Non-Uniform Chebyshev Excitation of a Linear Broadside Antenna Array Operating at 1.8GHz

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Abstract

A given configuration of a non-uniform antenna array for which the elements are equally spaced with unequal amplitude excitation using chebyshev excitation method has been studied in this work. The impact of the number, spacing and amplitude excitations of the elements on the radiation characteristics has been analyzed and compeared with its analogues of a linear broadside uniform and non-uniform binomial antenna arrays using 4NEC2 simulation software. The spacing between the elements varied from 0.1? to 2? in steps of 0.02? for a number of elements up to 10 elements. For GSM application at 1.8GHz frequency the best configuration to achieve the required gain of 13.9dBi was 7-elements at 0.86? spacing.

***Index terms*— chebyshev array, gain, half power beamwidth, max. side lobe level, no. of side lobes and radiation pattern.**

1 I. Introduction

ireless communication has become an integral part for modern word. The most popular standards for mobile phones in today's word is Global System for Mobile communication (GSM). A 4x4 rectangular microstrip patch antenna with the gain about (13.8 ~14.4) dBi for GSM application was presented by [1]. [2] achived the same gain range using a 2x2 microstrip patch antenna for the same application. A 13.7dBi gain for the same application was achived by [3] using a 7 dipole elements with 0.82? spacing forming a uniform linear broadside array operating at 1.8GHz. An anaolugous binomial excitation non-uniform linear broadside dipole antenna array has been used by [4] to achieved a 12.8 dBi gain with a 10-element and 0.82? spacing. In this study another technique for current excition known as Chebyshev excition of a nonuniform linear dipole antenna array has been studied for GSM application at 1.8GHz. Linear array antenna has a wide range of applications in radar and communication systems due to higher directivity, low side lobe and high gain when compared with other kinds of single radiating element antenna [5].

Dolph-Chebyshev arrays are typical examples of non-uniform arrays [6]. The excitation coefficients for this array relates to Tschebyscheff polynomials. A Dolph-Tschebyscheff array with no side lobes (or side lobes of ?? dB) reduces to the binomial design [7]. Tschebyscheff polynomial is defined by equation:

Author ? ?: Department of Physics, University of Sulaimani, Kurdistan Region, Iraq. e-mails: aras.mahmood@univsul.edu.iq, dlnya.ibrahim@univsul.edu.iq?? ?? (??) = cos(?? ?????? ?1 ??) ð ??"ð ??"??ð ??"ð ??" ? 1 ? ?? ? +1 (1) ?? ?? (??) = cos ?(?? ??????? ?1 ??) ð ??"ð ??"??ð ??"ð ??" ?? < ?1, ?? > +1 (2)

Where T denotes the Tschebyscheff and m is the order of the polynomial. For higher terms can be had from the recursion formula:Tm+1 (x) = 2 x T m (x) ? T m?1 (x)**(3)**

Steps to be followed while calculating Dolph-Tchebyscheff amplitude distribution are given by [8] which give Dolph-Tchebyscheff optimum distribution for a specified side lobe level.

2 II. Design and Simulation Results

In this work some basic radiation characteristics for a non-uniform linear dipole antenna array has been analized through the variation of the number of the elements and the spacing between them using Chebyshev method for specifing the amplitudes of the excitation currents of the elements. For a 1.8 GHz operating frequency the length (L) and the radious (R) of the array element (half wave length dipole antenna) has been calculated from [9,10] and the elements were arranged parallel to each other along the Z-axis. The results were also compaired with that of a similar uniform and binomial arrays.

