Simulation of Parameters on the Planar Array Microstrip Antenna

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Summary:

Microstrip antennas, being low-profile and lightweight, are becoming popular for various applications. In this work, arrays of rectangular patch microstrip antennas are presented here to study the effect of such an array on the radiation pattern in both the E- and H-plane with different patch dimensions and trequencies. The effect is unequally spaced between patches are also studied.

1. Introduction:

Microstrip antennas (MSAs) have a simple geometry and are increasingly used in numerous applications. That's why the methods for their analysis have been studied by many investigators.(1-4) They can be

Classified under two categories: rigorous solutions based on the sommerfield integral and approximate ones using the fringing field under the line.

Array microstrip antennas (AMSA) of high gain are used as a feeder for reflected antennas. 161. The other application of AMSA is for a millimeter-wave near-range radar sensor operating at 77 GHz, simulation of the antenna structure, performed using software based on the method of moments. 17. Printed MSA and array are known to have limitations in terms of bandwidth and efficiency, all imposed by the very presence of the dielectric substrate. Recently, a new type of AMSA is reported: it consists of a circuit, which includes only the metalization part of the printed circuit suspended over the ground plane (*).

2. Basic Structure:

A rectangular patch microstrip antenna coordinate system and cavity are shown in Fig. (1).

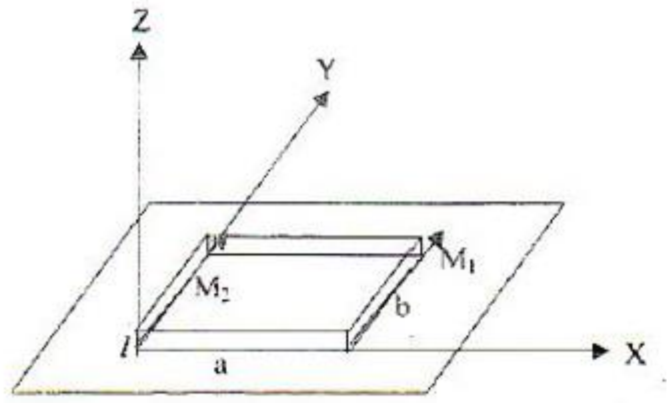


Fig. (1): Coordinate system and cavity of microstrip antenna.

In order to achieve a complete mathematical treatment, the simple cavity model is used, which is; the E-field has only the z component while the H-field only the x and y component. Both E and H-field are independent of the z coordinate for all frequencies, and the tangent component of the H-field along the edge has a negligible value.

The simple cavity model can be applied for patch antennas because they have very small dimensions along the y-axis. The field inside the cavity represents a

Superposition of all Tmno modes, the z-directed component for E-field can be measured as

$E.\ (\pi.\nu) = \Sigma\Sigma_{FE}\ (x,y)$

(1)

where Firm is the mode amplitude and en(x,y) is the directed orthonormalized E-field mode vector. The z component of E-field with respect to cavity model is written in the form

F. E cosk xcoskycosk, $_{z}$

(2)

while the x and y components of the H-field are

$H\,\frac{jo}{\varepsilon}$ cosk x sinkycosk

(3)

kE sin kxcos kycosk

(4)

$H\,\frac{j\omega}{\varepsilon}$

Where

$$K\frac{mn}{a}$$

$$K\frac{n\pi}{b}$$

$$K\frac{p\pi}{1}$$

$K_{ang} = k_{w} + k_{n} + k$

(5)

where k and k are the propagation constants in the x and y directions, and & is the dielectric constant of the substrate, while o is the angular frequency. For the dominant mode TM, we only have a magnetic current on the edge, defined by the general relation MxE, where F_1 is the electric field into aperture at the edge and is the outgoing unit vector from the edge, where

M_1 = -2x E = j2E.(x, y)

M2 = -2x E = j2E.(x, y)

(6)

are surface magnetic currents in the plane of x=0 and x=a, while at y=0 and y-b M-$_{M2}$-0, radiating in free-space

3. Far field components:

In order to analyze the radiating properties of microstrip patch antennas, we will assume the coordinate system as shown in Fig.(2).

