Diyala Journal of Engineering Sciences

ISSN 1999-8716
Printed in Iraq

Vol. 03 , No. 01, pp. 16-24 , June 2010

SIMULATION OF RECTANGULAR MICROSTRIP ANTENNA BY INTEGRATING MATLAB IN VISUAL BASIC

Hussain Falih Mahdi

Engineering College , Diyala University
(Received:17-5-2009 ; Accepted:16-11-2009)

ABSTRACT - Microstrip antenna has many applications nowadays. The rectangular microstrip antenna is one of the microstrip antenna types, it can be designed using many softwares. In this paper, a new method was suggested to do the simulation; by integrating Matlab in Visual Basic. Due to the good development of the personal computers, the simulations methods were activated and used widely. No software has the visual window that meets some of our requirements. It is well known that the visual basic is not completely a scientific language, thus, by adding to it a strong scientific ability, it will be very powerful language. This step was done successfully and the rectangular microstrip antenna was simulated in this way.

KEY WORDS:- matlab, visual basic, microstrip antenna, antenna simulation, matlab simulation program, com builder.

1- INTRODUCTION

In high-performance aircraft, spacecraft, satellite, and missile applications, where size, weight, cost, performance, ease of installation, and aerodynamic profile are constraints, and low-profile antennas may be required. Presently there are many other government and commercial applications, such as mobile radio and wireless communications that have similar specifications. To meet these requirements, microstrip antennas can be used. Some of the students that need to do a simulation for a microstrip antenna prefer to do it using visual basic, but when he start; his programming, he will face many complex problems that cannot be programmed simply in visual basic, even so, he needs at least of about 1500 code line to do a very simple simulation. At this point and without dispute he will leave the programming in

visual basic and go directly to Matlab to do his simulation because the Matlab is powerful in this field. Now if the abilities of the Matlab software were added to the visual basic, a very good result we will get as stated in the following sections.

2- RECTANGULAR MICROSTRIP ANTENNA DESIGN THEORY

The rectangular patch is by far the most widely used configuration. It is very easy to analyze using both the transmission-line and cavity models, which are most accurate for thin substrates. We will use the transmission-line model because it is easier to illustrate and simulate. It was indicated earlier that the transmission-line model is the easiest of all but it yields the least accurate results and it lacks the versatility. However, it does shed some physical insight, a rectangular microstrip antenna can be represented as an array of two radiating narrow apertures (slots), each of width (*W)* and height (*h)*, separated by a distance (*L)*. Basically the transmission-line model represents the microstrip antenna by two slots, separated by a low-impedance Z_c transmission line of length *L*. Because the dimensions of the patch are finite along the length and width, the fields at the edges of the patch undergo fringing. This is illustrated along the length in Figures 1 (a, b) for the two radiating slots of the microstrip antenna. The same applies along the width. The amount of fringing is a function of the dimensions of the patch and the height of the substrate. For the principal E-plane (xy-plane) fringing is a function of the ratio of the length of the patch *L* to the height *h* of the substrate (*L*/*h*) and the dielectric constant ε_r of the substrate. Since for microstrip antennas *L*/*h* >> 1, fringing is reduced; however, it must be taken into account because it influences the resonant frequency of the antenna. The same applies for the width. Since some of the waves travel in the substrate and some in air, an effective dielectric constant ε_{reff} is introduced to account for fringing and the wave propagation in the line. The effective dielectric constant is also a function of frequency. As the frequency of operation increases, most of the electric field lines concentrate in the substrate. Therefore the microstrip line behaves more like a homogeneous line of one dielectric (only the substrate), and the effective dielectric constant approaches the value of the dielectric constant of the substrate. For low frequencies the effective dielectric constant is essentially constant. At intermediate frequencies its values begin to monotonically increase and eventually approach the values of the dielectric constant of the substrate. The initial values (at low frequencies) of the effective dielectric constant are referred to as the static values [1], and they are given by

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-1/2} \qquad \text{…..(1)}$$

