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Dual-Band 8x8 Adaptive Array Antenna for 3.5/5 GHz

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Abstract

This paper gives result analysis for the adaptive antenna array is expected to meet data rate requirement for 4G communication for Direct Sequence CDMA (DS-CDMA) antenna application.In this paper 4G smart planner dual band phase array suitable Long Term Evolution (LTE) at 3.5 GHz for fourth generation (4G)and also Wireless Local Area Network(WLAN) at 5GHz system isdeveloped. The proposed planar array antenna is build using micro strip U slotted patch antenna element. Separate feeding techniques are used for every element of the smart planar array antenna and elevation direction at Sixty degree phase shift absent of any grating lobes. At Sixty degree phase shift, the gain is to be 22.62dB without changing in the mutual coupling. In this single element and linear sub arrays with 1x2 and 1x4 dimension of this element are designed.

Keywords: *Dual band phase array antenna, DS-CDMA, wireless local area network (WLAN), adaptive antenna*

INTRODUCTION

Antenna is a transducer which transmits or receives electromagnetic waves. Long Term Evolution (LTE) is substantially improving end-user throughputs sector capacity and reduces user plane latency to deliver significantly improved user experience. Micro strip antenna was first introduced in the 1950s. Micro strip antennas are the common types of wide range antennas for different applications due to their apparent advantages of light weight, low profile [1, 2]. In this paper, we present 3.5/5 GHzdual-band 8x8 adaptive planar array antenna. The adaptations of the antenna are done by achieving different beam shaping. The proposed adaptive array antenna is built using a micro strip rectangularU-slotted patch antenna element. The block diagram of Adaptive Array Antenna is shown in section 2.The developed array antenna design simulation and measurement forsingle antenna element (1x2 and 1x4)linear array antennas. Is shown in section 3.The Design of our Adaptive model is shown in section 4.Finally, Section 5gives the conclusion.

ADAPTIVE ARRAY ANTENNA

Adaptive arrays is one of the key technologies expected to dramatically improve the performance of future wireless Network systems because they have the potentialto expand coverage, increase capacity, and improve signal quality. The block diagram of Adaptive Array Antenna is shown in below Figure 1 [3–6].

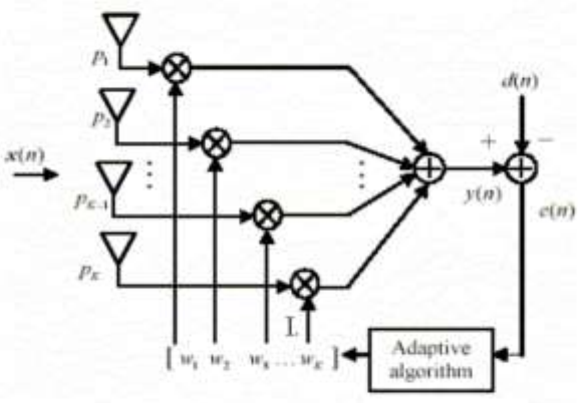


Fig.1: *Block Diagram of Adaptive Array Antenna.*

LITERATURE SURVEY

This section shows the developed array antenna design simulation and measurements for single element 1x 2 and 1x4linear array antennas.

Single Element Antenna

Figure 2 shows the geometry of an optimized antenna element (inmm). Rogers substrate, RT-Duroid 5880 (€= 2.2). Single substrateis used with 62' mil thickness. U-shaped slotted patch is used to provide the dual-band for both the Long Term Evolution and Wireless LAN applications [7–10]. Aslot antenna has special advantages such less conductor loss widerbandwidth, and better Separation between the radiating element and fed Network the effectiveness of dual-band slot antenna is confirmed, but for 2.4/5 GHz WLAN applications only. Our slot antenna is suitable for the both Wireless LAN and WiMAX/LTE 4G applications. Design simulation and optimization processes arecarried out with the aid of Antenna design system 2008 simulator which depends on MoM Numerical technique. MoM is one of the hardest to implementbecause it can involves careful evaluation of Green's functions and Electromagnetic coupling integrals. Maxwell's equations are transforming into integral Equations which upon discretization yield the coupling matrix equationof the structure. The advantages of this transform arethat the currentDistributions on the metal surfaces emerges the core unknowns thisis contrast to other techniques which typically have the electricand/or magnetic fields present everywhere in the solution spacethe core unknowns. Hence, the number of unknowns or the size of the matrix is smaller. This results in very efficient simulation technique, which is able to handle very complex structures. The fundamental basics MoM are best outlined as follows [11–14].

