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REVIEW ARTICLE

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GAIN ENHANCEMENT OF MICROSTRIP ANTENNA USING SQUARE ARRAY

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ABSTRACT

Antenna is the most important element in wireless and communication technology both at the transmitter or receiver. In practice, antenna should be concise, practical, inexpensive yet reliable. One type of antenna that has this kind of performance is microstrip antenna. In this study will be carried out the design and simulation of microstrip antenna array (square array) two and four elements designed in 1870 MHz frequency that can be applied in WiMAX technology. Based on the simulation results of the design as well as the analysis of the parameters of the antenna, it can be shown that the dimensions of the antenna after the optimization process is: L = 38.1 mm, W = 38.1 mm, and Y_{01} = 11. 3 mm.

Antenna return loss is -10.59dB at 1.795 GHz, -15.571dB at 1.8 GHz and -23dB at 1.895 GHz for 1x1, 1x2 and 1x4 array designs respectively. VSWR also shows the similar performance near the same frequency. The value of gain also indicates that the performance of array is also increasing as we increase the number of patches in the array. The gain of the array is of major concern. The value of gain is 0 dBi for 1x1 array, 1.5dBi for 1x2 and 4.4dBi for 1x4 arrays. The details are as shown in figure 5 and 6.

Key Words—microstrip antenna, FR4, Array, Gain.IE3D

INTRODUCTION

Currently the advancement and development of information technology and telecommunications is growing very rapidly with the development of modern society characteristics. As it happens today, computer network technology plays a very important role in data communications. An information systems and computer networks are now widely connected using wireless communication technology (e.g., Wi - Max). By using the technology of radio frequency (RF) , Wi - Max transmit and receive data over the air so as to minimize the use of cable connections . One important tool that should be considered in this system is the antenna; due to either poor quality of information in a transmission process is strongly influenced by the antennas used .In a communication system (Wi-MAX) there are many types of antennas that can be used. Antenna as communication devices cultivated made with relatively small dimensions, flexible, practical, and at an affordable cost. Therefore it is necessary to design a simple alternative antenna and at an affordable cost that can be applied to the Wi-MAX technology and other use.

In this study microstrip antenna is designed using FR4 substrate. The design of the initial stage is one by using the classical equations, and then simulated using the simulator IE3D™. Furthermore geometric shapes printed on the substrate and tested to determine the actual performance including return loss, reflection coefficient, VSWR, gain, radiation pattern and polarization.

II. Microstrip Antenna

Microstrip antenna is an antenna that consists of radiation elements (conductor), dielectric material of height 'h' and ground plane [4] , the patch and the ground plane is separated by a dielectric material of relative permittivity of ε_r . The value of ε_r ranges between 2.2 < ε_r < 12. The thickness of copper strip used as conductor is't'. The basic construction of microstrip antenna is shown in Figure 1

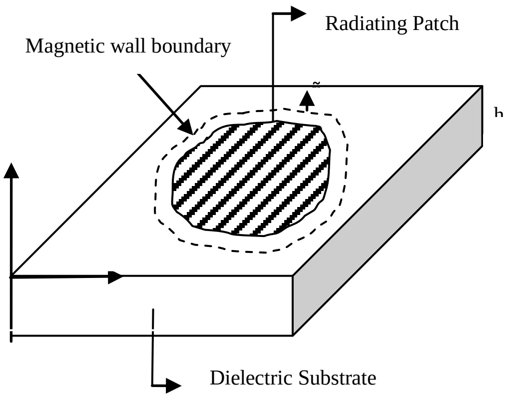


Figure 1. Structure of microstrip antenna

2.1 Antenna Dimensions Calculations

In this study the long side length of the radiating element square radiating element can be obtained by using the formula [1]

$$W = L = \frac{c}{2 \cdot f_r} \sqrt{\frac{2}{\varepsilon_r + 1}} \ (m) \quad (1)$$

Where:

W = L = The length of the side of a square radiating element (m)

c = propagation speed of light (3 x 10^8 m/s)

f_r = Resonant frequency of MSA (Hz)

ε_r = relative dielectric permittivity substrate (F/m)

