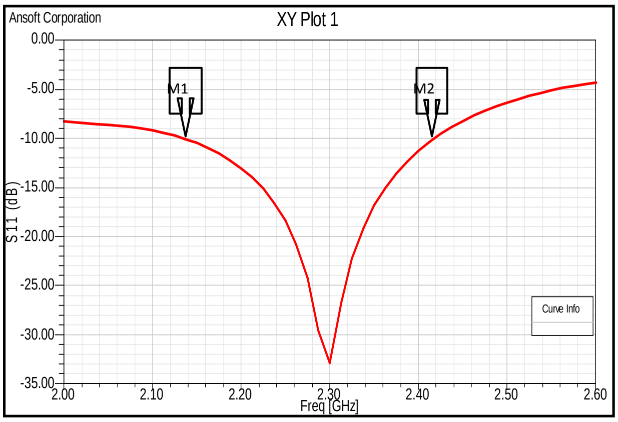

Fig.2: S_{11} and BW of the antenna with the parameters calculated theoretically

The result is less than satisfactory; this is why we opted to change the antenna dimensions and the feed position to obtain a resonant frequency around 2.4 GHz, with values optimum S_{11} and bandwidth.

Figure 3 shows the results obtained we correcting patch size and the feeding position such that: L = 25mm, W = 37mm, x_f = 6.79 mm and y_f = 18mm.

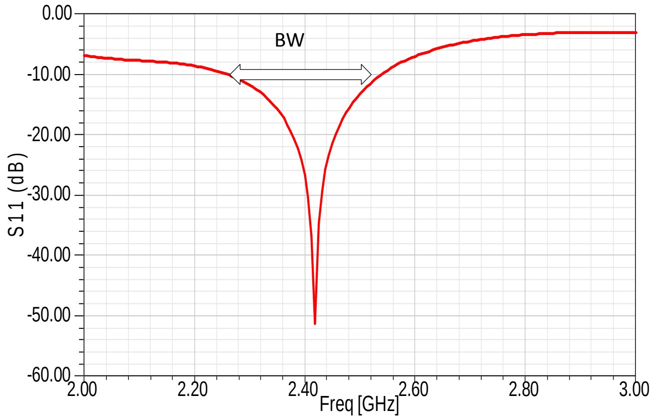

Fig. 3: S_{11} variation as a function of frequency for w = 37mm, L = 25mm, 6.79mm = xf and yf = 18mm

Table 2 shows the results obtained after rectification of the dimensions of the patch and the feed position and those published by [11]. This comparison shows that an improvement in the coefficient of reflection S_{11} and bandwidth.

Antenna characteristics	fr	S_{11}	BW
Results obtained	2.418 GHz	- 51.33dB	275 MHz
Results published by [11]	2.421 GHz	- 42.93dB	177 MHz

However the obtained results of bandwidth can be more improved by inserting a rectangular slot in the patch. Figure 4 shows a diagram of a microstrip antenna with a rectangular slot.

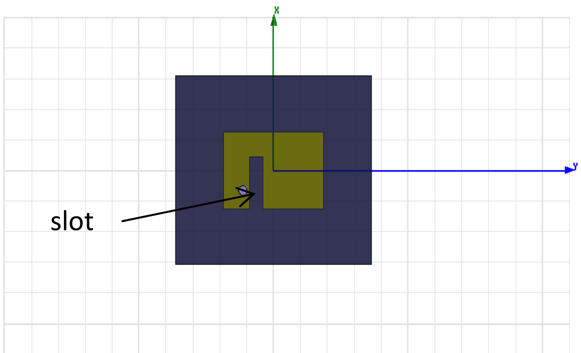

Fig.4: inserting a rectangular slot 5x15 mm^2 on the patch
After adjusting the size and location of the slot, the obtained results are shown in Figure 5.