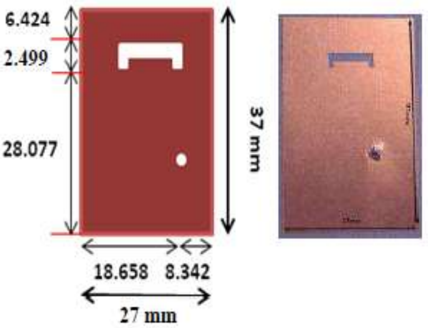
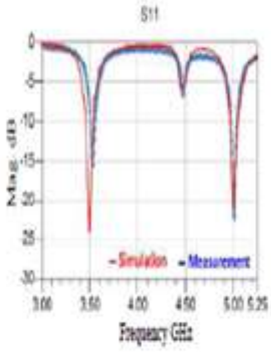


Fig. 2: *Geometryof a U-slotted Antenna Element.*



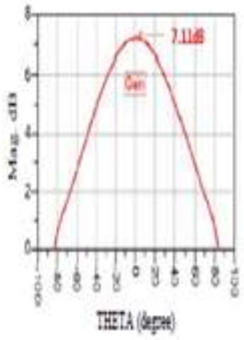


Fig.3 *Single Element* ***Fig.4*** *Single Element gain Reflection Coefficient*
Conventional MoMProcedure whereby the mixed potential integralequation is discretized into a matrix equation:

$$Z.I = V \quad (1)$$

Where Z denotes the conventional impedance matrix; I is theunknown current vector; and V is the excited voltage vector.

Thedesired solution I of (1) can be represented as:

$$I = \sum C_i I_i \quad (2)$$

Where$I_i$represent the characteristic basis currents, and Cidenotes the magnitudes these currents. I apply the Galerkin procedure once more and employ theCharacteristic Basis the test functions. This leads us to the following matrix equation for the reducedcurrent vector" IR whose entries are the Ci:

$$Z^R * I^R = B^T.V \tag{3}$$

Here $Z^R$is an $N £ N$ reduced system matrix given by

$$Z^R = B^T Z^{R\cdot} B \tag{4}$$

B is a matrix with N columns defined by

$$B = [I_1\ I_2 \ldots\ldots I_N] \tag{5}$$

The superscript “T" in the above given equations denotes the matrix transpose.Various methods for fast matrix-vector multiplication that is availablein the literature may be used to efficiently compute the coefficientsin eq.(3) if desired. As mentioned before substituting the solution ofEq. 3 into expression in Eq.no.2 gives the induced current.Antenna measurement is doneusing *hp* ®8510C network analyzer. a frequency bandwidth of 75MHz(LongTerm Evolutionfrequency band), and is --20*:*88 dB with a frequency bandwidthof 80MHz at 5 GHz (Wireless LAN frequency band), respectively. $S_{11}$for measurement is -15*:*12 dB at 3.5 GHz and -21*:*22 dB at 5 GHzrespectively. This ensuresmatching between simulation and Measurement. Figure 3 shows that the gain is better than 7 db with antenna efficiency of 93.43% at 3.5 GHz.

A. 1x2 Linear Array Antenna

Figure 5shows the geometry of 1*2 array antenna element optimized. Figure 6shows that the reflection coefficients.S_{11} for simulation is -23.83dB at 3.5GHz and -20.01dBat 5GHz respectively.S_{22} for simulation is -19.5dB at 5GHz and-20.88dB at 3.5GHz respectively.$S_{11}$for measurement is -18.73dB at 5GHz and -39.23dB at 3.5GHz respectively and S22for measurement is 15.21dB at 5GHz and35.82dB at 3.5GHzrespectively. This ensures matching between simulation and measurement. Figure 7 showsthe coupling coefficient S_{12}.This ensures good matching betweensimulation and measurement also. the reflection coefficientS_{11} for simulationis -23.83 dB at 3.5 GHzshows in Figure 2 that with

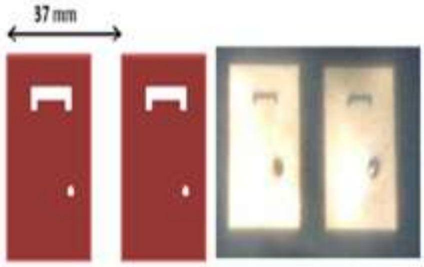
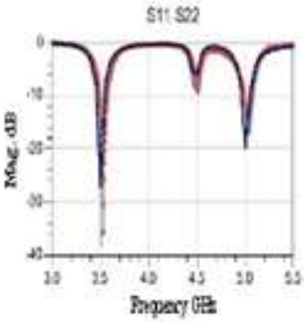


Fig. 5: *1x2 Linear Array Antenna.*



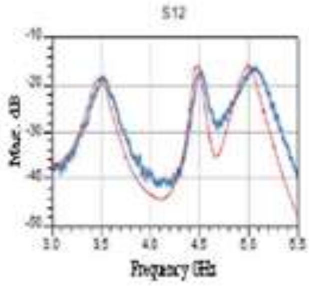


Fig. 6: *1x2 Array Reflection.* ***Fig. 7:*** *1x2 Array Coupling Coefficient*
S11Coefficient S12.

