Gain Enhancement of the CPW Microstrip Antenna using Array

Poonam Yadav, Monika Mathur
Department of Electronics & Communication Engineering,
Swami Keshvanand Institute of Technology, Management & Gramothan Jaipur, India.
Email: py9909@yahoo.com

Received 16 February 2017, received in revised form 10 March 2017, accepted 12 April 2017

Abstract: **Microstrip antenna are significantly used in current technological tendency i.e. in wireless communications. In integrated circuit technology coplanar waveguide (CPW) structure is generally used because of its design on the coplanar side of the patch. And it is one of the desirable characteristic of this type of technology. The gain is also the important performance parameter of any antenna. This paper presented the gain enhancement techniques of CPW fed microstrip antenna. The gain enhancement may be achieved by the array arrangement of antennas. Arrays are the arrangement of more than one element of patches in fruitful manner. In this paper the functioning enhancement by the gap between the patches of the array, has been analyzed. The gain has been enhanced up to the 9.86 dB with the 4x1 linear arrays of the designed structure from 3.63 dB of basic single antenna structure. The antenna designed frequency has been taken as 2.4 GHz. The designs were simulated by licensed HFSS Software version 16.**

Keywords- Microstrip patch antenna, linear array, CPW, HFSS Software, Gain.

1. INTRODUCTION

A microstrip patch antenna consists of radiating patch on the surface of a PCB, with ground plane on the other side of the PCB and feeding element which connect other element of antenna to communication system. Most microstrip antenna consists of two or more than two patches in form an array. The microstrip antenna has number of advantages over other antennas like low profile, mechanically rugged, low cost, light weight, easy to fabrication etc [1-2]. Due to these advantages it becomes most popular in kind of applications like mobile and satellite communication application, radio frequency identification, Wi-Max, and space satellite Television etc. The radiating patch can take many shapes like square, rectangular, circular, dipole, triangular, and elliptical or some other configuration but rectangular and circular shapes are mostly used [3]. By changing the parameter (like substrate material, dimension of antenna, feeding technique) we develop better performance of microstrip antenna. The patch antenna array is also being used for enhancing the gain [4-6]. In this presented paper we want to raise the gain so we used array structure instead of single patch. The resonant frequency for our work is 2.4GHz. Because the frequency ranges from 2.4GHz to 2.5GHz is used in industrial, scientific and medical systems. The substrate material used for our design technique is "FR4epoxy" substrate which has relative permittivity of 4.4. HFSS software is used to simulate return loss, and antenna gain. HFSS software is used to do simulation; visualization, solid modeling, and it provide solution of 3-D EM problems with speedily and accurately. A coplanar waveguide (CPW) is known as electrical planar transmission line. All of the three conductors are on the same side of the dielectric substrate, hence this structure is known as coplanar. Which have various advantages over microstrip feed line such as lower loss, the alignment problem is overcome because in CPW feed line etching is done on same side of the substrate, wider impedance bandwidth, coplanar configuration because it have all of the three conductors are on the same side of the dielectric substrate.

2. PATCH ARRAY ANALYSIS

2.1. Design and analysis of 1x1 arrays

In our work, initially we selected dielectric constant 4.4 and substrate thickness 1.6mm. Then, we calculated the length, width, effective dielectric constant, input impedance of the patch, and dimension of the fed line. The resonant frequency for our design is 2.4GHz. Calculated dimensions for single patch element are shown below:

- The width of the patch (W) = 38.036 mm
- Effective dielectric constant of the patch = 3.9.
- Extension of the patch length, ΔL of the patch = 0 .767mm.
- Actual length of the patch, L = 29.64 mm.
- Input impedance of the patch (Z_c) = 243 Ω.

The design of CPW microstrip antenna is shown in Figure.1 with above dimensions.