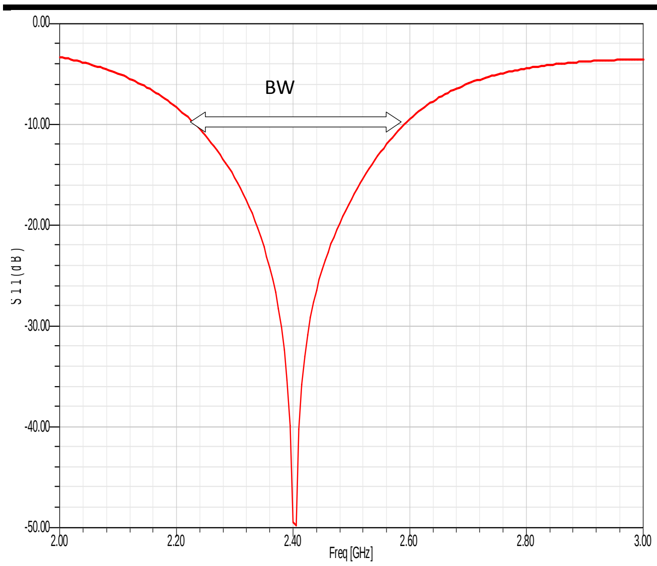

Fig. 5: The reflection coefficeient and bandwidth of the antenna designed with a rectangular slot on the patch.

The parameters of the location and size of the slot that give the best results are respectively (xs, ys) = (1.75mm, -11.5mm) and Lsxws = 15x5mm^2 (Figure 4).

This figure shows that the bandwidth 350 MHz which represents a 22% improvement.

IV. CONCULSION

In this work we studied and optimized functioning of a planar antenna with a rectangular patch fed by a coaxial cable, by adjusting the location of its feed point and inserting a rectangular slot on the radiating element.

The results obtained are remarkable since the antenna operates at 2.4 GHz resonance frequency with a reflection coefficient S_{11} = -49.44 dB bandwidth of 350 MHz or 14.5% of center frequency, what is very satisfactory compared with the one published with other types of feed.

REFERENCES

[1] O. Edvardsson,“On the influence of capacitive and inductive loadingon different types of small patch/PIFA structures for use on mobile phones,” Int. Conf. Antennas Propag., Manchester, U.K, pp. 762–765., Apr. 17–20, 2001.

[2] A. De, C. K. Chosh and A. K Bhattacherjee, “Design and Performance Analysis of Microstrip Patch Array Antennas with different configurations” International Journal of Future Generation Communication and Networking pp. 97-110 Vol. 9, No. 3, 2016.

[3] R. G. Voughan.. Two-port higher mode circular microstrip antennas. IEEE, Trans. Antennas Propagat. 36(3): 309-321. 1988

[4] Parikshit Vasisht , and Taruna Gautam, “ Design of V-Slotted Trapezoidal Patch Antenna in WI-MAX Band Using Optimized Feed Location Method,” IJETAE, ISSN: 2250-2459, Vol. 2,Issue 6,June - 2012.

[5] Robinson and Y. Rahmat-Samii.. Particle Swarm Optimization in Electromagnetic. IEEE Transaction on antennas and propagation. 52(2): 397-407. 2004

[6] A.A.Deshmukh and G. Kumar, “Compact broadband gapcoupled shorted L-shaped microstrip antennas,‖ in IEEE Antennas and Propagation International Symposium, vol 1, (Baltimore, Maryland), pp. 106–109, IEEE, July 2001

[7] Anubhuti Khare, and al. “New Multiband E-Shape Microstrip Patch Antenna on RTDUROID 5880 Substrate and RO4003 Substrate for Pervasive Wireless Communication”, International Journal of Computer Applications (0975 – 8887) Volume 9– No.8, Nov. 2010.

[8] S K Behera, “Novel Tuned Rectangular Patch Antenna As a Load for Phase Power Combining” Ph.D Thesis, Jadavpur University, Kolkata, India.

[9] Antennas Kazi Tofayel Ahmed, Md. Bellal Hossain, Md. Javed Hossain “Designing a high bandwidth Patch Antenna and comparison with the former Patch” Canadian Journal on Multimedia and Wireless Networks Vol. 2, No. 2, April 2011

[10] P. M. T. Ikonen, S. I. Maslovski, C. R. Simovski, and S. A. Tretyakov, “ON ARTIFICIAL MAGNETODIELECTRIC LOADING FOR IMPROVING THE IMPEDANCE BANDWIDTH PROPERTIES OF MICROSTRIP ANTENNAS”, IEEE Transactions on Antennas and Propagation, vol. 54, no. 6, pp. 1654-1662, 2006

[11] Karim A. Hamad “DESIGN AND ENHANCEMENT BANDWIDTH RECTANGULAR PATCH ANTENNA USING SINGLE TRAPEZOIDAL SLOT TECHNIQUE”, ARPN Journal of Engineering and Applied Sciences VOL. 7, NO. 3, MARCH 2012.