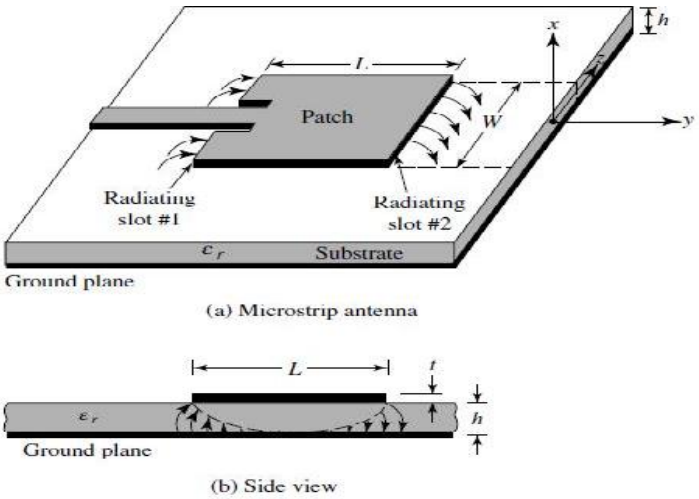

Fig. (1):- Rectangular Microstrip Antenna (a), and its side view (b)

Because of the fringing effects, electrically the patch of the microstrip antenna looks greater than its physical dimensions. For the principal E-plane (xy-plane), this is demonstrated in Figure 2 where the dimensions of the patch along its length have been extended on each end by a distance ΔL, which is a function of the effective dielectric constant ε_{reff} and the width-to-height ratio (W/h). A very popular and practical approximate relation for the normalized extension of the length is [1]

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)} \qquad \text{.....(2)}$$

Since the length of the patch has been extended by ΔL on each side, the effective length of the patch is now ($L = \lambda/2$)

$$L_{eff} = L + 2\Delta L \qquad \text{.....(3)}$$

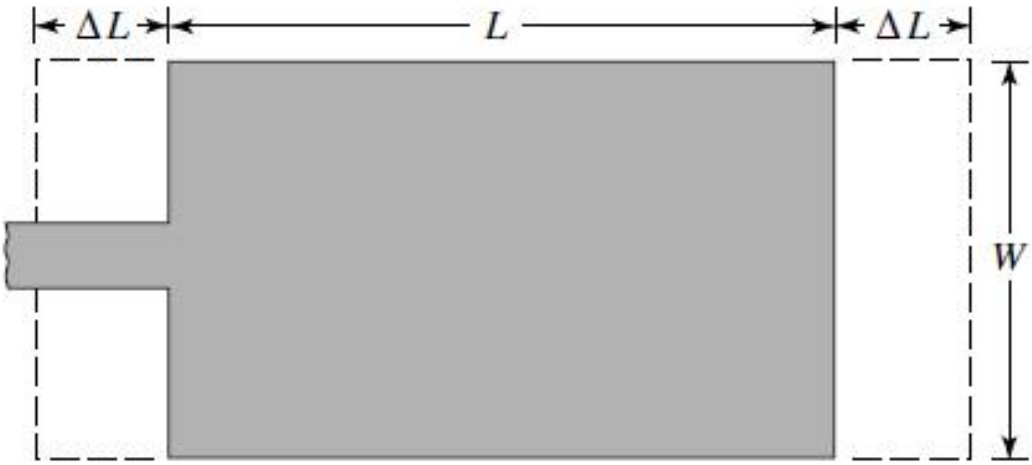

Fig. (2):- Physical and effective length of rectangular microstrip patch

For an efficient radiator, a practical width that leads to good radiation efficiencies is

$$W = \frac{1}{2f_r\sqrt{\mu_o \varepsilon_o}}\sqrt{\frac{2}{\varepsilon_r+1}} = \frac{v_o}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \qquad .....(4)$$

Where υ_0 is the free-space velocity of light.