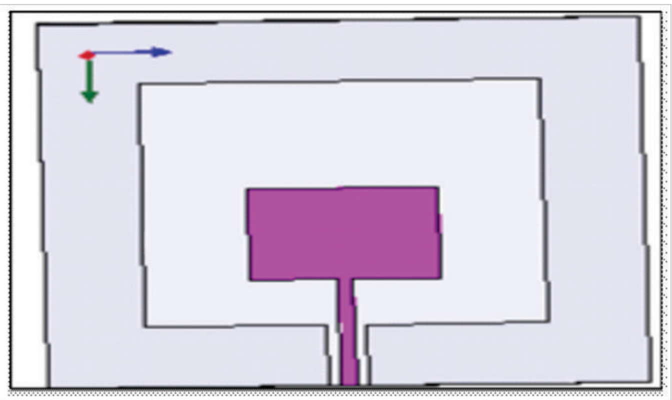

Figure.1: Design for 1x1 CPW-fed microstrip antenna

2.2 Design and analysis of 1x2 arrays

In 1x2 array, height of the substrate, dielectric constant value of the substrate, and resonant frequency were same so we used same dimension of single patch. Then, after knowing length, width, and input impedance of the patch, the feed arrangement can be taken as 50Ω feed line split into two 100 Ω. Then we found the width of microstrip line (w_1) of 50 ohm impedance line is 3 mm and of 100 ohm (w_2) is 0 .8 mm. And distance between antennas elements is set at 1.08λ_{reff}mm.

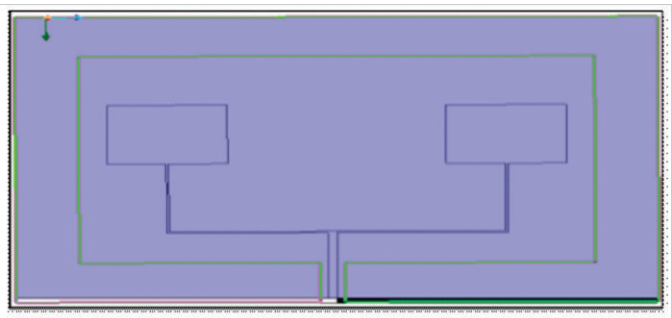

Figure.2: Design for 1x2 CPW-fed microstrip antenna

2.3 Design and analysis of 1x4 arrays

In 1x4 arrays, height of the substrate, dielectric constant value of the substrate, and resonant frequency were same so we used same dimension of single patch. Distance between each patch elements is set at 1.08 λ_{reff} mm. Antenna is fed by 50 ohms coaxial probe through a connector.

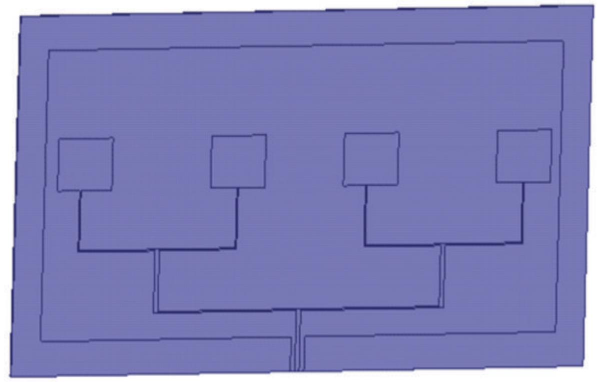

Figure.3: Design for 1x4 CPW-fed microstrip antenna

3. RESULT

3.1. S-parameter plot for return loss v/s frequency

In this paper we checked our design on HFSS simulator. There are many simulator tools based on 3-D, full-wave, finite element method to analyzed electrical behavior of the components. HFSS software is one of them. It is included for engineering task because it is provide answer with feedback about the truth solution. HFSS software calculates S-parameters, resonant frequency, radiation pattern, gain and fields. After completing our design we checked on HFSS simulator and it provide these figures. For our design we selected the central frequency 2.4GHz (central frequency is as the one at which the return loss is minimum. The antenna operates at the frequency range of 2.2-2.6GHz, with bandwidth 400MHz and center frequency 2.4GHz. Figure.4 shows simulated result of S-Parameter for 1x1 designed CPW antenna. It shows -25.57dB loss at resonant frequency 2.4GHz.

