Design, Analysis and Study of 2x1 Rectangular Microstrip Antenna Array At 2.45 GHz for Beam Steering

Mr. Patil Sarang M.*, Prof.Dr.Bombale U.L..**

*Electronics Engineering Department, Bharati Vidyapeeth's College of Engineering Morewadi, Kolhapur, Maharashtra, India.

**Department of Electronics Technology, Shivaji University, Kolhapur, Maharashtra, India.

Abstract

This paper presents an experimental Phased Array Antenna System operating at 2.4 GHz. Antenna element excitation amplitudes are taken to be constant. Antenna element excitation phases are changed. The obtained radiation patterns provide steerable main lobes and nulls at predefined directions including control of the side lobes at specified levels. Units of the system are presented in detail and their architecture is explained. A phase calibration is used to compensate the system. Measurements of radiation patterns are presented and are compared with calculated patterns.

Keywords: Microstrip, patch antennas, beams steering.

1. INTRODUCTION

In wireless communication the transmission and reception of the signal is through the isotropic antennas. Since this antenna radiates in all direction, this system has a limitation of high power and reduced transmission length[1]. So the transmission in desired direction is required which inspires scientists to develop Directional Antenna (DA). Directional antenna has a characteristic of radiating in one particular direction. Real time application requires transmission of the signals in desired direction without mechanical movement of antenna.

Many applications require radiation characteristics that may not be achievable by a single antenna element. It may, however, be possible that an aggregate of radiating elements in an electrical and geometrical arrangement (*an array*) will result in the desired radiation characteristics [2]. The arrangement of the array may be such that the radiation from the elements adds up to give a radiation maximum in a particular direction or directions, minimum in others, or otherwise as desired

Beam-steering phased antenna arrays find many applications in microwave radar and communication systems. A conventional phased Antenna array uses a power distribution network, Phase shifters, and control signals to provide its output signals with the desired phase distribution to its radiating antennas. This approach, however, utilizes components such as a feeding network and variable phase shifters not only bulky but also lossy, thus increasing design complexity [3]. In addition, beam steering is designed for single frequency operation due to the limitation of phase shifters.

In the proposed system, the total 180^0 angle is covered with discrete beam forming in desired direction. The direction of transmission is controlled through personal computer and controller unit. To change the direction of transmission, the PC is interfaced to the antenna hardware circuitry, the angle in which the direction to be changed is given through the PC.

To demonstrate the implementation of the digital beam forming, phase array is to be built for 2.4 GHz [4], Transmission in order to allow testing and demonstrational use of the array in the unrestricted Industrial, Scientific and Medical (ISM) band. The demonstrated technique, however, can be implemented at any frequency and with minor changes for a transmitting array as well.

Microstrip antenna is printed type of antenna consisting of a dielectric substrate sandwiched in between a ground plane and a patch [6]. The concept of Micro strip antenna was first proposed in 1953, twenty years before the practical antennas were produced. Since the first practical antennas were developed in early 1970‟s, interest in this kind of antennas was held in New Mexico [7]. The microstrip antenna is physically very simple and flat, these are two of the reasons for the great interest in this type of antenna.

Microstrip antennas have several advantages compared to other bulky type of antennas. Some of the main advantages of the microstrip antennas are that it has low fabrication cost, its lightweight, low volume, and low profile configurations that it can be made conformal, it can be easily be mounted on rockets, missiles and satellites without major modifications and arrays of these antennas can simply be produced.

DESIGN PROCEDURE:

The designed antenna is an 2×1 linear array. The first step in the design is to specify the dimensions of a single microstrip patch antenna. The patch conductor can be assumed at any shape, but generally simple geometries are used, and this simplifies the analysis and performance prediction. Here, the half-wavelength rectangular patch element is chosen as the array element (as commonly used in microstrip antennas) [8]. Its characteristic parameters are the length L, the width w, and the thickness h, as shown in below Figure

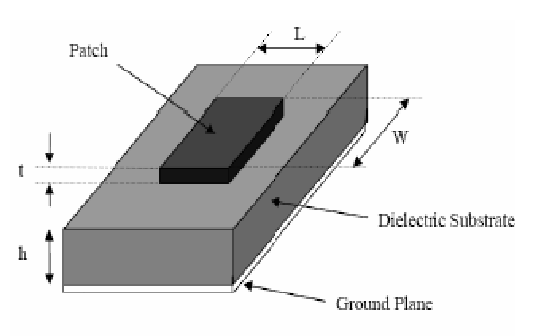

Figure 1.