3 a) Effect of Number of Elements on the Performance of Dipole Array Antenna

The first proposed study was the impact of the number of elements on the radiation charactistics for linear array chybeshiv excitation. When the spacing between the elements were fixed at (0.5?) and the number of elements were changed from 2 to 10 elements the current excitation amplitudes for the elements has been calculated using the steps given by [8] using the major to minor lobe ratio of 20dBi. Table (1) tabulates the current excitation amplitudes for all the 10-elements. The design simulation and optimization processes were carried out with the aid of the 4NEC2 simulator (antenna design procedure using 4NEC2 were mentioned in **??**11]) after equating the phase of the elements current to zero for broadside array. Table (2) tabulates some of the outputs of the 4NEC2 simulator for this section. The above data (Table 2) was translated to Fig. The second part is to investigate the impact of the variation of the spacing of a chebyshev excitation linear dipole array with 10 elements has been calculate using the steps of [8] to calculate the excitation current amplitudes. Table **??**3) contains some of the outputs of the utilized software (4NEC2); it shows a smooth and a systematic increase of both the gain, max.SLL and the number of side lobes respectively with the spacing up to 0.9? while the HPBW in vertical plane decreases with the spacing and that for horizontal plane remained constant. At the third part of this analysis, both the number of the elements and the spacing between them were varied to see their impacts on the same radiation characteristics as before . The spacing is varied up to 2? at steps of 0.02? for each number of the elements from 2 to 10 elements separately. Table (4) tabulates the outputs for the specified parameters at the best spacing for maximum gain only. The variation of the gain with the spacing up to 2? for different number of array elements is shown in the Figure 3 below. (5) tabulates the variation of these characteristics with the number of the elements having 0.5? spacing between them. From the above table (5) it is clear that for all the arrays as with different elements both uniform and cebyshev excitations give almost the same gain and it is more than that of the binomial arrays. Ingeneral uniform array gives more directive beam (narrow HPBW) while binomial arrays give wider major lobes.

At 0.5? spacing the binomial array has not any side lobes while both uniform and chebyshev arrays have the same number of side lobes for any element numbers but with different intensities such that the intensity of the side lobes for the uniform array excitations is higher than that of the chebyshev.

The same comparison has been made for a 10 element arrays with different spacing and the results has been shown in the table (**??**) below.

Table **??** : Comparison between uniform,binomial and chebyshev 10 element array at different spacing At 1.8GHz operating frequency it is clear that the optimum separation for uniform and chebyshev excitations is 0.9? which gives the best gain, but for binomial array it was 0.8?

The same comparison has been made for different of element arrays with different spacing and the results has been shown in the table (7) below. From the above table it is shown that the optimum separation for three method are difference for example in 10-element for chebyshev arrays was (d=0.9?), which gave the best radiation properties while for binomial arrays the optimum space dimension was (d=0.8?), uniform array with space between elements (d=0.92?) had best radiation properties. The sequence of high gain and good HPBW starts from uniform excitation to chebyshev then binomial arrays.

IV. Conclusions) is too much, while in chebyshev arrays for same number of elements, the center coefficient ?? 0 = 1.5579) and the last coefficient (?? 5 = 1), in practical its easy generate signals with variation in amplitude between the center and the edge. 3. When the spacing between the elements was ?, all the three different excitations produce both broadside and end fire radiation patterns together. 4. For a fixed element spacing at 0.5? the number of side lobes for both uniform and chebyshev excitations increase equally by two lobes per each number increment of elements but with different intensities such that the intensity of the side lobes for the uniform array excitations is higher than that of the chebyshev while the binomial array has not any side lobes. 5. When the spacing between the elements increases from 0.1? to 0.8? at fixed fix number of 10 element, both the uniform and chebyshev arrays have the same rate of increase of side lobes with the sequence of high gain from uniform excitation to chebyshev then binomial arrays. This page is intentionally left blank [1] [2]

[2]Non-Uniform Chebyshev Excitation of a Linear Broadside Antenna Array Operating at 1.8GHz