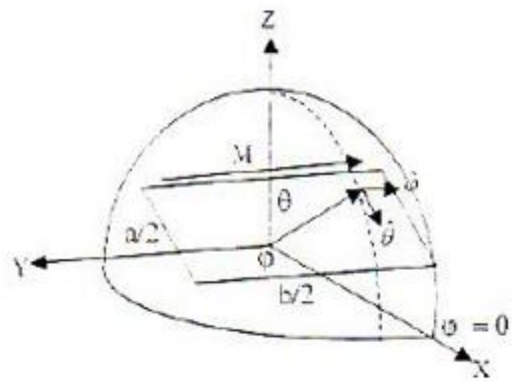


Fig. (2): Coordinate system of microstrip patch, after

The radiated fields in the Fraunhover zone have the expressions. [171]

$$E_\theta = -\frac{jk}{2\pi r} e^{-jkr} E_0 \int \int e^{[illegible]}\left(e^{-\frac{k_0 a \sin\theta \cos\varphi}{2}} + e^{\frac{k_0 a \sin\theta \cos\varphi}{2}}\right) dx\,dy \cos\varphi$$

(7)

$$E_{\varphi}=-\frac{jk}{\pi r}e^{-jkr}E_{o}\int_{0}^{t}\int_{-W/2}^{W/2}e^{jk_{o}y\sin\theta\cos\varphi}\left(e^{-\frac{jk_{o}L\sin\theta\cos\varphi}{2}}+e^{\frac{jk_{o}L\sin\theta\cos\varphi}{2}}\right)dydx\cos\theta\sin\varphi \tag{8}$$

where E, k, are the exited field and propagation constant in the free spectrum, respectively. (0, o and r) and t are the far field point component and substrate thickness of the microstrip, respectively.

4. Planar Array microstrip antenna:

The diagram of a planar array antenna is shown in Fig.(3).

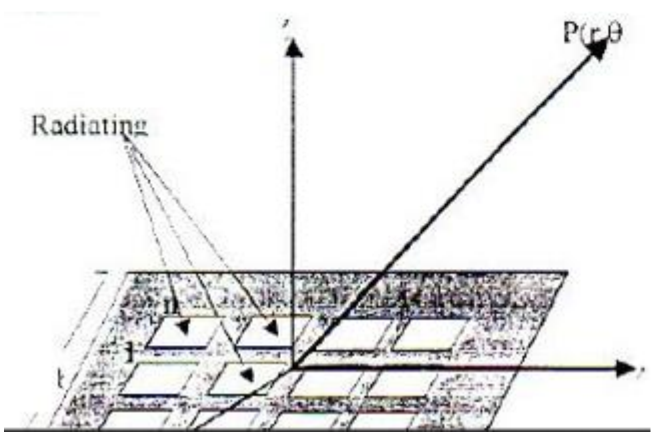


Fig. (3): Planar array microstrip antennas

The radiation field for an array antenna is found by multiplying the array factor with the radiation pattern of one element. The array factor for a planar array with m elements on the x-coordinate and n elements on the y-coordinate is given by

$$E_{array} = E_{o} \sum_{m=1}^{M} e^{[illegible]} \sum_{n=1}^{N} e^{[illegible]} \qquad (9)$$

where o is the phase factor between two elements, and dx and dy are the distances between two consecutive elements along the x- and y-axes, respectively. E is the radiated field by a patch.

5. Numerical results:

To study the behavior and radiation properties of the rectangular patch microstrip antenna, Equations (7) and (8) are simulated by a computer model to calculate the radiation pattern in the far-zone. The simulation method is done by solving Eqs. (7) and (8) numerically using the Simpson method to solve the double integral

To check the validity of our simulation the parameters of microstrip antenna are a = 14.3 mm b = 9.5 mm h = 2 mm and f = 1.8 GHz. Fig.(4) shows the radiation pattern for both E and H-plane