To meet the initial design requirements (operating frequency = 2.4 GHz, and beam width = 90) various analytical approximate approaches may be used. Here, the calculations are based on the transmission line model [9]. Although not critical, the width w of the radiating edge is specified first. In practice, the length L is slightly less than a half wavelength (in the dielectric). The length may also be specified by calculating the half wavelength value and then subtracting a small length to take into account the fringing fields [7-9]

Therefore many kinds of miniaturization techniques, such as using of high dielectric substrates, resistive or reactive load and increasing the electrical length of the antenna, Also it gives a good directivity and high gain with good performance characteristics [10].The proposed array Antenna will be working on 2.45Ghz frequency range. i.e.(ISM-band) The patch resonance to produce a broadband response. Representative results for the VSWR response, S- parameter and radiation patterns are shown in Figures 2, 3 and 4. The gain of the antenna is higher than the traditional Microstrip antenna.
The dimensions of the antennas are listed in Table 1.

Table 1: Dimensions of the antenna

Antenna	εr	W	L	h	s	d
1	4.4	38.89	102	1.588	9	36.51

An inset feed microstrip antennas is designed to resonate at 2.45 GHz frequency with dielectric constant (εr) = 4.4, substrate thickness h=1.588 mm, L=6 mm, W=8.88 mm on a ground plane. All dimensions of the antenna are in mm.
The length and the width of the patch are calculated initially by the relationships (1)-(6) given in

$$W = \frac{v_o}{2F_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \qquad (1)$$

Where V_0 is the free space velocity of the light.

$$L = \frac{C}{2 \times F_r \times \sqrt{\varepsilon_{reff}}} - 2\,\Delta l \qquad (2)$$

$$\Delta L = 0.412 \times h \times \left[\frac{(\varepsilon_{reff} + 0.03) \times (W + 0.26h)}{(\varepsilon_{reff} - 0.258) \times (W + 0.8h)}\right] \qquad (3)$$

Where ¢ L is extension in length due to fringing effects.
The effective dielectric constant is given by,

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \times \left[1 + \left(\frac{12 \times h}{W}\right)\right]^{-\frac{1}{2}} \qquad (4)$$

The ground plane dimensions would be given as,

Lg=6(h) +L= 6(1.588) +28.49= 38.018 mm (5)

Wg=6(h) +W= 6(1.588)+28.49=38.018 mm (6)

Figure 2 show the geometry of inset feed microstrip array antenna with two patches in the array. The patch is energized electromagnetically using 50 ohm SMA connector.

Hence wide bandwidth is generated as the resonant circuits become coupled. The slots aggregate the currents, which give additional inductance controlled by the patch width. HFSS software has been used to calculate the return loss (S 11) ,directivity vs frequency,3D radiation pattern & field gain Vs frequency. Firstly the example single patch antenna is designed with patch dimensions L = 28.49mm, W =28.49mm for resonating frequency of 2.45 GHz. The bandwidth for the antenna is around 2GHz.

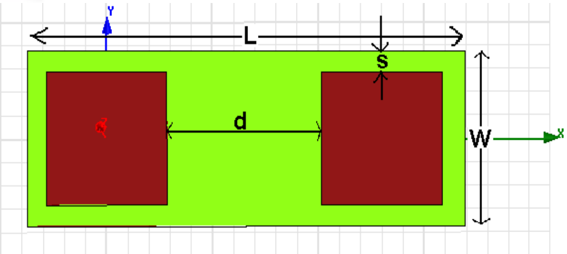

Figure 2.

The present work signifies that by introduction of two Patch in the same size, the Directivity gets enhanced about 9bdB i.e., Figure 3,4 and Figure 5 show the return loss (S11) vs. frequency curve for the proposed inset feed microstrip patch antenna without slot and with two slots of same physical patch dimensions. The positions of the slots were varied to see the effect on the microstrip antenna bandwidth. It was observed that antenna performance could be controlled by introducing slots to a large extent in terms of increased bandwidth, As the slots move in Y direction the bandwidth gets increases for the proposed design. From the present work it can b e inferred that as the slots are moving along the Y axis in both the directions, of course in specified range the bandwidth and other performance parameters are also improving significantly.

