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 \(\varepsilon_r\) 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 \(\varepsilon_{\text{eff}}\) 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

\[
\varepsilon_{\text{eff}} = \frac{\varepsilon_{r}+1}{2} + \frac{\varepsilon_{r}-1}{2} \left[1 + 12 \frac{h}{W}\right]^{-1/2}
\]

.....(1)
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 $\Delta L$, which is a function of the effective dielectric constant $\varepsilon_{\text{reff}}$ and the width-to-height ratio $W/h$. A very popular and practical approximate relation for the normalized extension of the length is [1]

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

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

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

For an efficient radiator, a practical width that leads to good radiation efficiencies is
Where \( v_0 \) is the free-space velocity of light.

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

\[
R_{in}(y = y_c) = \frac{1}{2(g_{12} + 1)} \left[ \cos^2 \left( \frac{\pi}{L} y_c \right) + \frac{c^2 + e^2}{r_c^2} \sin^2 \left( \frac{\pi}{L} y_c \right) - \frac{r_c}{r_c} \sin \left( \frac{2\pi}{L} y_c \right) \right] \quad \text{(4)}
\]

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

\[
Z_c = \begin{cases} \frac{60}{\sqrt{\epsilon_{reff}}} \ln \left[ \frac{8h + W_0}{W_0 + 4h} \right], & \frac{W_0}{h} \leq 1 \\ \frac{60}{\sqrt{\epsilon_{reff}}} \left[ W \frac{W_0}{h} + 1.393 + 0.667 \ln \left( \frac{W \frac{W_0}{h} + 1.44} \right) \right], & \frac{W_0}{h} > 1 \end{cases} \quad \text{(5)}
\]

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

\[
G_{12} = \frac{1}{125 \pi^2} \int_0^\infty \left[ \sin \left( \frac{k_0 W \cos \theta}{\cos \theta} \right) \right]^2 J_\alpha \left( k_\alpha L \sin \theta \right) \sin^2 \theta \, d\theta \quad \text{(6)}
\]

\[
G_1 = \frac{W}{120 k_\alpha} \left[ 1 - \frac{1}{24} \left( k_\alpha h \right)^2 \right] \quad \frac{h}{\lambda_\alpha} < \frac{1}{10} \quad \text{(7)}
\]

\[
B_1 = \frac{W}{120 k_\alpha} \left[ 1 - 0.636 \ln \left( k_\alpha h \right) \right] \quad \frac{h}{\lambda_\alpha} < \frac{1}{10} \quad \text{(8)}
\]

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

\[
E_r \equiv E_\theta \equiv 0 \quad \text{(9)}
\]

\[
E^z = j \frac{2k_\alpha E_0}{\pi r} \left[ \sin \theta \sin \left( \frac{k_\alpha W \cos \theta}{2 \cos \theta} \right) \right] \cos \left( \frac{k_\alpha z}{2} \sin \theta \sin \phi \right) \quad \text{(10)}
\]

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

\[
D = \begin{cases} 6.6 \quad \text{for } W \ll \lambda_\alpha \\ \frac{B_1}{W} \quad \text{for } W \gg \lambda_\alpha \end{cases} \quad \text{(11)}
\]

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

\[
E - \text{HPBW} = 2 \cos^{-1} \left[ \frac{0.03 \lambda_\alpha}{\sqrt{31^2 + h^2 + 1^2}} \right] \quad \text{(12)}
\]

\[
H - \text{HPBW} = 2 \cos^{-1} \left[ \frac{1}{2 + k_\alpha W} \right] \quad \text{(13)}
\]
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, it has a lot of built in mathematical operations and all are very accurate and strong 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. By using this tool, integrations can be accomplished with other programming languages that support the COM tool. 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 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 $\theta$ in degrees and the angle $\phi$ 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 $\theta$ and $\phi$
4- CONCLUSIONS

The rectangular microstrip antenna has many mathematical calculations as was stated in the sections above such as the Bessel function $j_0$ and the sinc function and the numerical integrations, all were done by Matlab within the Matlab function $\text{[W, Leff, L, EHPBW, HHPBW, DirdB, Y, Rin0]} = \text{rect (freq,er,h,zin)}$, 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

تصميم هوائي الشريحة الدقيقة المستطيلة بواسطة تكمل الفجوال بيسك بالماتلاب

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الخلاصة
إن هوائي الشريحة الدقيقة له العديد من التطبيقات في هذه الأيام. الشكل المستطيل لهوائي الشريحة الدقيقة هو أحد 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 جداً.

تم تنفيذ هذه الخطوة بنجاح وتمت محاكاة الهوائي الشريحة الدقيقة المستطيل الشكل بهذه الطريقة الناتجة من دمج الماتلاب بالفجوال بيسك.