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Study of Inter-Element Space Effect in LinearMicrostripArray Antenna

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***Abstract*-Microstrip antenna arrays are used in smart antenna systems now a days. In this paper we have studied effect of inter-element space variation between patch elements of linear patch array antenna viz. two element array, four element array with uniform spacing and non-uniform spacing.All the configuration of array were simulated onAnsoftHFSS v.14.0 at frequencies 2.3 GHz and 7.3 GHz. Rectangular patch is taken as single element with probe input with SMA connector. It is observed that non uniform spacing results much better gain and beamwidth in comparison to uniform inter-element spacing.**

***Index*- Microstrip patch antenna array, PAA, Smart Antenna**

I. INTRODUCTION

Smart antenna system are used in mobile communication for better beam handling. Microstrip antenna array are becoming best choice for smart antenna array due their wide advantages of easy to design, light weight, low cost etc. In this study we have used different linear uniform microstrip array antenna and compare the effect of spacing between antenna elements in array.

Planar array are formed by linear arrays in two dimension. Planar array are used in both communication and radar systems. Planar arrays of printed radiating elements are best when used for low cost scanning array applications.Main design consideration of planar array is selection of inter-element spacing to avoid grating lobes. [1]

Phased array antenna (PAA) isantenna system with a no. of antenna elements, in which, the radiation pattern can be reinforced in a particular direction & suppressed in all other undesired directions. The direction of PAA radiation can be electronically controlled and steered by applying different weights or excitation to elements. These unique capabilities found in PAA results in a broad range of applications such as in mobile communication, radar etc.[2]. The term adaptive antenna or smart antenna is used for a phased array when the weighting on each element is applied in a dynamic fashion.[3]

It was suggested that grid spacing may be around 0.5 λ_0, [1] but it is from edge to edge of element. In this paper we have taken different cases of different spacing and different elements. All the cases are simulated by Finite Element Method (FEM) onAnsoft HFSS v.14 [4]