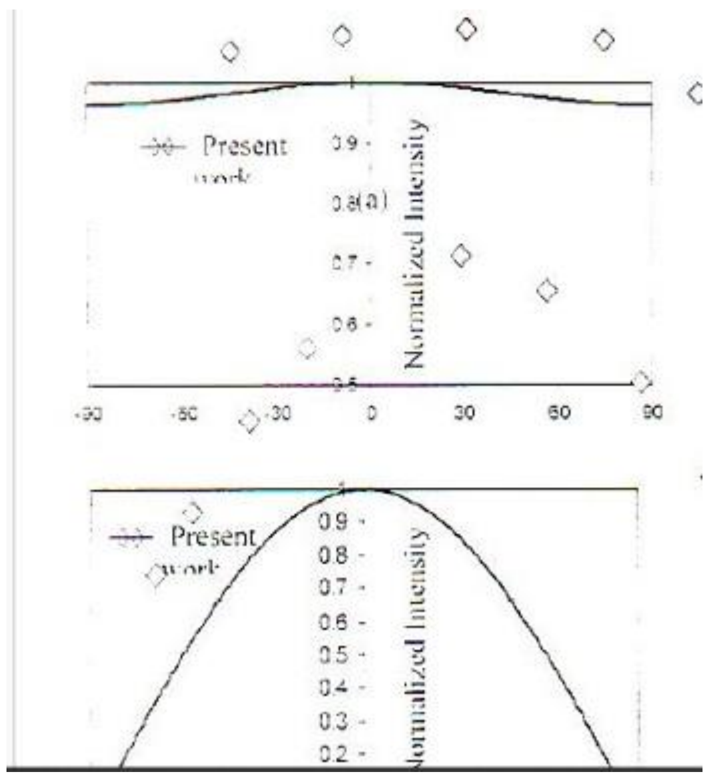


Fig. (4): Radiation pattern (a) E-plane (b) Il-plane for a rectangular patch microstrip antenna of a = 14.3 nm b = 9.5 mm h-2 mm at f = 1.8 GHz, after (7)

In case of showing the effect of frequency change. Fig. (5) demonstrates the radiation pattern for the same patch dimensions with f = 2.4 GHz, note that the figures are normalized