1 4 Linear Array Antennas*

Figure 8 shows the geometry of 1*4 array antenna element optimized. Fig.9 shows the reflection coefficients ($S_{11}S_{22}S_{33}$ andS_{44}).This ensures matching between simulation and measurement. Figure 9 shows the coupling coefficients (S_{12},S_{13}andS_{14}.) This alsoensures good matching between simulation and measurement. Table 1 summary the antenna gain efficiency bandwidth,recoupling coefficients andreflection coefficients for single element, 1*2,and 1*4 linear array antennas at 3.5GHz

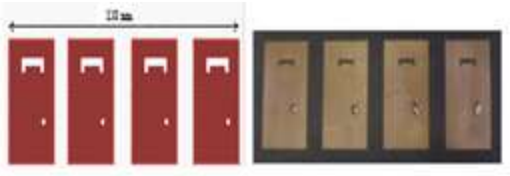


Fig. 8: *1x4 Linear Array Antennae.*

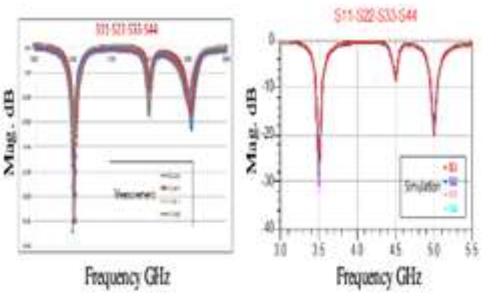


Fig. 9: *1x4 Array Reflection Coefficient S11,S22,S33,S44 for Measurement and Simulation.*

DESIGN OF OUR ADAPTIVE MODEL

In this section, we are present proposed smart array antenna explainingthe idea of approach. We examine the accuracy and efficiency ofsimulation method by comparing it with another one. The proposed smart (8*8) adaptive array antennas with the same dimensions of our previous work arepresented. The adaptation is fulfilled by achieving different beam shaping. This is done bychanging the feeding amplitudes distributions of the array element inazimuth and elevation directions, different feeding phase shiftangles between different array antenna elements in azimuth directions. Where the steering areperformed by changing only phases of the elements.

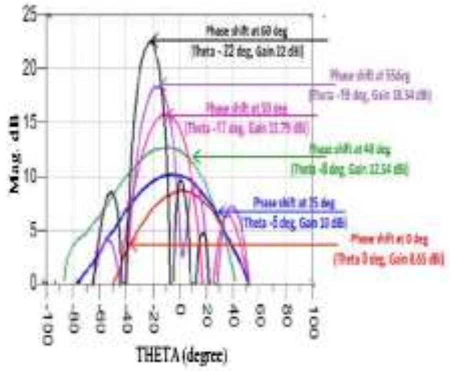


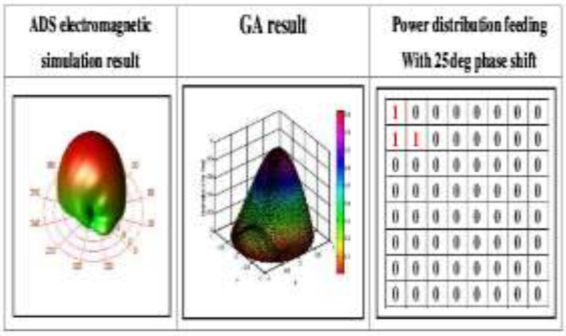
Fig. 10: *Gains with Different Angles at Different Phase Shift Angles.*

Table 1: *Phase Shift Difference, Designated Steer Angle, and Gain of (8x8) Planar Array Antenna.*

Phase difference (degree)	0	25	40	50
Designated Streer Angle ɵ(degree)	0	±5	±8	±17
Gain dBi	8.65	10	12.54	15.79

Table 1 shows complete matching between both results take into consideration that the optimization process was done using a Genetic Algorithm. Using a Generic Algorithm, gives very efficient optimize at exploring the entire space it is relatively poor infeeding the precise local optimize solution in region where the algorithm converges. As result, the validity of simulation method isobtained and at the same time it get more efficient optimize process than Genetic Algorithmprocess.This process is one of the existing simulation methods that used extensively to designing different types of antennas in the literature.