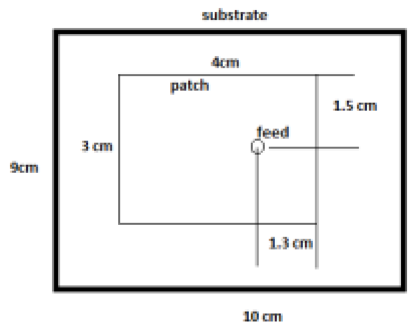

Figure 1. Single rectangular patch with substrate

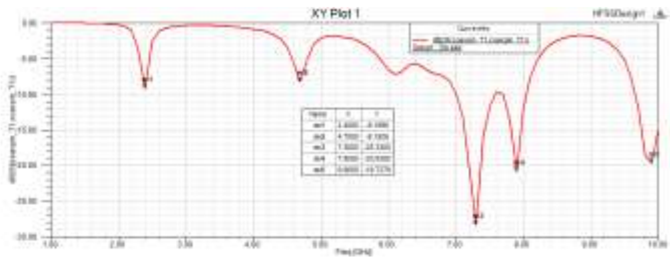

Figure 2. Single rectangular patch S11 (db) graph

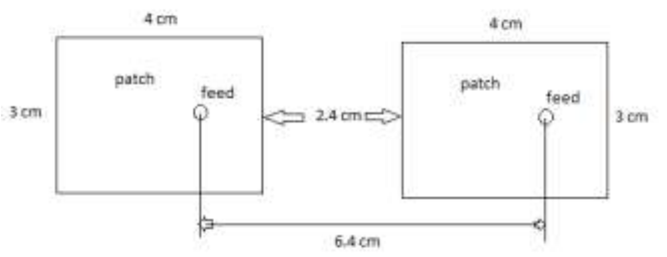

Figure3. Two element array with feed to feed distance of 6.4 cm

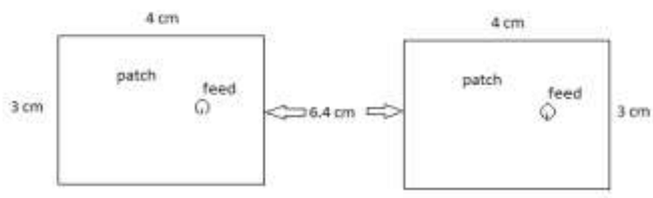

Figure 4. Two element array with edge to edge distance of 6.4 cm

Figure 5. Four element array with feed to feed distance of 6.4 cm

Figure 6.Four element array with edge to edge distance of 6.4 cm

Figure 7. Four element array of non-uniform spacing 2.4 cm, 6.4 cm, 2.4 cm

Figure 8. Four element array of non-uniform spacing 6.4 cm, 2.4 cm, 6.4

TABLE I

COMPARISON OF DIFFERENT CASES

No of Elements	Inter-element spacing (cm)	Center Freq. GHz	S11 (dB)	Bandwidth MHz	Gain (dB) at phi=90^0	Beam width (degree)
1		7.3	-29.3189	600	1.655	60^0
2	2.4 cm	7.3	-24.7038	580	6.1231	55^0
2	6.4 cm	7.3	-25.4439	590	1.956	30^0
4	2.4 cm, 2.4 cm, 2.4 cm	7.3	-22.4878	510	5.1833	70^0
4	6.4 cm, 6.4 cm, 6.4 cm	7.3	-26.3967	550	1.7795	30^0
4	2.4 cm, 6.4 cm, 2.4 cm	7.3	-23.1023	515	5.1243	75^0
4	6.4 cm, 2.4 cm, 6.4 cm	7.3	-23.6719	565	4.8617	80^0

II. DESIGN AND CONFIGURATION OF ARRAY

A. *Design of rectangular patch*

A rectangular patch of 4cm x 3cm is taken with substrate Rogers/ RT Duroid 5880 ε_r=2.2 with thickness h=0.32cm.

This patch is designed for frequency 2.34GHz using design equations given in [5] and giving good return ratio at 2.4 GHz and at harmonics of this frequency i.e. 4.7 GHz, 7.3 GHz and 9.9 GHz. It is seen from its return loss diagram in Fig.2, this patch antenna shows better results on 7.3 GHz and good bandwidth of 600 MHz.

By the design equation given in [5]

$$f_r = \frac{c}{W\sqrt{2(\epsilon_r+1)}} \qquad (1)$$

Where f_r is resonant frequency, c is velocity of light in free space, W width of patch and ϵ_r is relative dielectric constant of substrate.

$$f_r = \frac{c}{2L\sqrt{\epsilon_r}} \qquad (2)$$

Where L is length of patch.

$$\Delta L = (0.412 \times h)\frac{(\epsilon_r+0.3)(\frac{W}{h}+0.264)}{(\epsilon_r-0.258)(\frac{W}{h}+0.8)} \qquad (3)$$

Where h is height of substrate and ΔL is extension of length due to fringing.

$$L = \frac{\lambda}{2} - 2\Delta L \qquad (4)$$

From Fig.2 and design equation (1-4) it is confirmed that frequency 2.34 GHz is center frequency. Half wavelength distance for this frequency is approx. 6.4 cm.

Generally microstrip array are tested with various feed arrangements such as corporate feed, series feed etc. but in smart antennas , each element has separate feed using coax feed because each element is to be excited separately by some DSP processor using adaptive algorithms [3].

B. *Configuration of Arrays*

In present case we have studied six cases of arrays, comparison of which is shown in table-I. First, two element array with feed to feed spacing of half wavelength and then edge to edge spacing of half wavelength is compared. Second, four element array with uniform spacing of feed to feed spacing of half wavelength and edge to edge to spacing of half wavelength. Third, Four element array with non-uniform spacing as shown in Fig.(7) and Fig. (8).It is mentioned in [6] that non uniform spacing can be utilized to minimize the first side lobe levels. It was clearly visible that non uniform spacing cases are giving good gain and beam width at the cost of bandwidth. In [7] also better gain are achieved by uniform planar array of 3x3 array of rectangular patch but non uniform spacing may result much better results in two dimension planar arrays.

III. Conclusion & Future Work

Uniform linear array with two element and four element have been studied and their performance compared with each other. Six configurations of array antennas are formed for frequency 7.3 GHz giving good bandwidth of 600 MHz and beamwidth in the range of 60^0-80^0. It is found that half wavelength inter-element spacing is a good measure but if it is applied non-uniformly then it give better results. In smart antenna array system, non-uniform spacing can be utilized efficiently with high gain and bandwidth. Non uniform inter-element spacing may be tested in two dimension planar patch arrays.