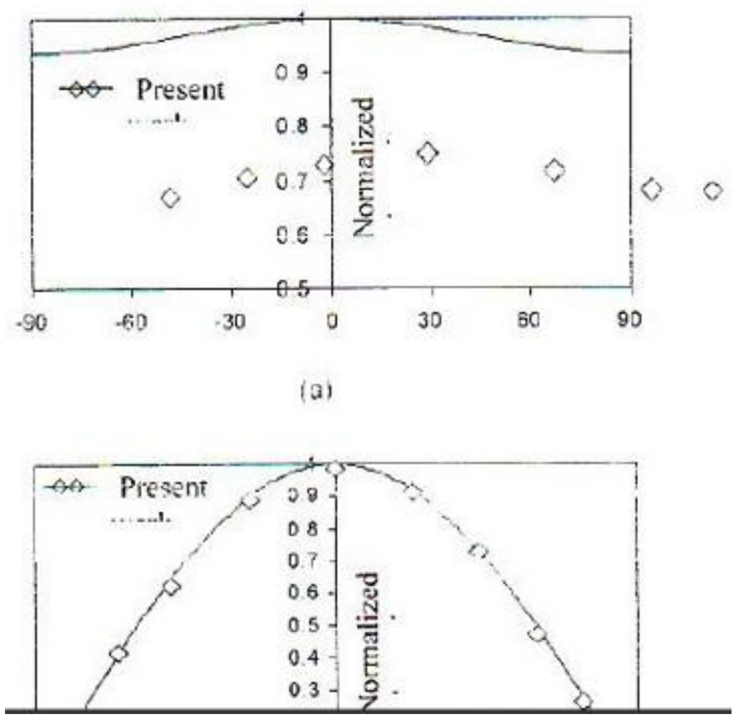
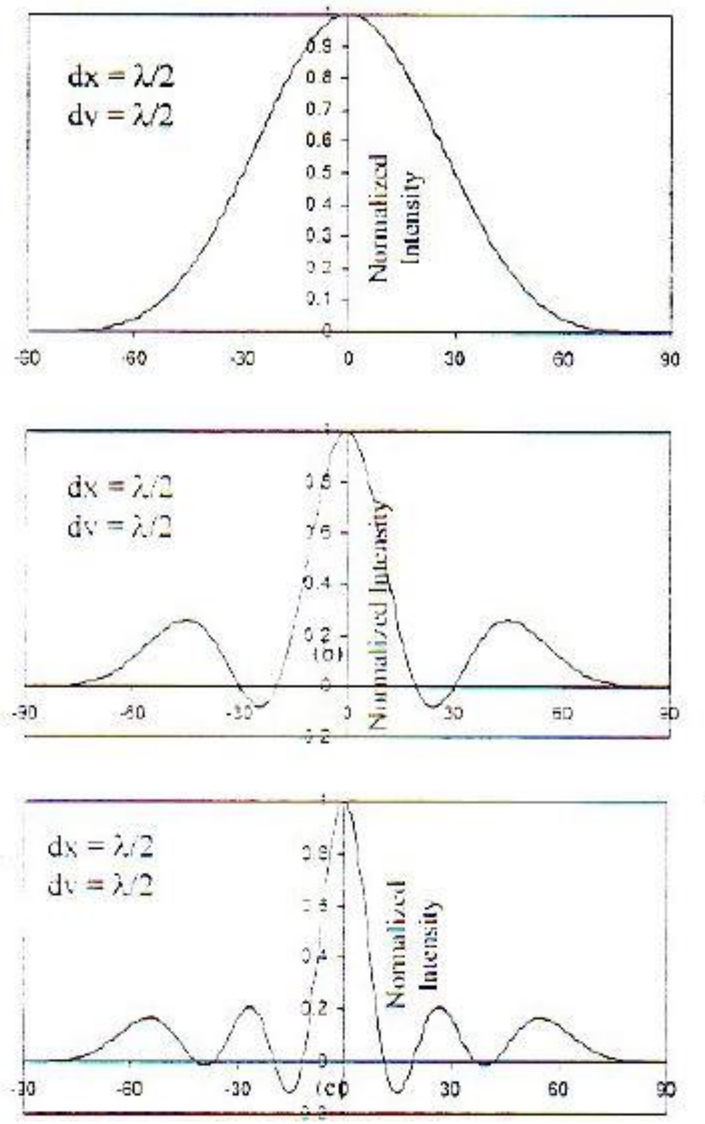


Fig. (5): Radiation pattern (a) E-plane (b) H-plane for a rectangular patch microstrip antenna of a = 14.3 mm b = 9.5 mira h-2 mm at f = 2.4 GHz, after (7).

From figures (4) and (5), the radiation pattern is sensitive to the frequency in directivity and efficiency.

To study the effect of the number of the planar array on the radiation pattern, Fig. (6) shows the radiation pattern of 4, 16, and 36 elements in the E-plane at f = 1.8 GHz



dx = λ/2
dy = λ/2
Normalized Intensity
-90
-60
-30
0
30
60
90
(b)
(c)

Fig. (6): Radiation pattern of the planar array of rectangular patch microstrip antenna of (a) 2x2 elements, (b) 4x4 elements, and (c) 6x6 elements.

It is clear from the above figures (5) and (6) that the radiation pattern is enhanced with increasing the number of patches, and it should also be noted here that all the figures are normalized.

Fig. (7) represents the radiation pattern of the above structure with 1 = 2.4 GHz