2. SIMULATED RESULT FOR 2X2 PATCH ANTEENA ARRAY

1. Return loss Measurement:

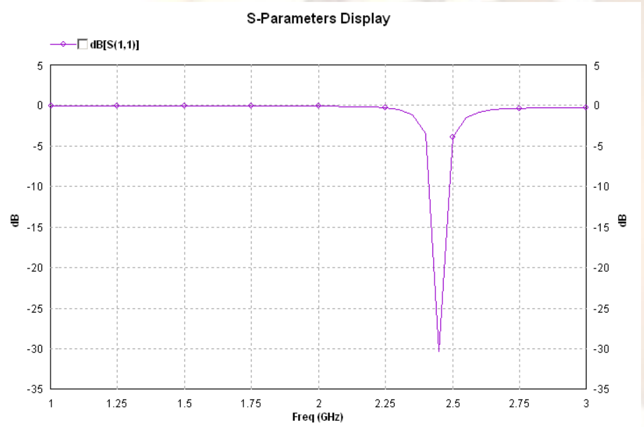

Figure 3.

From figure 3 The Return loss obtained at 2.45 GHz is -30 dB and band width obtained at -10 dB is about 40MHZ.

2. Directivity vs. Frequency:

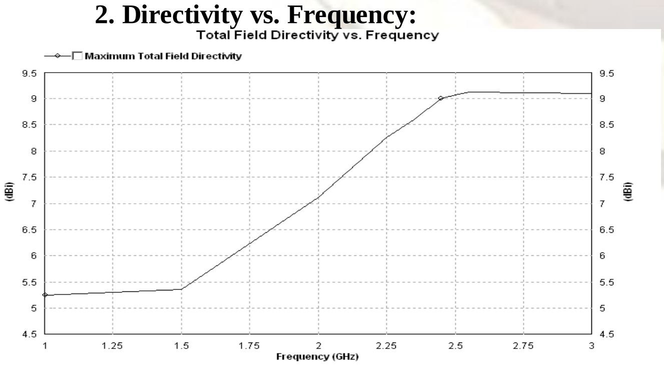

Figure 4

From the figure 4, directivity obtained at 2.4 GHz is 9 dBi

3. 2-Dimensional Radiation Pattern:

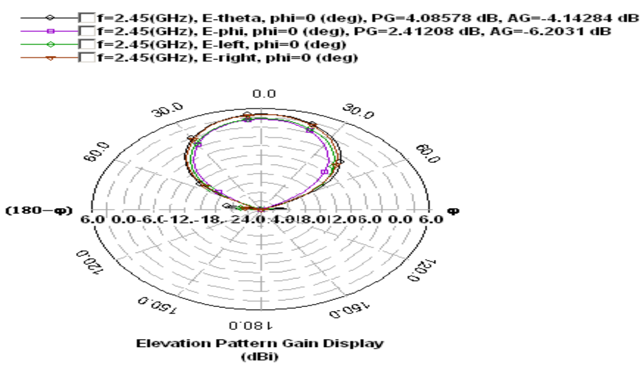

Figure 5

4. Gain vs. frequency:

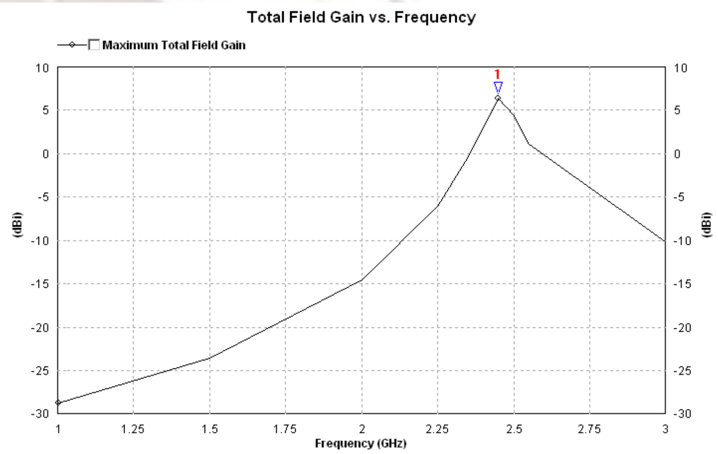

Figure 6.

