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DESIGN AND ANALYSIS OF SQUARE PATCH ANTENNA AND ITS ARRAYS AT 5 GHZ

P. LIKITHA[1] & M. SURENDRA KUMAR[2]

[1]M. Tech Scholar, Department of ECE, KLR College of Engineering & Technology, Paloncha, Khammam, Telangana - State, India

[2]Principal, KLR College of Engineering & Technology, Paloncha, Khammam, Telangana - State, India

ABSTRACT

The patch antenna is a radiating element which radiates along the walls of edges. The size of the patch antenna reduces by increasing the resonant frequency. The gain and bandwidth of single patch antenna is not sufficient for military applications. For this purpose the patch array antenna is designed. In the present work a square patch antenna design at resonant frequency 5GHz and its array analysis is presented. Array antennas has wide applications in both military, wireless communications. The side lobe levels of linear and planar patch antenna array are -13.5dB. This is not suggestible for tracking the targets.

In this present work the side lobe level are decreased in the patch array antenna by introducing the standard amplitude distribution and side lobe level is reduced from -13.5dB to -31.24dB. In this work raised cosine amplitude distribution is used to reduce side lobe level up to -31.24dB.

KEYWORDS: Antenna Array, Square Patch Antenna Array, Raised Cosine Amplitude Distribution, Pattern Multiplication

INTRODUCTION

Micro strip patch antennas are among the most common antenna types in use today, particularly in the popular frequency range of 1 to 6 GHz. This type of antenna had its first intense development in the 1970s, as communication systems became common at frequencies where its size and performance were very useful. More recently, those same properties, with additional size reduction using high dielectric constant materials, have made patch antennas common in handsets, GPS receivers and other mass-produced wireless products.[1][2] In spite of this antenna, in this project micro strip antenna is designed with frequency of 5GHZ. Compared to a circular patch for a given frequency the square geometry is smaller in size. In modern communication system requires low profile, light weight, high gain, and simple structure antennas to give surety reliability, mobility, and high efficiency characteristics. This paper presents design and simulation of a square micro strip patch array antenna at 5 GHz for wireless communications that provides a radiation pattern along a wide angle of beam and achieves a good gain.

FORMULATION

Design of Square patch Antenna

A patch antenna (also known as a squaremicrostrip antenna) is a type of radio antenna with a low profile, which can be mounted on a flat surface. It consists of a flat rectangular sheet or "patch" of metal, mounted over a larger sheet of metal called a ground plane. [3]

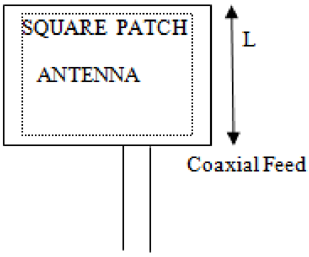

Figure 1: Microstrip Square Patch Antenna

The square patch micro strip antenna can be designed at frequency of 5 GHz using transmission line model and fabricated on Arlon Diclad 880 substrate, whose dielectric constant is 2.2. The Superstrate material can be used same as substrate and whose dielectric constant ($\in r2$) =2.2, substrate and Superstrate dimension is 100×100mm for designing of patch antennas.

For a single slot the far field at a distance r from the origin is:

$$E_{\phi} = -jV_0 wk_0 \frac{e^{-jk_0 r}}{4\pi r} F(\theta,\phi)$$
$$E_{\theta} = 0 \tag{1}$$

For θ=π/2, F (φ) the E-plane pattern can be determined from

$$F(\phi) = \frac{\sin\left(\frac{k_0 h}{2}\cos\varphi\right)}{\frac{k_0 h}{2}\cos\varphi} \tag{2}$$

Similarly,for φ=π/2, F (θ) will represents the h-plane pattern and may be written as

$$F(\theta) = \frac{\sin\left(\frac{k_0 w}{2}\cos\theta\right)}{\frac{k_0 w}{2}\cos\theta}\sin\theta \tag{3}$$

Designed Parameters

Table 1

S. No	Parameters	Value
1	Length	2.2cm
2	Width	2.2cm
3	Resonant frequency	5Ghz

Raised Cosine Amplitude Distribution

The normalized amplitude distribution of uniform distribution [4] is given by

$$A(X) = 1 + \cos\left(\frac{\pi X}{l}\right) \tag{4}$$

By using the above formula the amplitude distribution plotted and is given below.