Using modal expansion analysis, the input resistance for the inset feed is given approximately by [1]

$$R_{in}(y = y_o) = \frac{1}{2(G_1 \mp G_{12})}\left[\cos^2\left(\frac{\pi}{L}y_o\right) + \frac{G_1^2+B_1^2}{Y_c^2}\sin^2\left(\frac{\pi}{L}y_o\right) - \frac{B_1}{Y_c}\sin\left(\frac{2\pi}{L}y_o\right)\right] \qquad .....(5)$$

Where Y_c=1/Z_c, and Z_c is given by [1]

$$Z_c = \begin{cases} \frac{60}{\sqrt{\varepsilon_{reff}}} ln\left[\frac{8h}{W_o} + \frac{W_o}{4h}\right], & \frac{W_o}{h} \le 1 \\ \frac{120\pi}{\sqrt{\varepsilon_{reff}}\left[\frac{W_o}{h} + 1.393 + 0.667 ln\left(\frac{W_o}{h} + 1.444\right)\right]}, & \frac{W_o}{h} > 1 \end{cases} \qquad .....(6)$$

Where W_0 is the width of the microstrip line, G_{12}, G_1, and B_1 can be calculated using [1]

$$G_{12} = \frac{1}{120\pi^2}\int_0^{\pi}\left[\frac{\sin\left(\frac{k_o W}{2}\cos\theta\right)}{\cos\theta}\right]^2 J_o(k_o L \sin\theta)\sin^3\theta\, d\theta \qquad .....(7)$$

$$G_1 = \frac{W}{120\lambda_o}\left[1 - \frac{1}{24}(k_o h)^2\right] \qquad \frac{h}{\lambda_o} < \frac{1}{10} \qquad .....(8)$$

$$B_1 = \frac{W}{120\lambda_o}[1 - 0.636 ln(k_o h)] \qquad \frac{h}{\lambda_o} < \frac{1}{10} \qquad .....(9)$$

The far-zone electric fields radiated by each slot, using the equivalent current densities are written as [1]

$$E_r \cong E_\theta \cong 0 \qquad .....(10)$$

$$E_\emptyset^t = j\frac{2hE_o}{\pi r}\left\{\sin\theta\frac{\sin\left(\frac{k_o W}{2}\cos\theta\right)}{\cos\theta}\right\}\cos\left(\frac{k_o L_e}{2}\sin\theta\sin\emptyset\right) \qquad .....(11)$$

The directivity of the rectangular microstrip antenna can be expressed as [1]

$$D = \begin{cases} 6.6\ (dimensionless) & for\ W \ll \lambda_o \\ 8\left(\frac{W}{\lambda_o}\right) & for\ W \gg \lambda_o \end{cases} \qquad .....(12)$$

The E- and H-plane beamwidths, can be approximated [1] by

$$E - HPBW = 2\cos^{-1}\sqrt{\frac{7.03\lambda_o^2}{4(3L_e^2+h^2)\pi^2}} \qquad .....(13)$$

$$H - HPBW = 2\cos^{-1}\sqrt{\frac{1}{2+k_o W}} \qquad .....(14)$$

3- INTEGRATING MATLAB WITH VISUAL BASIC

Visual basic itself is a powerful visually programming language, but to do for example a plotting program for a sine wave signal we will need to do the plot of the axes, the grid if required, the numbering of the axes and the very important feature which is the auto scale for the axes. If it is needed to print the resultant picture of the simulation, we will need to add this facility to the picture window by programming it from the very principle, if a rotation for the picture was required, also must be added by programming it from the principle steps. Many others facilities may be needed in the results window and all must be added by programming it. All these problems need more time to be done. Certainly the person who need to do a simulation program, do not have much time, so that, he will use another language that provide these facilities as built in. The above is for the visual problems only. Now for the scientific programming, such as, numerical integration, system equations, matrix multiplications, matrix inversion, matrix factorization and hundreds of the mathematical operations all are not available in visual basic and to do programming for one of these operations such as the matrix inversion, a huge number of line code will be required to complete it and I am sure, the results will not be very accurate if it is compared to Matlab. The Matlab is the abbreviation of Matrix Laboratory [(5)], it has a lot of built in mathematical operations and all are very accurate and strong [(5)] as well as, it have the ability for visualization but it is very limited compared with visual basic, in other words, it is not flexible as that in visual basic therefore, visual basic will be a very good environment to build such a programs. There is a method in Matlab that can distribute the Matlab programs to other languages such as the visual C++ and visual basic. Unfortunately, not all the programmers do have any knowledge about this facility; it is called the Matlab COM builder [(5)]. By using this tool, integrations can be accomplished with other programming languages that support the COM tool [(5)]. In this paper, we did such integration in steps starting at the programming our mathematical simulation and save it as a Matlab m-file and build the COM using the COM builder in Matlab and make a reference in visual basic to this function (in our program for this paper it was named Microstrip_3) and call it using the visual basic code as a last step. This operation, adds many abilities to visual basic and the code to do a Rectangular patch Microstrip antenna simulation in visual basic, was reduced in a ratio of about 80%. This big ratio will save more time and will give the programmer to put many other things for the interfacing window. Many authors [(3,4,5)] did simulations for the microstrip antennas and other microstrip devices but in a languages of not visually interfacing with the users. Our simulations will have a visual interfacing window as shown in figure 3.