If the impedance of the transmission line feed does not match the input impedance of the radiating element, the channel impedance should be inserted for the adjustment of achieving the maximum received signal. This adjustment is done using impedance transformers ¼ λ by the equation [2]:

$$Z_T = \sqrt{Z_o . Z_L} \quad (2)$$

with:

Z_T = impedance transformers (Ω)

Z_0 = the characteristic impedance of the transmission line (Ω)

Z_L = impedance load (Ω)

To calculate the dimensions of microstrip transmission line used in the equation below [5]:

$$W_0 = \frac{k}{Z_o} x \frac{h}{\sqrt{\varepsilon_r}} \ \text{(mm)} \quad (3)$$

where :

W_o = the width of the transmission line (mm)

k = Z_0 (free space) (120π Ω = 377 Ω)

h = substrate thickness (mm)

Z_0 = Characteristic Impedance (Ω)

ε_r = relative dielectric permittivity of substrate (F/m)

The distance between the radiating element is determined by the following equation [3]:

$$r \geq 0{,}6\lambda_d \ \text{(mm)} \quad (4)$$

where:

r= the distance between the radiating element(mm)

λ_d = for microstrip transmission line (mm)

To determine the dimensions of radiating elements, the reference frequency (f_r) must first be determined which is used to search for free space wavelength (λ_0) (m).

$$\lambda_0 = \frac{c}{f_r} \quad (5)$$

Once the value of λ_0 is obtained, the wavelength of the microstrip transmission line (λ_d) can be calculated by the equation:

$$\lambda_d = \frac{\lambda_o}{\sqrt{\varepsilon_r}} \ \text{(m)} \quad (6)$$

Some forms of complementary design of microstrip antenna structure are planned in the form of a transmission line impedance adjustment channel. The distance between the radiating elements, the wavelength of the microstrip transmission line (λ_d) are then computed, referring to the classical sources [1] [2].

III. Design and Simulation of Square Microstrip Antenna Array

In this design, the substrate material used has the following specifications:

Dielectric: Fiber glass epoxy – FR 4

Dielectric constant (ε_r) = 4.5

Dielectric thickness (h)= 0.0016 m = 1.6 mm

Loss tangent= 0.018

The thickness of the conductor material (t) = 0.0001 m

Conductivity of copper (σ)= 5.80 x 10^7 mho m^{-1}

Resonant frequency (f_r) = 1.87 GHz

Characteristics impedance = 50 Ω

Ground plane= 1.5 times the patch dimension

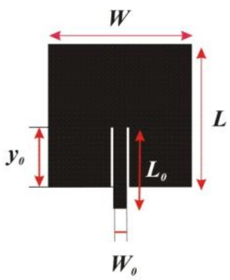


Figure 2. Display of IE3D square (L=W) Antenna Element

Using equation (1), (5) and (6), the TM_{10} mode propagation obtained lengths and width of the sides of quadrilateral (square) are 38.1 mm x 38.1 mm. The transmission line is designed using the direct rationing coaxial probe feed, while the value of the transmission line impedance is 50 Ω.

3.2 Simulation Results

The simulation is performed using IE3D simulator, to a radiating element (single square element). The graphs of various return losses, gain and VSWR for 1x1, 1x2 and 1x4 array are then compared and it has been noticed that there is a remarkable increase in the performance of array. The details of the performance are as shown in the figures. TABLE I. indicates the comparasion of gain.

Simulation results show that the optimum value of S11 is located around the desired frequency of 1870 MHz with a slight variation as we increase the number of array. The shape radiating elements are shown in Figure 6, 7 and 8.