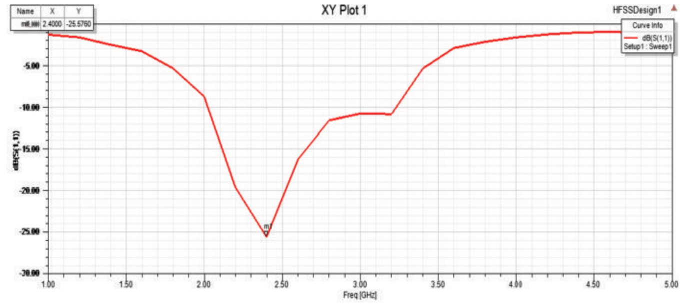

Figure.4: S-parameter vs. frequency plot for 1x1 array

Figure.5 shows simulated result of S-parameter for 1x2 CPW antenna structure. It shows -20.58dB loss at resonant frequency 2.4GHz.

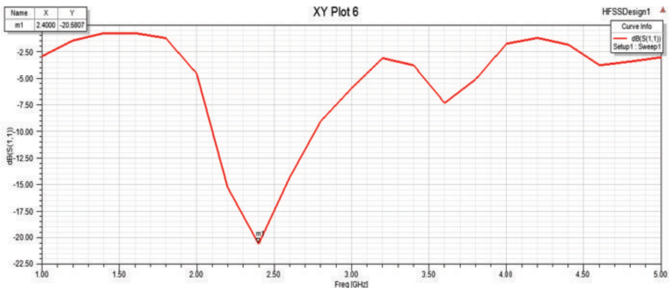

Figure.5: S-parameter vs. frequency plot for 1x2 array

Figure.6 shows simulated result of S-parameter for 1x4 CPW antenna structure. It shows -19.01dB loss at resonant frequency 2.4GHz.

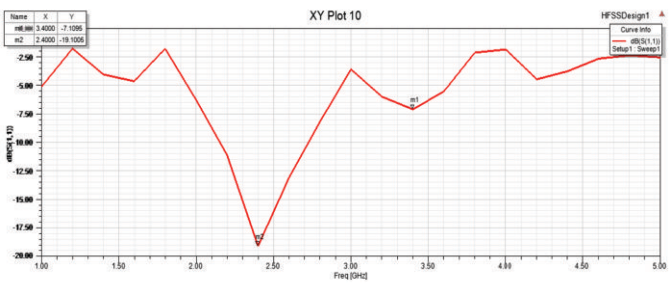

Figure.6: S-parameter vs. frequency plot for 1x4 array

3.2. Gain plot

The gain of the given antenna in a given direction is defined as the radiating energy in that direction with respect to the energy which is radiated by the isotropic antenna in that direction. The gain of the antenna in given direction is the combined product of antenna efficiency and its directivity.

Gain = Efficiency x Directivity

Figure.7 shows simulated result of gain for 1x1 CPW antenna structure. It shows 3.63dB gain at resonant frequency 2.4GHz .

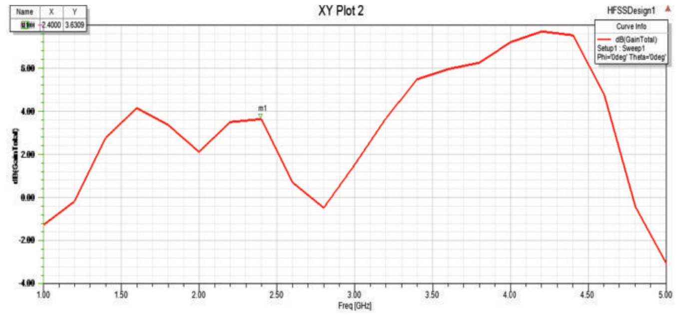

Figure.7: Gain vs. frequency plot for 1x1 array

Figure.8 shows simulated result of Gain for 1x2 CPW antenna structure. It shows 6.21dB gain at resonant frequency 2.4 GHz.

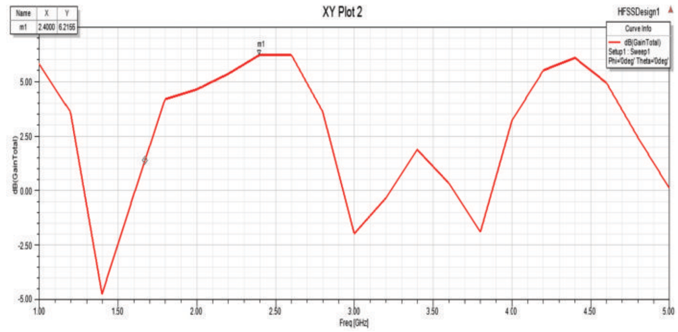

Figure.8: Gain vs. frequency plot for 1x2 array

Figure.9 shows simulated result of gain for 1x4 CPW antenna structure. It shows 9.86dB gain at resonant frequency 2.4GHz