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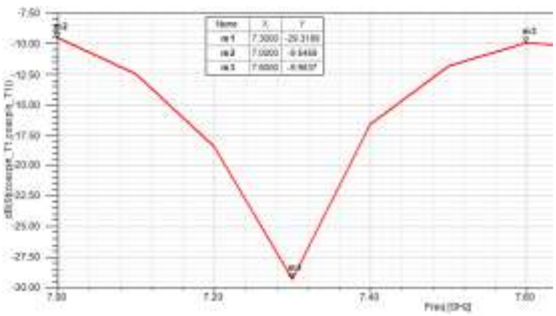

Figure 9. Single microstrip patch antenna return loss

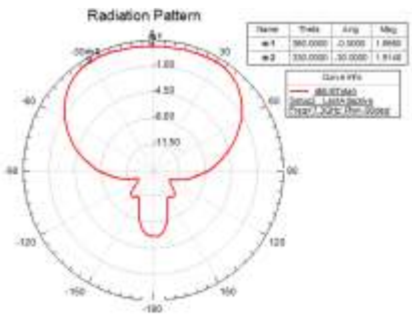

Figure 10. Single microstrip patch antenna radiation pattern

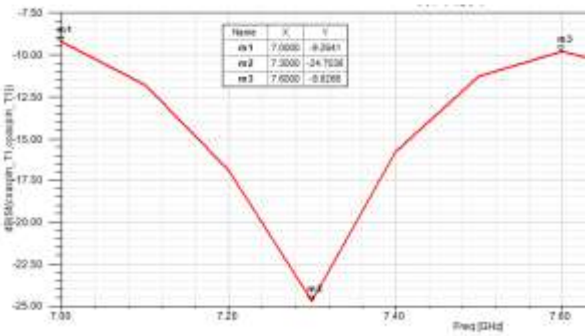

Figure 11. Return loss of antenna array of Fig.3

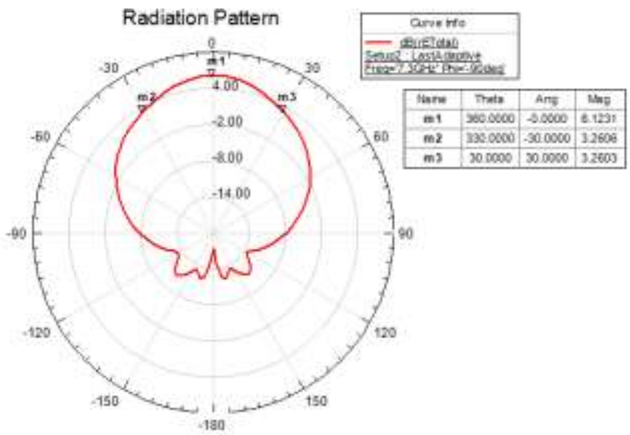

Figure 12. Radiation pattern of antenna array of Fig.3

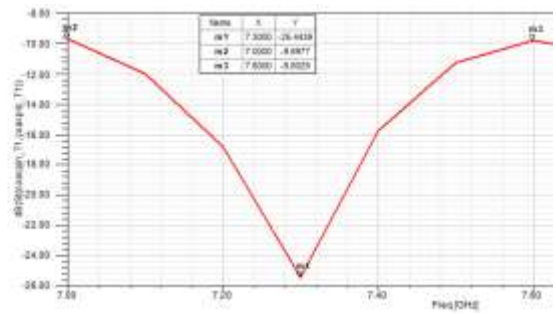

Figure 13. Return loss of antenna array of Fig.4

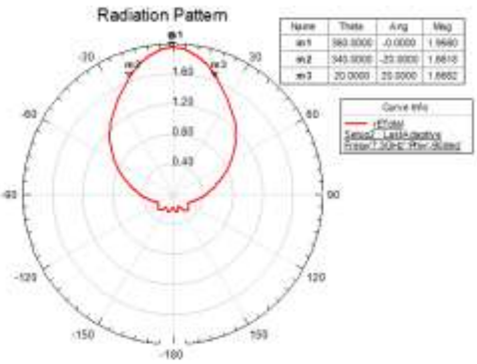

Figure 14. Radiation pattern of antenna array of Fig.4

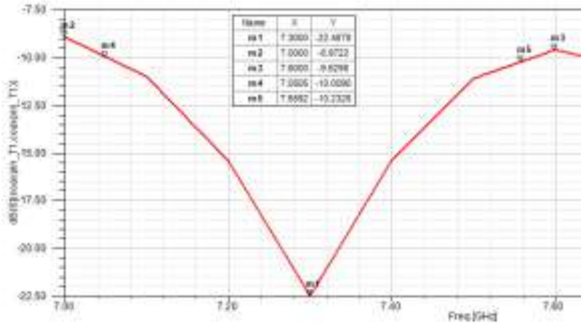