Simulation results also show that the performance of the array is in the good approximation with return loss, since both the terms can be used interchangeably as per the following equation:

$$VSWR = \frac{1+|\Gamma|}{1-|\Gamma|} \qquad (2)$$

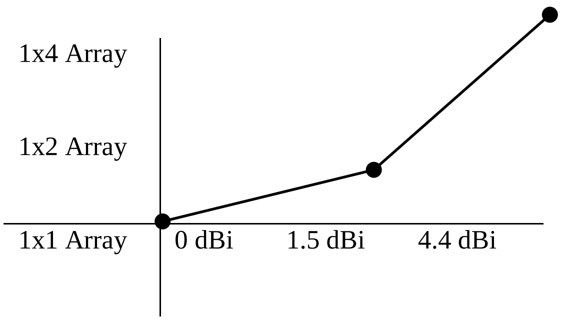
Optimum value of VSWR is also located around the desired frequency of 1870 MHz with a slight variation as we increase the number of array. Figure 5 Gain plot for 1x1, 1x2 and 1x4. The gain of the array is of major concern. The value of gain is 0 dBi for 1x1 array, 1.5dBi for 1x2 and 4.4dBi for 1x4 arrays. The details are shown in figure 5.

The detail of the gain improvement is as shown in the given table:

TABLE I. GAIN COMPARISON

Array arrangement	Maximum Gain
1x1 array	0 dB
1x2 Array	1.5 dB
1x4 Array	4.4 dB

The increase in the gain is as shown in the figure.