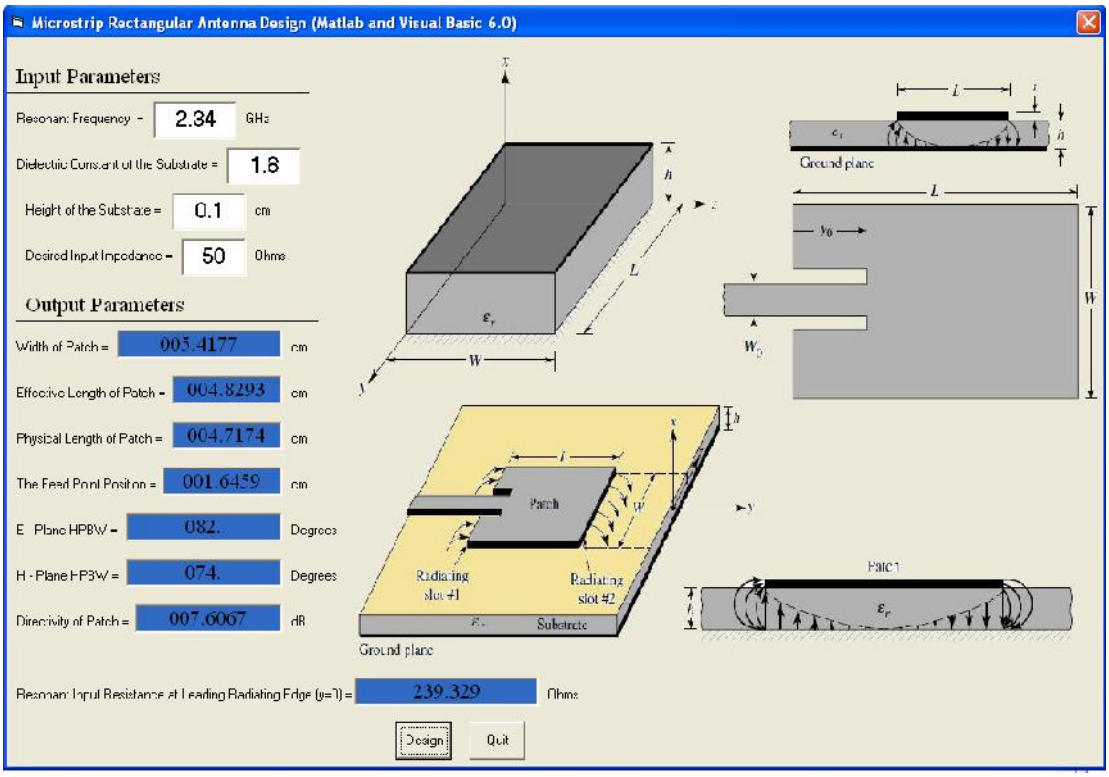

Fig. (3):- Design of rectangular microstrip antenna

4- RECTANGULAR MICROSTRIP ANTENNA SIMULATION IN VISUAL BASIC

The rectangular microstrip antenna patch was designed in Matlab and the design program converted to a function of resonance frequency, dielectric constant, substrate height, and the desired input impedance Z_{in}. As shown in the design window of the visual basic program in figure 1. The Matlab function was converted to a standalone file this called from inside visual basic. The function name was Microstrip_Rectangular. This function can take the above mentioned four parameters and give eight outputs which are the width of patch in centimeter, the effective length of patch in centimeter, the physical length of the patch in centimeters, directivity of the patch in decibel, the feed point position in centimeter, the E-plane half power beam width, the H-plane half power beam width, and the resonant input resistance at leading radiating edge y=0. All these output parameters are shown in figure 1, also there are other outputs which are the plots of the E and H plane patterns of the rectangular microstrip antenna and the plot of the radiation patterns in decibel with respect to

the angle θ in degrees and the angle φ in degrees. These plots are shown in figure 4 and 5 respectively.