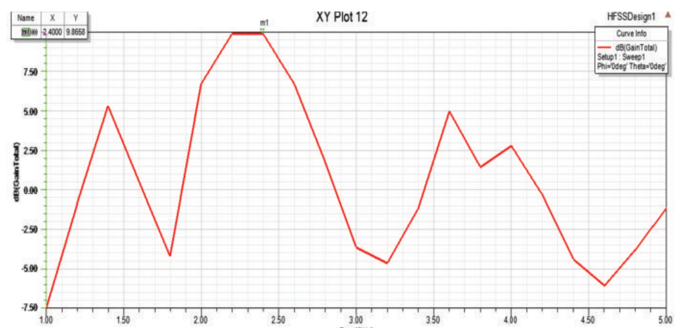

Figure.9: Gain vs. frequency plot for 1x4 array

According to this work if we further want to enhance the gain than we have to increases the number of patch elements in the array. Directivity depends upon the gain so it may also improve. Element mutual coupling loss is increasing as we increase number of patch to form an array because spacing between the elements is decrease. So element mutual coupling loss is higher in 1x4 patch elements as compared to 1x1, and 1x2 patch elements.

And feeding network has been arranged for that impedance matching properly done for it. If we are increase number of patch elements to the design to convert the given design in format of an array then we will be needed more calculations for length and width, and proper arrangement of impedance line. So complexion directly increases for design of feed network as we increase number of patch elements to convert the given design in format of an array. Power consumption is more in 1x4 patch elements as compared to smaller arrays i.e. for 1x1 patch element and 1x2 patch elements.

4. CONCLUSION

In this paper we design CPW microstrip patch antenna with 1, 2, and 4 patch elements and analyzed their gain enhancements by compare the results of the all possible arrangements. The array has been designed in such a way that the gap between the two designs is 1.08 ƛreff mm fixed. S-parameter simulation has been done for the designed antennas. It has been observed that in 1x1 patch element design the gain was 3.63dB, for 1x2 patch elements the gain increases towards 6.21dB and for 1x4 patch elements it is increased to 9.86dB. We concluded that if we increases the number of patch antenna elements by keeping the gap of 1.08 ƛreff mm we achieve better gain as compare to 1x1. Bandwidth, directivity and radiated power is also improve in 1x4, and 1x2 as compared to 1x1 CPW antenna.

ACKNOWLEDGMENT

This work was supported by Swami Keshvanand Institute of Technology, & Management. The authors express the thanks to the management and the department of electronics & communication engineering for providing us the platform to do the work.

REFERENCES

[1]. Kin-Lu Wong, "Compact and Broadband Microstrip Antennas", John Wiley & Sons, Inc., 605 Third Avenue, New York, 2002, page 221-273, ISBN-0-471-41717-3.

[2]. C. A. Balanis, "Antenna Theory Analysis and Design" John Wiley & Sons, Third Edition, 2010, page 811-876, ISBN - 978-81-265-2422-8.

[3]. Thomas A. Milligan, "Modern Antenna Design", John Wiley & Sons, Inc. publication, Second Edition , 2005, page 1-30, ISBN-13 978-0-471-45776-3 .

[4]. A. De. , C. K. Chosh and A. K Bhattacherjee, " Design and Performance Analysis of Microstrip Patch Array Antennas with Different Configurations", International Journal of Future Generation Communication and Networking vol. 9, no. 3 (2016), pp. 97-110.

[5]. V.R. Anitha and S. Narayana Reddy," Design of an 8 X 1 Square Microstrip Patch Antenna Array", International Journal of Electronic Engineering Research, vol. 1, no. 1 (2009) pp. 71–77.

[6]. Yahya S.H. Khraisat, "Design of 4 elements Rectangular microstrip patch antenna with high gain for 2.4 GHz applications", Canadian center of science & Education, Modern applied science, vol. 6, No. 1, January (2012), pp.68-74.

◆ ◆ ◆