Gain variations for 1x1, 1x2 and 1x4

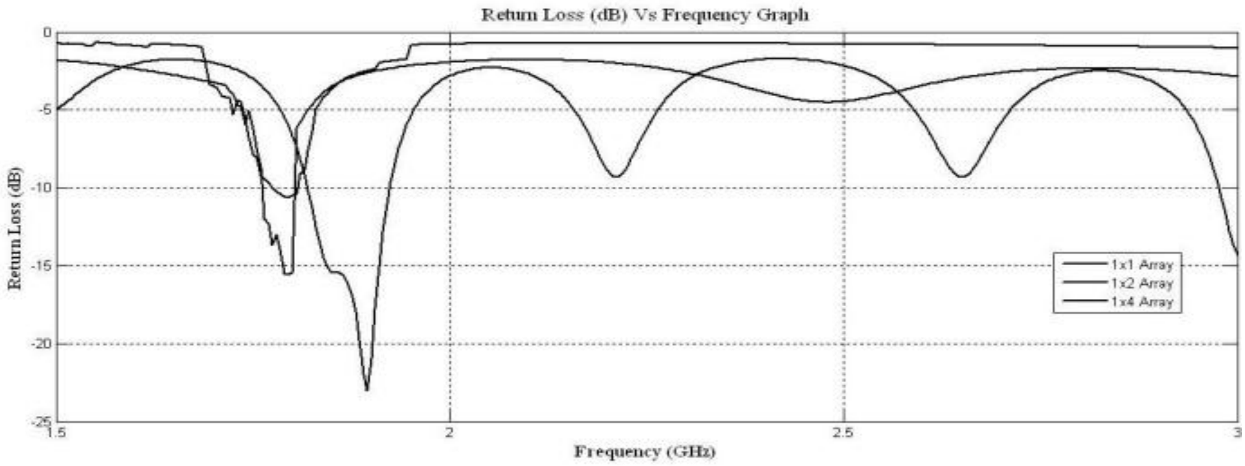


Figure 3: Return loss graph for 1x1, 1x2 and 1x4

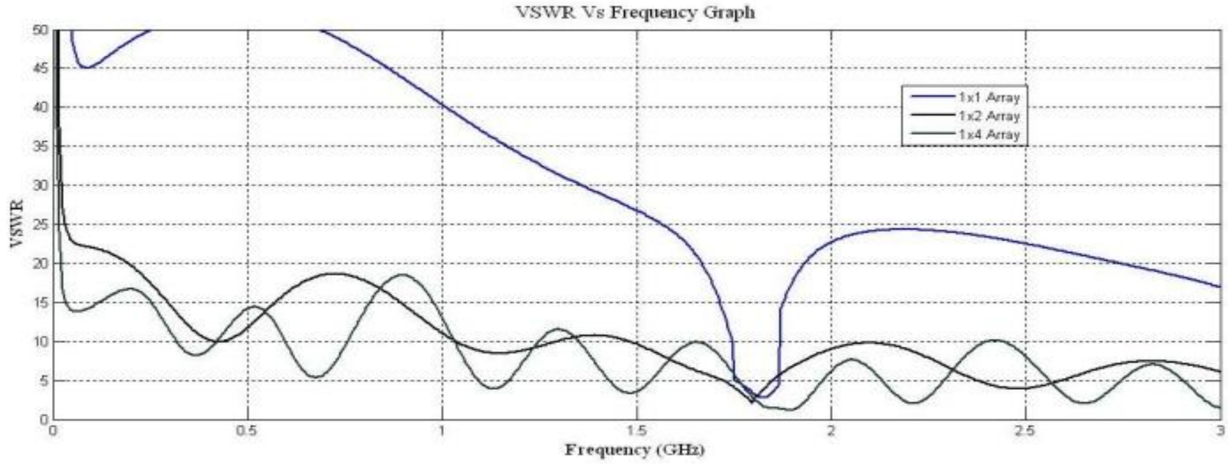


Figure 4: VSWR graph for 1x1, 1x2 and 1x4

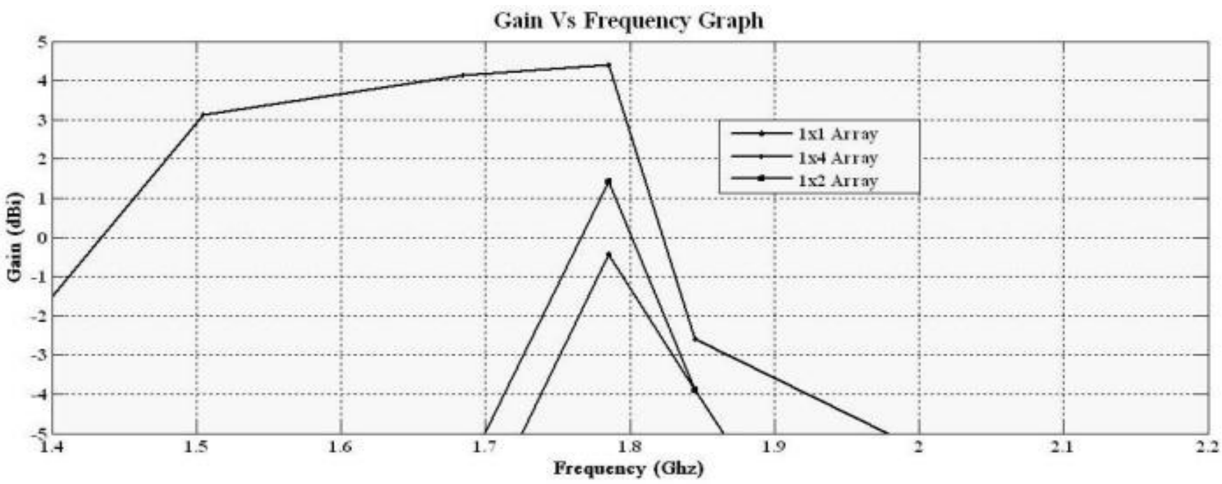


Figure 5 Gain plot for 1x1, 1x2 and 1x4

3.3 Design of Square Array Antenna

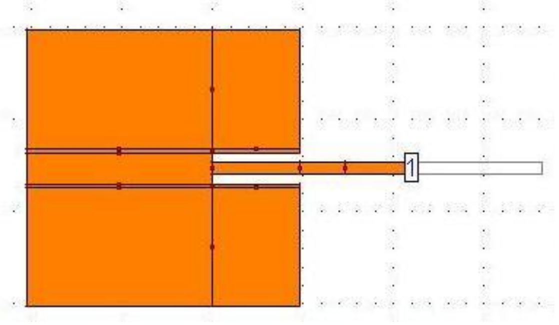


Figure 6: 1x1 radiating element (IE3D)

The basic element consists of the following dimensions: width, W = 38.1 mm; element length, L = 38.1 mm; inset feed, Yo = 11.3 mm .The width of the transmission line, Wo = 2.8 mm; transmission line length, Lo = 14.3 mm.