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Figure 1: (1) 2016 F©

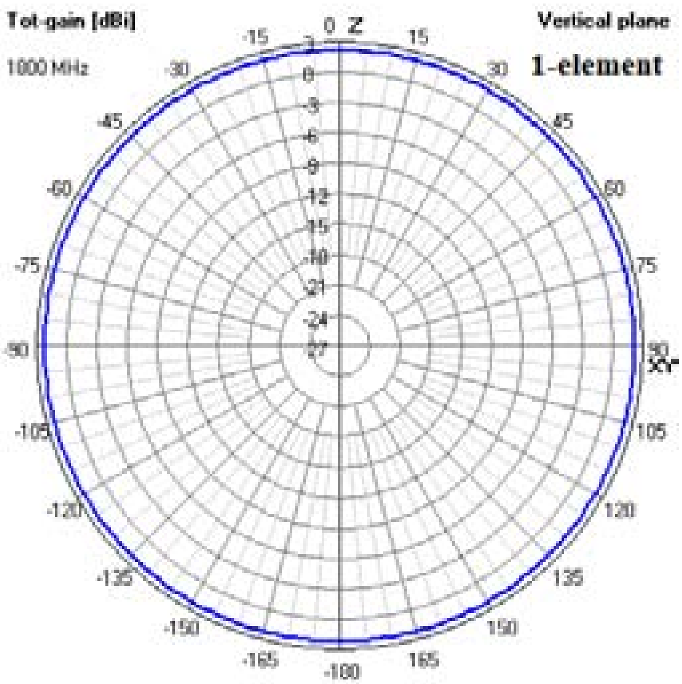

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Figure 2: Figure 1 :

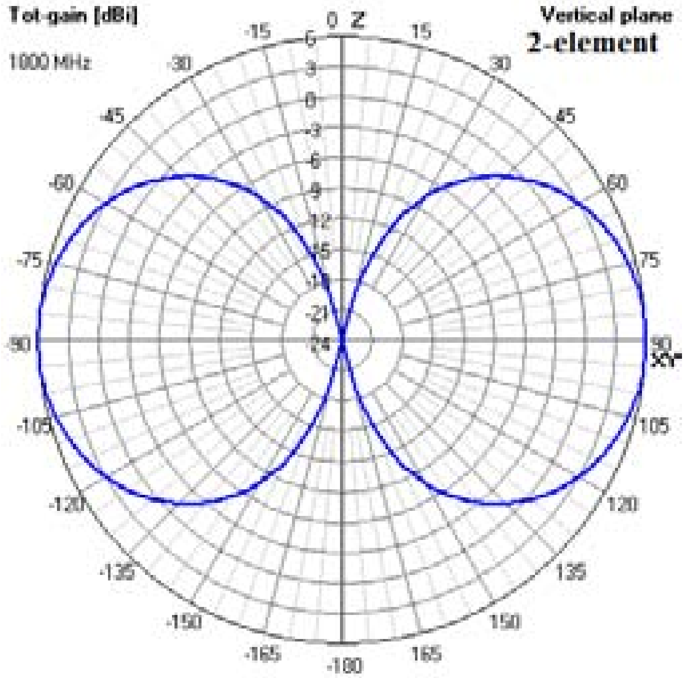

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Figure 3: Figure 2 :Figure 2 :

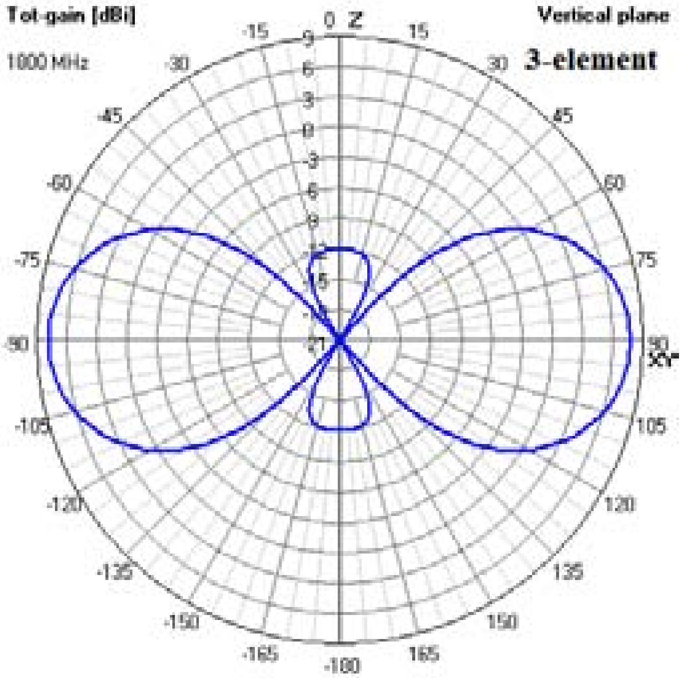

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Figure 4: Figure 3 :