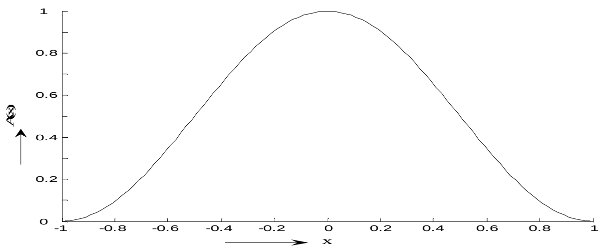

Figure 2: Raised Cosine Amplitude Distribution along the Line Source

Pattern Multiplication

Principle of pattern multiplication states that the radiation pattern of array is the product of pattern of an individual element antenna with Array Factor. [4]. Array factor is a function dependent only on the geometry of the array and the excitation (amplitude, phase) of the elements.

Pattern multiplication is defined that resultant pattern is equal to the array factor multiplied with the element pattern i.e, E (θ) resultant = Element Pattern× Array Factor

$$E_T = E_e \times AF$$

$$E(u) = \sum_{n=1}^{N} A(x)\, e^{j\frac{\pi l}{\lambda} u x_n} \tag{5}$$

$$E_e = \frac{\sin\left(\frac{k_0 h}{2}\cos\varphi\right)}{\frac{k_0 h}{2}\cos\varphi} \tag{6}$$

Where x_n is the location of the n^{th}element,

$$X_n = \frac{2n - N - 1}{N} \tag{7}$$

N=number of elements in an Array

u = sin Θ

RESULTS

The Raised cosine amplitude is used to decaying the side lobe levels to the required level. The side lobe level of a linear array is -13.5 dB which is most advisable for point to point communication. In the present work by using standard amplitude distribution is used to reduce the side lobe level is reduced up to -31.0 dB and which is compared with the uniform linear array. Plots are drawn for small and large arrays of N=10, 20, 40figures are presented from 3 to 5. The specific element locations are presented in the tabular forms from the Tables 1-4

In the present work the practical element arrays are designed for small and large arrays .the results are compared with the ideal arrays which came with good agreement.. The square patch antenna isused in this work to produce narrow beams and high gain, by neglecting inter element interference the designed wave guide arrays for N=10,20,40,80,100 by adopting standard amplitude distribution to these arrays side lobe level are also reduced and are compared with the isotropic arrays and the plots are presented from 10 to 12.

Table 2: Raised Cosine Amplitude Distribution with Specific Location of N=10 Elements

S. No	Location xn	Amplitude A(xn)
1	-0.9	0.0489
2	-0.7	0.4122
3	-0.5	1.0000
4	-0.3	1.5878
5	-0.1	1.9511
6	0.0	2.0000
7	0.1	1.9511
8	0.3	1.5878
9	0.5	1.0000
10	0.7	0.4122
11	0.9	0.0489

Table 3: Raised Cosine Amplitude Distribution with Specific Location of N=20 Elements

S. No	Location x_n	Amplitude $A(x_n)$
1	-0.95	0.0123
2	-0.85	0.1090
3	-0.75	0.2929
4	-0.65	0.5460
5	-0.55	0.8436
6	-0.45	1.1564
7	-0.35	1.4540
8	-0.25	1.1701
9	-0.15	1.8910
10	-0.05	1.9877
11	0.00	2.0000
12	0.05	1.9877
13	0.15	1.8910
14	0.25	1.1701
15	0.35	1.4540
16	0.45	1.1564
17	0.55	0.8436
18	0.65	0.5460
19	0.75	0.2929
20	0.85	0.1090
21	0.95	0.0123

Table 4: Raised Cosine Amplitude Distribution with Specific Location of N=40 Elements

S. No	Location X_n	Amplitude $A(X_n)$
1	-0.9750	0.0031
2	-0.9250	0.0276
3	-0.8750	0.0761
4	-0.8250	0.1474
5	-0.7750	0.2396
6	-0.7250	0.3506
7	-0.6750	0.4775
8	-0.6250	0.6153
9	-0.5750	0.7666
10	-0.5250	0.9215

11	-0.4750	1.0785
12	-0.4250	1.2334
13	-0.3750	1.3827
14	-0.3250	1.5225
15	-0.2750	1.6494
16	-0.2250	1.7604
17	-0.1750	1.8526
18	-0.1250	1.9239
19	-0.0750	1.9724
20	-0.0250	1.9969
21	0.0250	0.9994
22	0.0750	0.9944
23	0.1250	0.9844
24	0.1750	0.9694
25	0.2250	0.9494
26	0.2750	0.9244
27	0.3250	0.8944
28	0.3750	0.8594
29	04250	0.8194
30	0.4750	0.7744
31	0.5250	0.7244
32	0.5750	0.6694
33	0.6250	0.6094
34	0.6750	0.5444
35	0.7250	0.4744
36	0.7700	0.3994
37	0.8250	0.3194
38	0.8750	0.2344
39	0.9250	0.1444
40	0.9750	0.0494