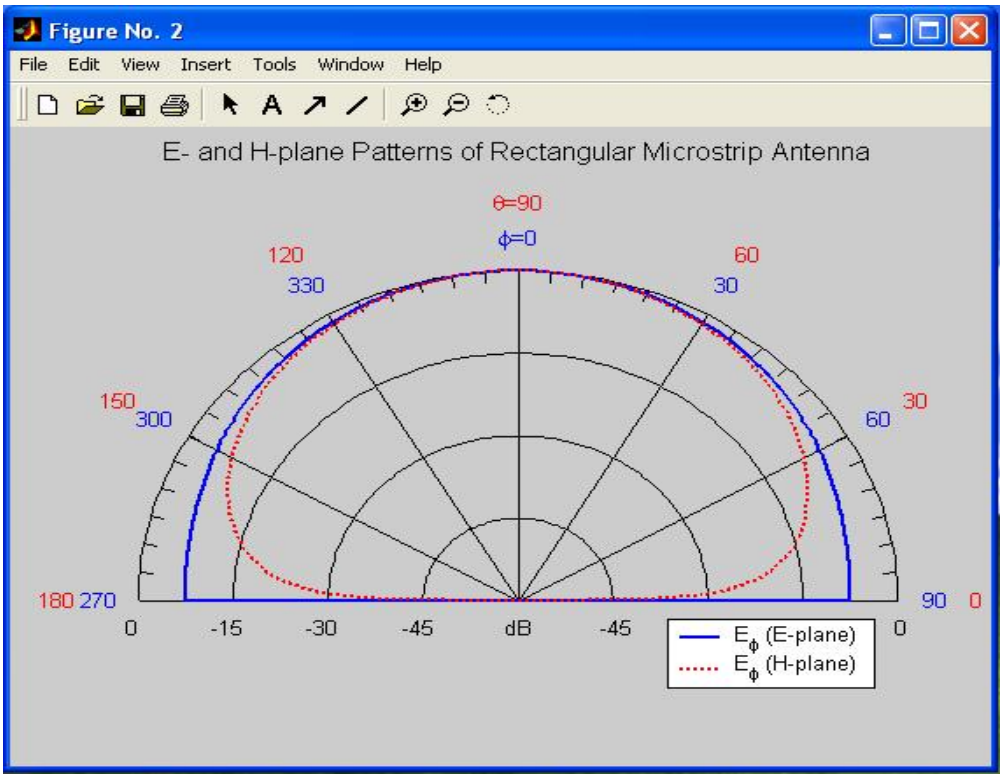

Fig. (4):- the E- and H- plane patterns of the rectangular Microstrip Antenna

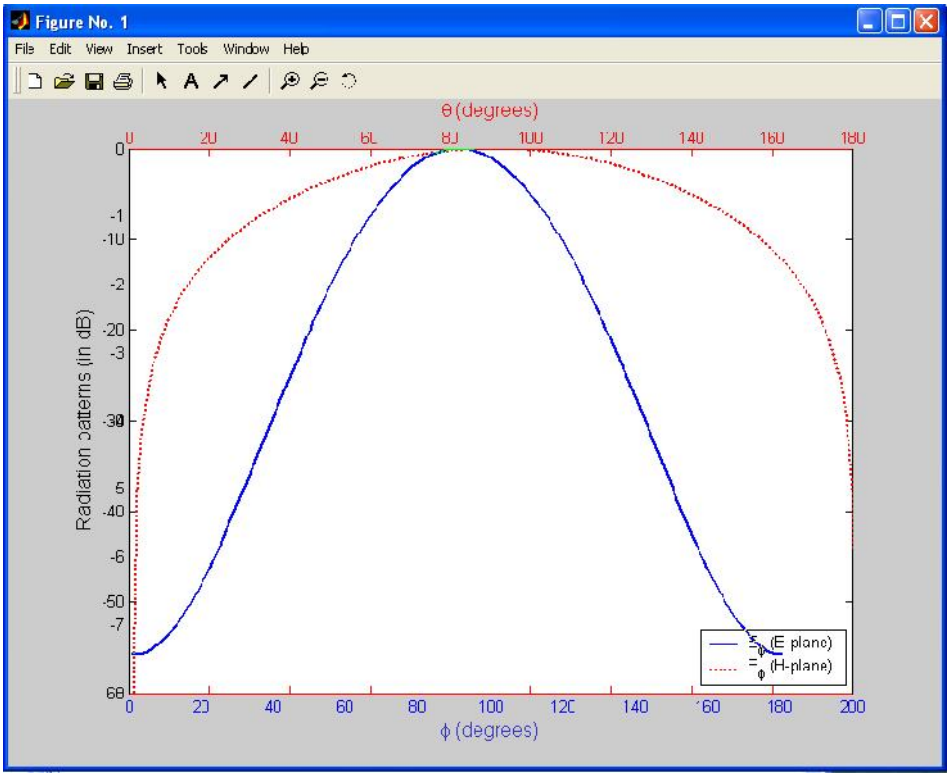

Fig. (5):- the radiation patterns verses θ and φ

4- CONCLUSIONS

The rectangular microstrip antenna has many mathematical calculations as was stated in the sections above such as the Bessel function j_o and the sinc function and the numerical integrations, all were done by Matlab within the Matlab function [W, Leff, L, EHPBW, HHPBW, DirdB, Y, Rin0] = rect (freq,er,h,zin), about 48 other sub functions which are already built in Matlab was used and the total function rect was converted to a standalone file and called by visual basic. This reduces the amount of the required code for the simulation or the design by a very good ratio. The results were very accurate and very clear to the reader and in a nice interfacing window for the user (as it was stated in section (3).

6- REFERENCES

1. Constantine A. Balanis, “Antenna Theory Analysis and Design”, Third Edition, © 2005 by John Wiley & Sons.
2. Matlab formal web site www.mathworks.com.