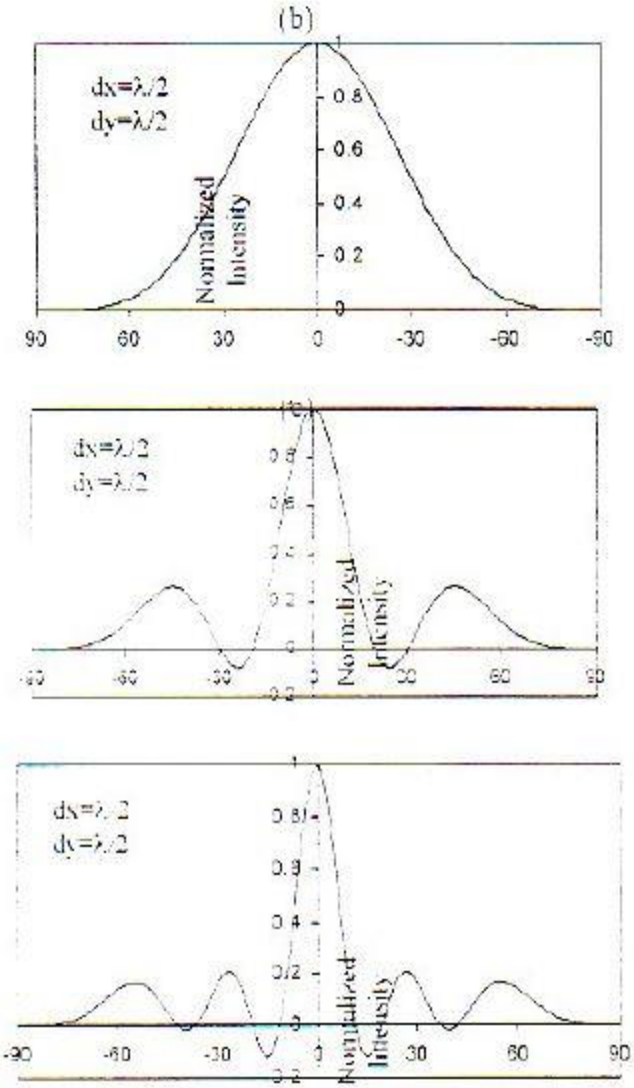
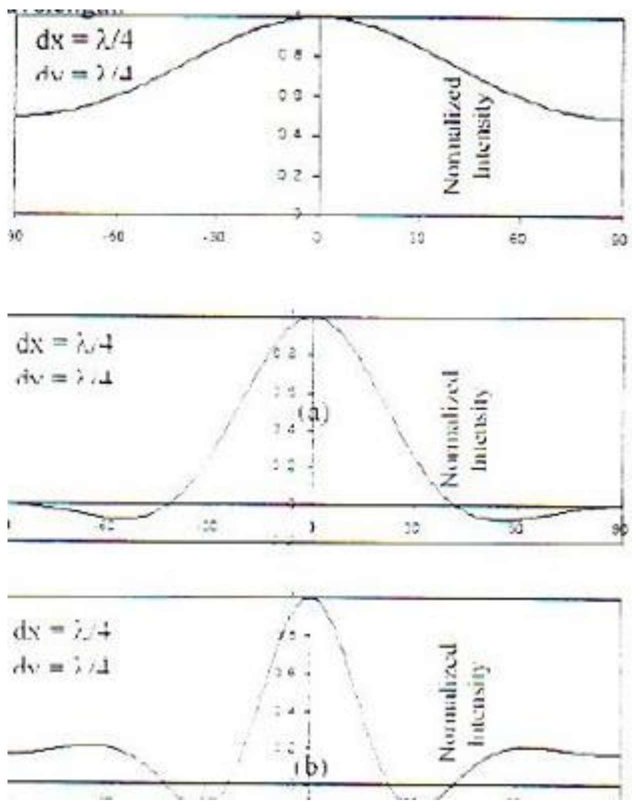


Fig.(7): Radiation pattern of the planar array of rectangular patch microstrip antenna of (a) 2x2 elements, (b) 4x4 elements and (c) 6x6 elements.

Fig.(8) shows the radiation pattern of planar array as display in figure (7) with one difference that is the space between elements dx and dy equal to quarter wavelength.



In case of unequally spaced array elements, Fig.(9) and Fg.(10) depicts the radiation pattern of 4x4 planar array rectangular patch microstrip antennas with dx = 2/2, dy=1/4 and dx = 2/4, dy = 2/2 respectively with h=2 mm and f= 1.8 GHz in q=0.