From the figure 6, field gain obtained at 2.4Ghz is 5.93 dBi

5. Radiation pattern (3-D) for 2x1arrays: E –theta pattern:

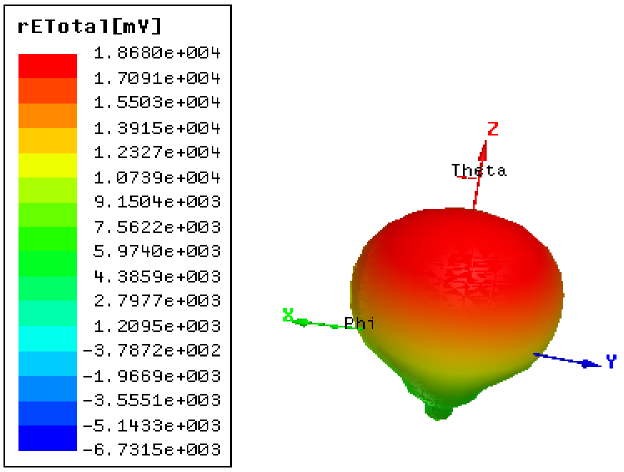

Figure 7

3. CONCLUSION AND FUTURE OUTLOOK

An experimental phased array antenna system is developed in this Paper. The use of IF processing to control the radiation pattern characteristics proved to be an approach providing stability and easy control of the radiation patterns as verified by the measurements and comparison with theoretical results, which shows good agreement. System provides radiation patterns with steerable main lobes and nulls at prespecified positions within the azimuth region 0◦ ↔ 180◦.The possibility of using the developed conformal array as focal plane radiator in a large reflector antenna is an interesting application being considered.

REFERENCES

1. Antenna Theory - Analysis and Design - by Balanis - [2006]
2. L. Stark, "Microwave Theory of Phased-Array Antennas—A Review," *Proc. IEEE*, Vol. 62, pp. 1661–1701, December 1974.
3. F. M. Kashif, W. Qadeer, and S. I. Shah, "Efficient implementation of quadrature amplitude modulation transmitters," *in IEEE INMIC Technology for the 21st Century*, 2001.
4. W. Aerts, P. Delmotte, G. A. E. Vandenbosch "Conceptual Study of Analog Baseband Beam Forming: Design and Measurement of an Eight-by-Eight Phased Array", Transaction on Antenna Propagation, vol. 57, No. 5, pp. 000-999, 2009.
5. . Aliakbarian* , V. Volski * , E. van der Westhuizen+ , R. Wolhuter+, and G. A. E. Vandenbosch "Analogue versus Digital for Baseband Beam Steerable Array used for LEO Satellite Applications"
6. POZAR D.M., and SCHAUBERT D.H., "Microstrip Antennas, the Analysis and Design of Microstrip Antennas and Arrays", IEEE Press, New York, USA, 1995
7. Guru Parsad, Tirupathi." Design, Analysis and Study of 2x2 Rectangular Microstrip Antenna Array At 430 MHz for Wind Profiler RADAR" International Journal of Computer Applications & Information Technology Vol. 1, No.1, July 2012
8. J.R.JAMES, P.S.HALL and C.WOOD, "Microstrip Antenna Theory and Design", London, UK,: Peter Peregrinus, 1981.
9. M. Amman, Design of Microstrip Patch Antenna for the 2.4 Ghz Band, Applied Microwave and Wireless, pp. 24-34, November /December 1997 JAMES J.R., and HALL P.S., "Handbook of Microstrip Antennas" Peter Peregrinus Ltd., London, UK, 1989.
10. K.R.CARVER and J.W.MINK, "Microstrip Antenna Technology", IEEE Trans. Antenna Propag., Vol.AP-29, pp.2-24, Jan 1981.
11. I.J.BAHL and P.BHARTIA, "Microstrip Antennas", Dedham, MA: Artech House, 1980.

4. AUTHORS:

Mr.Patil Sarang M.
Has received B.E in Electronics & Telecommunication in 2009 from BVCOE,Kolhapur. and Pursuing M.Tech (Electronics) from the DOT,SU Kolhapur, under the guidance of Prof. Dr.U.L.Bombale. Currently he is working as a Assit.Professor, In BVCOE, Kolhapur (India).
Email-sarang.p86@gmail.com
Ph.No-+919766747908

Prof. Dr. U.L Bombale Has received PhD from Dhirubhai Ambani Institute of Information & Communication Technology, (DA-IICT) Gandhinagar, Gujarat, India, under the guidance of Dr. Sanjeev gupta. M.E in Electronics & Telecommunication in 1994 from COE, Pune, and Currently he is working as a Professor in Dept. of Technology ,Shivaji university, Kolhapur (India).
Email-uttam_bombale@rediffmail.com
Ph.No-+919049274380