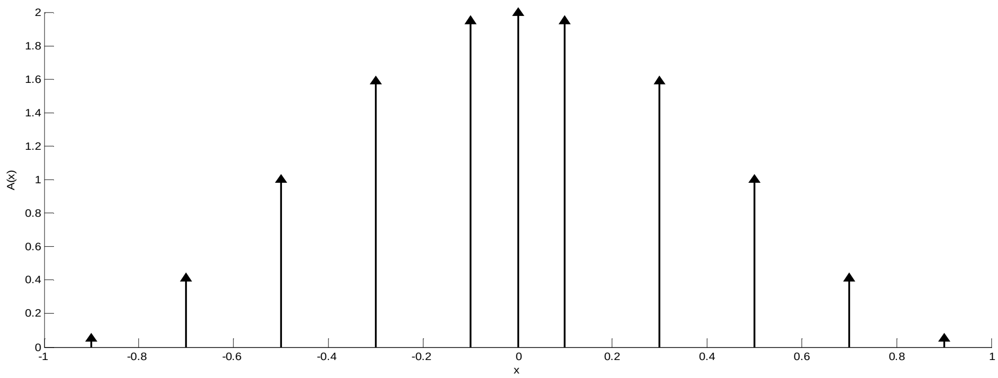

Figure 3: Rraised Cosine Amplitude Distribution with Discrete Location of N= 10

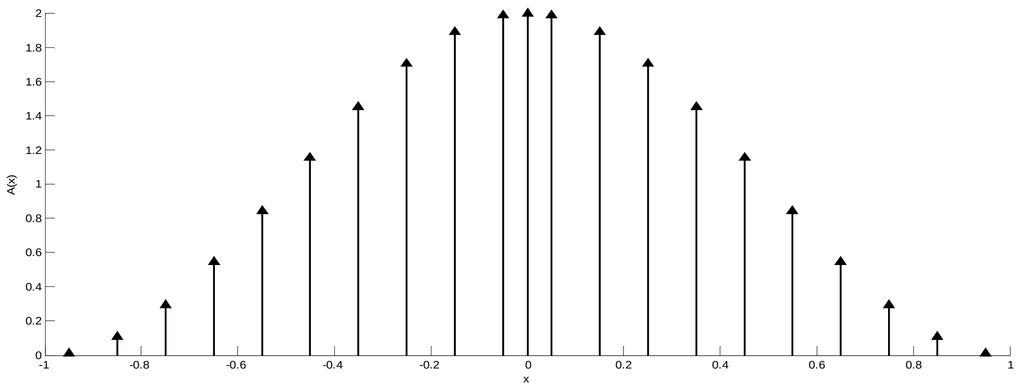

Figure 4: Raised Cosine Amplitude Distribution with Discrete Location of N= 20

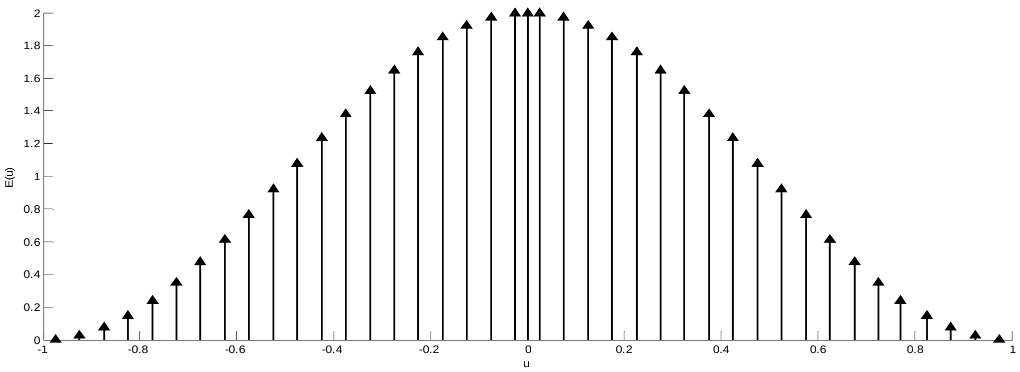

Figure 5: Raised Cosine Amplitude Distribution with Discrete Location of N= 40

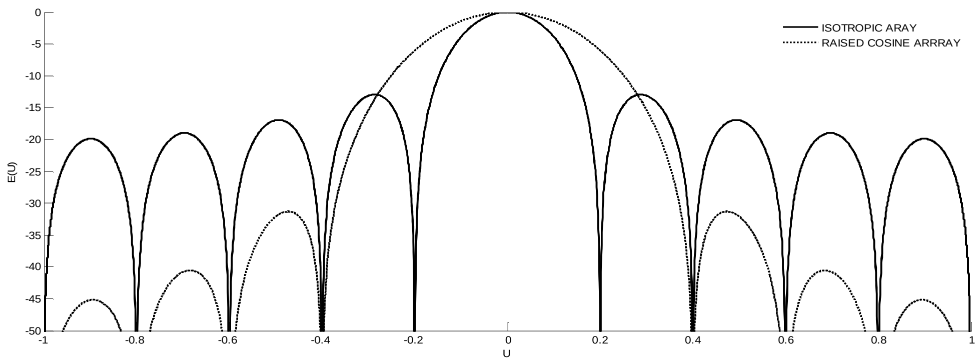

Figure 6: Rraised Cosine and Isotropic Arrays for N=10 Elements

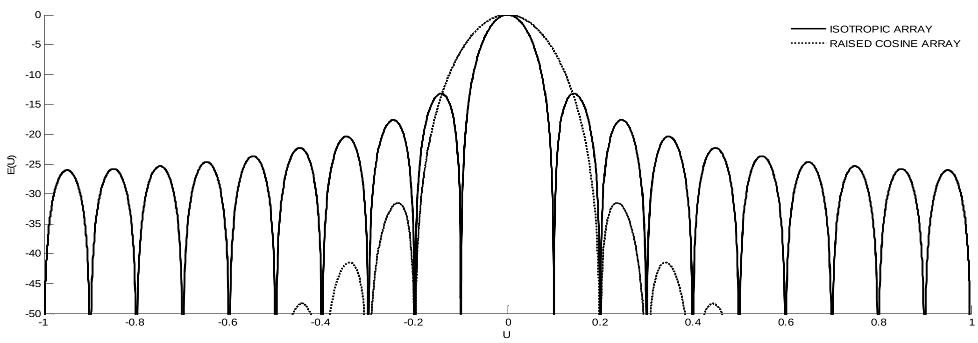

Figure 7: Raised Cosine and Isotropic Arrays for N=20 Elements

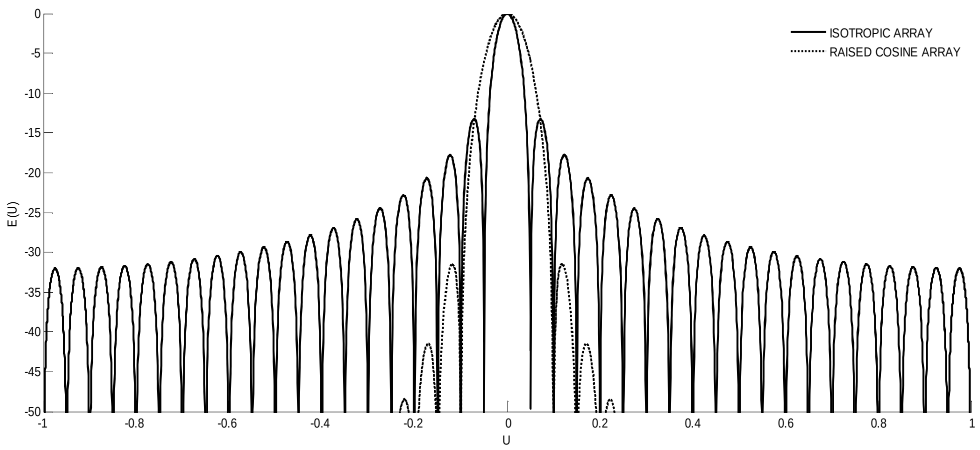

Figure 8: Raised Cosine and Isotropic Arrays for N=40 Elements

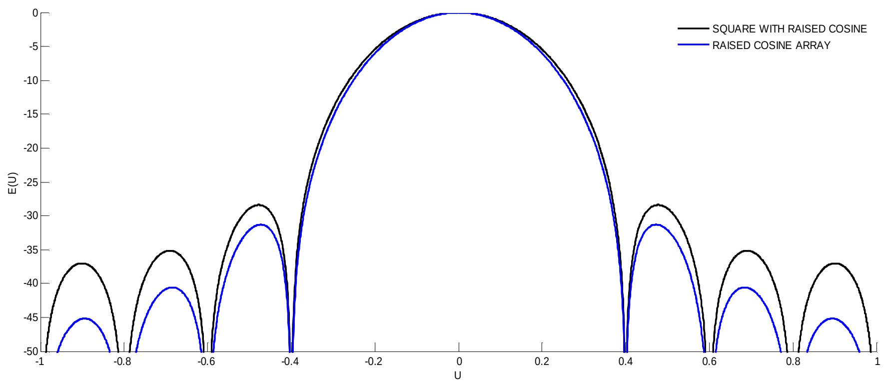

Figure 10: Synthesized Isotropic Arrays with and Without Square Patch Antenna for N=10

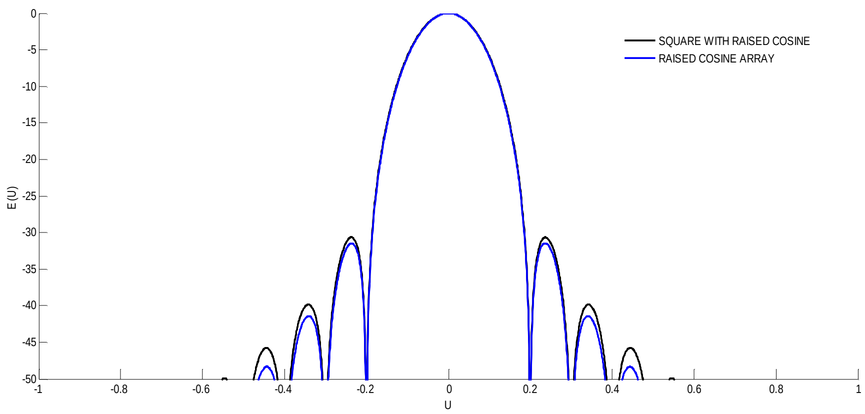