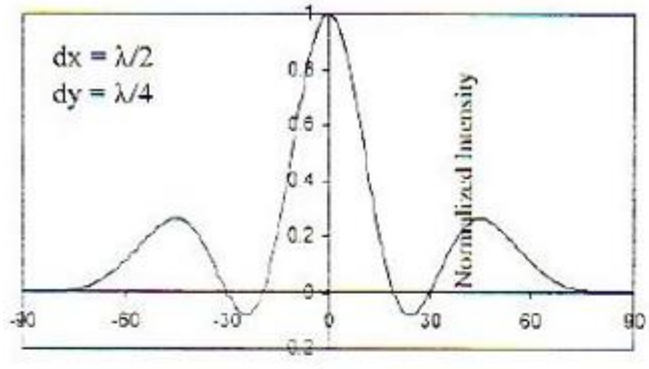
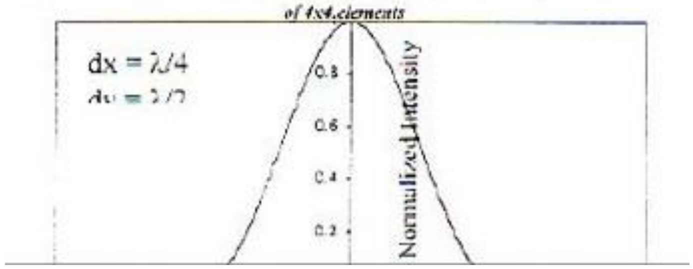
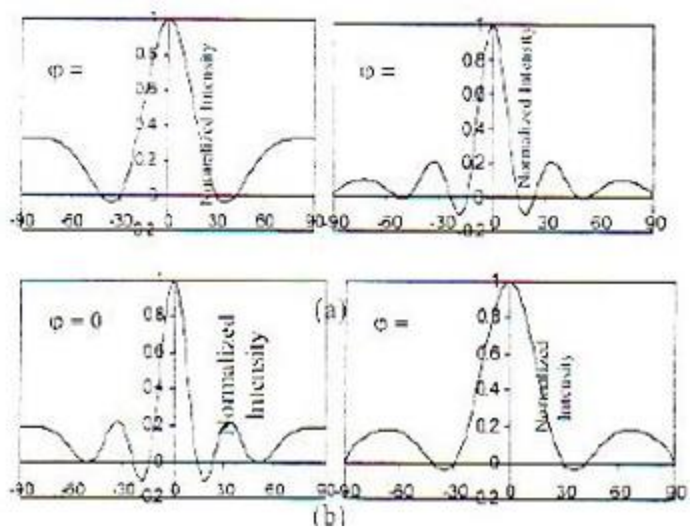


Fig.(9): Radiation pattern of the planar array of rectangular patch microstrip antenna of 4x4 elements



It is clear to show that the figures (9) and (10) when compared with Fig. (6) and Fig. (8) the results tell us the distance between elements in x-directed in dominant in E-plane and vice versus. Finally to show the effect of random elements in x and y-directed, Fig. (11) show result in case of 3 elements in x-directed and 5 elements in y-directed and in case of 5 elements in x-directed and 3 elements in y-directed in q=0 and (=π/2.



6. Conclusions:

From the previous figures, one can conclude the following:

The radiation pattern of one element of a rectangular patch microstrip antenna is highly influenced by the operating frequency.

The radiation pattern properties can be enhanced by increasing the planar array patch.

To enhance the directivity, the space between the patches of the planar array must be arranged.

Finally, the number of patches in the x- and y-directed direction is also important to enhance the radiation properties.

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محاكاة المعاملات مصفوفة الحوائيات ثنائية البعد

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الخلاصة:

استخدمت الهوائيات الشريطية بمدى واسع في كثير من التطبيقات نظرًا لخفة وزنها وأوزانها الضخمة في هذا العمل مصفوفة ثنائية البعد من الهوائيات الشريطية ذات المشع المستطيل الشكل استخدمت لداسة تأثير هذه المصفوفة على هيكل الاشعاع كدالة للمسافة بين المشعات والتردد في المستويين الكهربائي والمغناطيسي. كما تم دراسة تأثير اختلاف المسافة بين المشعات بلاتجاه العمودي والافقي على هيكل الاشعاع .