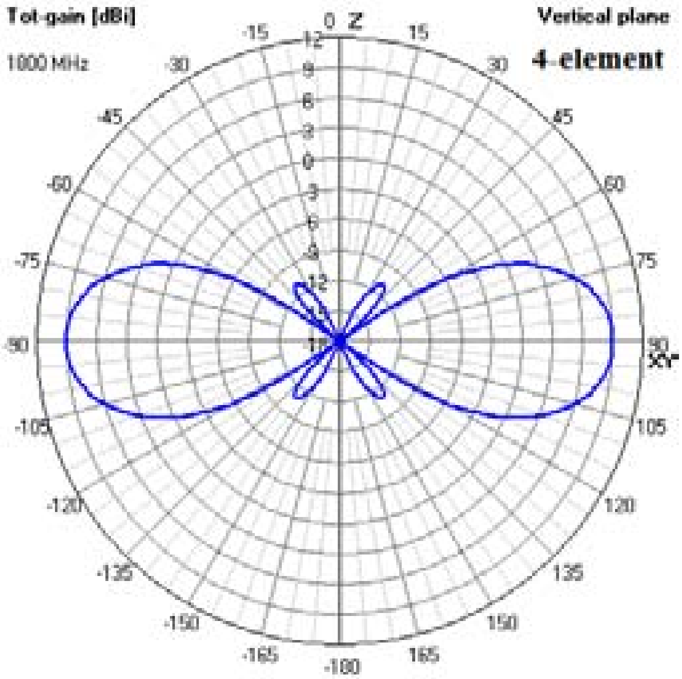

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Figure 5: Figure 4 :

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No. of Elements			
N=1	1		
N=2	1	1	
N=3	1	1.636 1	
N=4	1	1.736 1.736 1	
N=5	1	1.607 1.929 1.607 1	
N=6	1	1.439 1.855 1.855 1.439 1	
N=7	1	1.276 1.683 1.837 1.683 1.276 1	
N=8	1	1.139 1.507 1.72	1.721.507 1.139 1
N=9	1	1.023 1.355 1.596 1.662 1.596 1.355 1.023 1	
N=10	1	0.926 1.212 1.436 1.558 1.558 1.436 1.212 0.926 1	

Figure 6: Table 1 :

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Figure 7: Table 2 :

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Elements spacing(?)	Gain (dBi)	HPBW (vertical Plane) degree	HPBW (horizontal Plane) degree	max. SLL (dBi)	No. of SLL
0.1	5.89	60	80	-?	0
0.2	9.33	28	80	-10.8	4
0.3	11.1	20	80	-8.75	8
0.4	12.31	12	80	-7.52	12
0.5	13.22	12	80	-6.37	16
0.6	13.96	8	80	-5.93	20

Figure 8: Table 3 :

0.7	14.58	8	80	-5.37	24
0.8	15.12	8	80	-4.97	28
0.9	15.58	4	80	-0.15	34
1	11.30	4	76	-8.45	28

Figure 9:

4

Figure 10: Table 4 :

5

					elements						
Number		uniform Array ref.3				Binomial Array ref.4				Chebyshev Array	
of Elements	Gain (dBi)	HPBW (ver. plane)	SLL max. (dBi)	No. of SLL	Gain (dBi)	HPBW (ver. plane)	SLL max. (dBi)	No. of SLL	Gain (dBi)	HPBW (ver. plane)	SLL max. (dBi)
1	2.14	80	-?	0	2.14	80	-?	0	2.14	80	-?
2	5.97	60	-?	0	5.97	60	-?	0	5.97	60	-?
3	7.80	36	-1.3	2	7.41	44	-?	0	7.72	40	-12.1
4	9.2	28	-1.97	4	8.29	36	-?	0	9.03	28	-10.9
5	10.2	20	-1.82	6	8.92	32	-?	0	10.07	24	-9.28

Figure 11: Table 5 :

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6	11.06	16	-1.36	8	9.42	28	-?	0	10.92	20	-8.84	8
7	11.74	16	-0.89	10	9.82	24	-?	0	11.62	16	-7.54	10
8	12.35	12	-0.61	12	10.2	24	-?	0	12.23	12	-7.4	12
9	12.88	12	-0.07	14	10.4	20	-?	0	12.75	12	-6.53	14
10	13.36	8	0.29	16	10.7	20	-?	0	13.22	12	-6.37	16

Figure 12: Table 7 :

Figure 13:

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