Figure 11: Synthesized Isotropic Arrays with and Without Square Patch Antenna for N=20

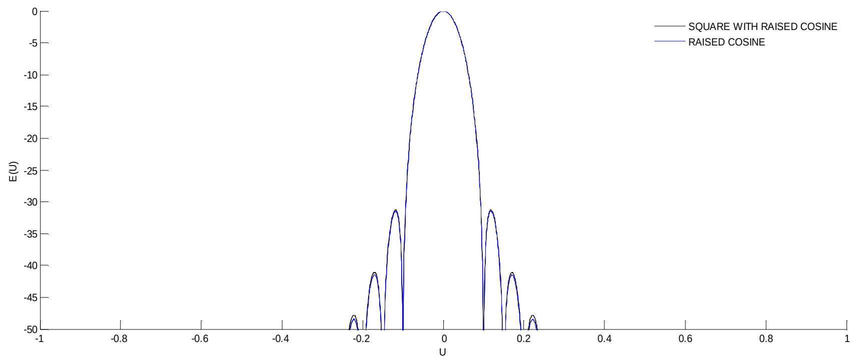

Figure 12: Synthesized Isotropic Arrays with and Without Square Patch Antenna for N=40

CONCLUSIONS

To reduce side lobes level of an Isotropic antenna arrays we use raised cosine amplitude distribution. By Comparing Uniform, raised cosine amplitude distribution we observe that the first side lobe level of Uniform Amplitude distribution is high comparing with other amplitude distribution radiation patterns & beam width is less comparing with parabolic amplitude distributions. The amplitude distributions are used in practical antenna elements i.e., in square patch antenna. The normalized form of square patch antenna can be indicated by equation (7). By using this amplitude distribution it provides low side lobe level, Narrow beam width & high gain. This type of array antenna system is preferred in the wireless communication and radar applications.

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AUTHOR'S DETAILS

1. **Ms. P. Likhitha** received her B. Tech From JNTU-Kakinada with Distinction, Presently pursuing M. Tech , from KLR College of engineering and Technology-Paloncha affiliated to Jntu-Kakinada.

2. **Dr. M. Surendra Kumar** received his B.Tech from Nagarjuna University and M. Tech, Ph.D from Andhra University. He has 19 years of teaching experience. He published 23 technical papers in National and International conferences and journals. His fields of interest are Antennas and wave propagation, Microwave engineering and Radar Engineering. Presently he is working as a Principal in K L R College of Engineering & Technology-Paloncha, Khammam -Dist, Telangana