3.3 Design of Two- Element Array Antenna

After calculation and simulation so that the dimensions of a single radiating element best obtained maximum working at a frequency of 3 GHz , then do the preparation of radiating elements in the array . Microstrip array antenna technology also has the same definition as the antenna array in general, which is a combination of several elements radiating in the field including the transmission line which acts as a feeder (feed point) for each of the radiating elements are arranged. The shape of the antenna is planned as follows:

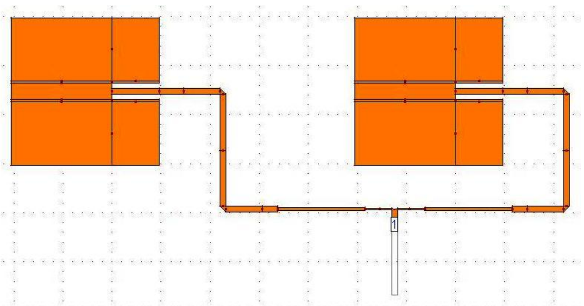


Figure 7. 1x2 microstrip antenna array

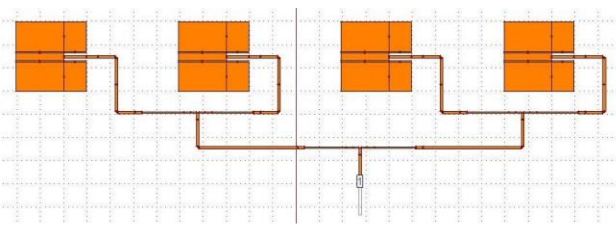


Figure 8. 1x4 microstrip antenna array

Figure 7 and 8 shows the structures of 1x2 and 1x4 array.

CONCLUSION

Based on the simulation results of the design as well as the analysis of the parameters of the antenna, it can be concluded that the dimensions of the antenna after the optimization process is to radiating element: L = 38.1 mm, W = 38.1 mm, and Y01 = 11, 3 mm. Antenna return loss is -10.59dB at 1.795 GHz, -15.571dB at 1.8 GHz and -23dB at 1.895 GHz for 1x1, 1x2 and 1x4 array design respectively. VSWR also shows the similar performance near the same frequency. The value of gain also indicates that the performance of array is also increasing as we increase the number of patches in the array. The gain of the array is of major concern. The value of gain is 0 dBi for 1x1 array, 1.5dBi for 1x2 and 4.4dBi for 1x4 array. The details are as shown in figure 5 and 6.

REFERENCES

[1]. Xu, H. X., G. M. Wang, and M. Q. Qi, "Hilbert-shaped magnetic waveguided metamaterials for electromagnetic coupling reduction of microstrip antenna array,"IEEE Transaction on Magnetics, Vol. 49, No. 4, 1526–1529, 2013.

[2]. Samir Dev Gupta, "Effect of Mutual Coupling in E and H plane on Microstrip Antenna Array Conformal on Cylindrical Surface," in 978-1 -4799-1 607-8/13/2013, IEEE ,2013.

[3]. Balanis, Constantine A. 1982. Antena Theory: Analysis and Design, 2nd Edition. John Wiley and Sons, Inc.

[4]. Kraus, John Daniel. 1988. Antennas. McGraw-Hill International, New York.

[5]. M. M. Olaimat and N. I. Dib, " A Study of 15-75o-90o Angles Triangular Patch Antenna," Progress In Electromagnetics Research (PIER), Vol. 21, pp. 1-9, 2011.

[6]. Wong, Kin-Lu. 2002. Compact and Broadband Microstrip Antennas. John Wiley & Sons, Inc., New York.

[7]. G. A. Deschamps, "Microstrip microwave antennas", 3rd USAF Symp. on Antennas, 1953

[8]. Girish Kumar and K. P. Ray, "Broadband Microstrip Antennas", Artech House, London, ISBN 1-58053-244-6, 2003.

[9]. D. D. Greig and H. F. Engleman, "Microstrip - a new transmission technique for the kilomegacycle range", Proc. IRE, vol. 40, pp. 1644-1650, 1952.

[10]. J. Bahl and P. Bhartia, Microstrip Antennas, Artech House, Dedham, MA, 1980.

[11]. IE3D User's Manual, Release 14.1, Zeland Software Inc., May 2008

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