3. Dons I. Wu’, and John Huang, “CAD and Optimization of Circularly-Polarized Microstrip Arrays”, 0-7803-2009-3/94/4.00 © 1994 IEEE.
4. Marcano. C.Terret, L. M. Diaz and B. Allocca, “CAD FOR THE SYNTHESIS OF RECTANGULAR MICROSTRIP ANTENNAS”, SBMOlIEEE h4lT-S uIIOC'95 Proceedings.
5. Jian-X. Zheng, “Electromagnetic Simulation of Microstrip Patch Antennas”, 0-7803-20093/94/$4.00 0 1994 IEEE.

تصميم هوائي الشريحة الدقيقة المستطيلة بواسطة تكميل الفجوال بيسك بالماتلاب

حسين فالح مهدي

مدرس مساعد

كلية الهندسة . جامعة ديالى

الخلاصة

إن هوائي الشريحة الدقيقة له العديد من التطبيقات في هذه الأيام. الشكل المستطيل لهوائي الشريحة الدقيقة هو احد أنواع هوائيات الشريحة الدقيقة. يمكن تصميم هذا النوع باستخدام عدة برامجيات. في هذا البحث اقترحت طريقة جديدة للمحاكاة وذلك بدمج الماتلاب (Matlab) بلغة الفجوال بيسك (Visual Basic). من المعروف إن الفجوال بيسك هو لغة برمجة ليست علمية بشكل كامل، ولذلك إذا تم إضافة إمكانية برمجة علمية سوف يمكن الحصول على لغة برمجة قوية جدا. تم تنفيذ هذه الخطوة بنجاح وتمت محاكاة الهوائي الشريحة الدقيقة المستطيل الشكل بهذه الطريقة الناتجة من دمج الماتلاب بالفجوال بيسك.