Figure 15. Return loss of antenna array of Fig.5

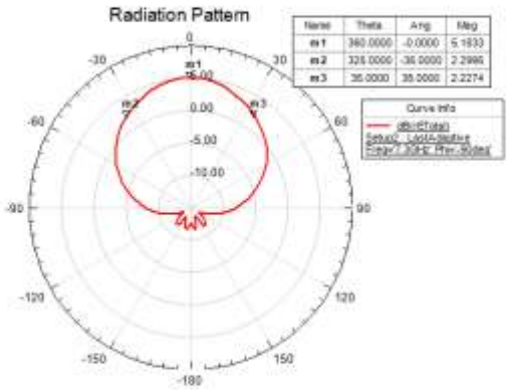

Figure 16. Radiation pattern of antenna array of Fig.5

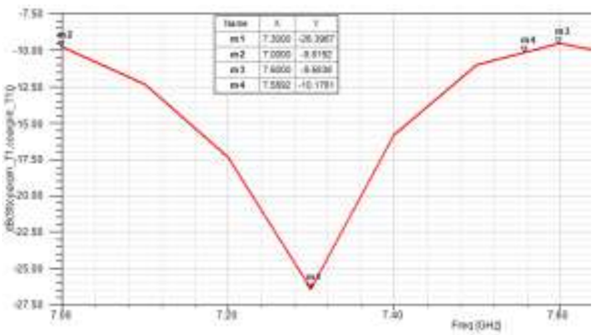

Figure 17. Return loss of antenna array of Fig.6

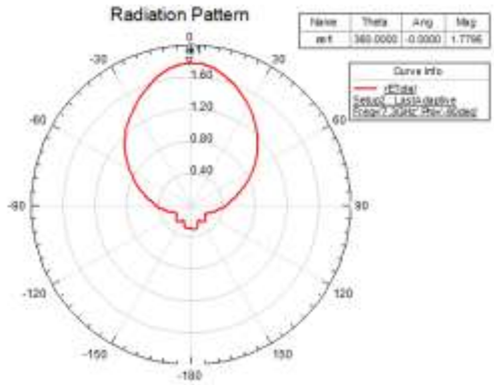

Figure 18. Radiation pattern of antenna array of Fig.6

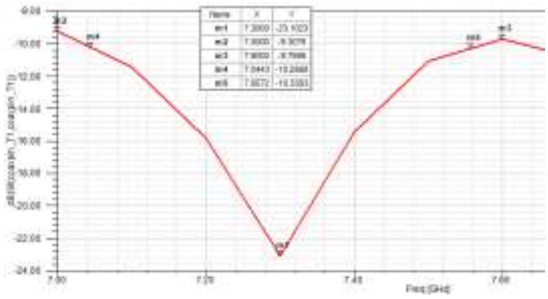

Figure 19. Return loss of antenna array of Fig.7

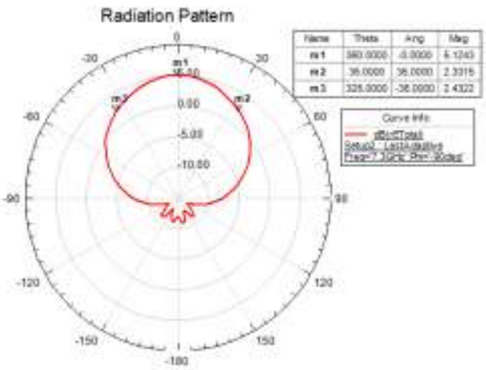

Figure 20. Radiation pattern of antenna array of Fig.7

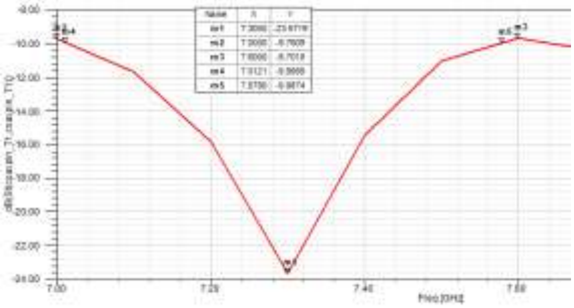

Figure 21. Return loss of antenna array of Fig.8

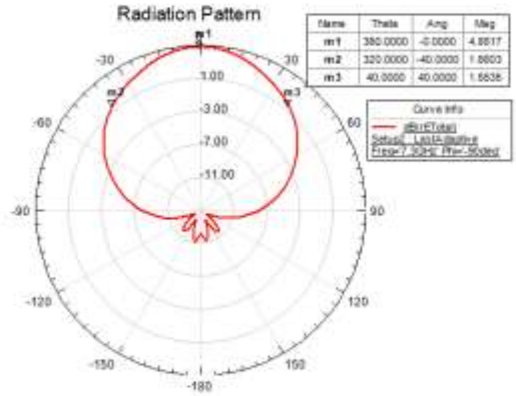

Figure 22. Radiation pattern of antenna array of Fig.8