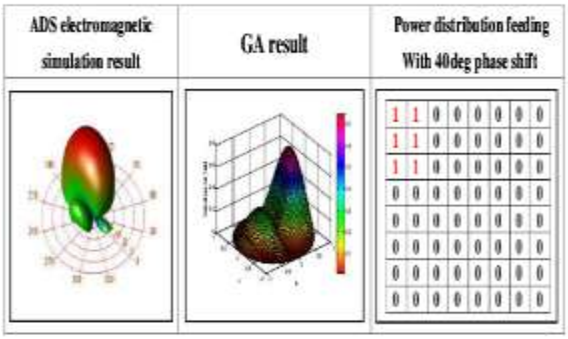
Table 2: *The Thinned Elements at Theta "0"deg.*



ADS electromagnetic simulation result	GA result	Power distribution feeding With 25deg phase shift

1	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

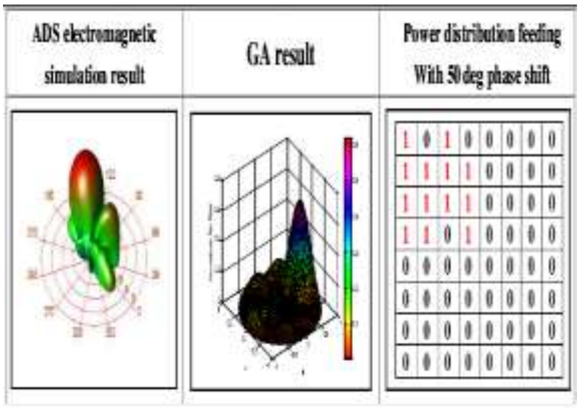
Table 3: *The Thinned Elements at Theta "25"deg.*



ADS electromagnetic simulation result	GA result	Power distribution feeding With 40deg phase shift

1	1	0	0	0	0	0	0
1	1	0	0	0	0	0	0
1	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

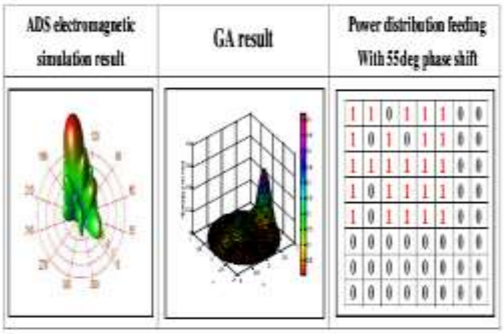
Table 4: *The Thinned Elements at Theta "40"deg*



ADS electromagnetic simulation result	GA result	Power distribution feeding With 50 deg phase shift

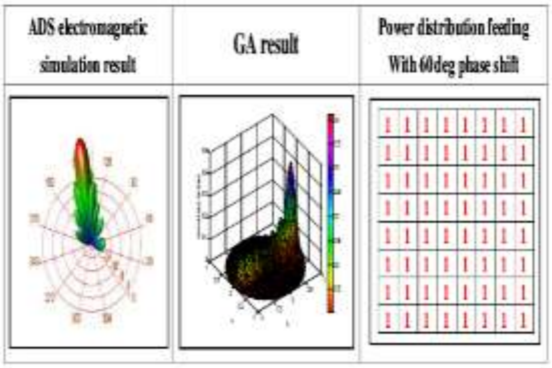
1	0	1	0	0	0	0	0
1	1	1	1	0	0	0	0
1	1	1	1	0	0	0	0
1	1	0	1	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Table 5: *The Thinned Element at Theta 50 deg.*



ADS electromagnetic simulation result	GA result	Power distribution feeding With 55deg phase shift

1	1	0	1	1	1	0	0
1	0	1	0	1	1	0	0
1	1	1	1	1	1	0	0
1	0	1	1	1	1	0	0
1	0	1	1	1	1	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0



ADS electromagnetic simulation result	GA result	Power distribution feeding With 60deg phase shift

1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1

The proposed smart planar adaptive array antenna with 8*8 dimensionswill be used to achieve different beam shaping by changing the feedingamplitudes distribution of the array antenna elements in both azimuth and elevation directionsdifferent feeding phase shift angles between various array elements in azimuth directions with values of 0,25,40,50&55 and 60degrees. The electromagnetic simulation results will be verified using a GA. Tables 3, 4, 5, 6, 7, and 8show complete result.

CONCLUSION

This paper is a survey on the technological advancements in Adaptive array antenna over long years. The technological advancement of the Adaptive array antenna is increasing day by day. A lot of research work is going on Adaptive array antenna for its better utilization in the future. It is observed that the initially research work reports about a single element antenna design and then simulation tests are carried out for further analysis. After verification of single element antenna performances, simulation tests for an array of 8-antenna are carried out.

3.5/5GHz dual-band 8*8 smart adaptive array antenna has been developed. This smart antenna is suitable for both MIMO Long Term Evolution **(**LTE) 4G and WLAN applications.The adaptation of antenna has been done by changing the feeding amplitudes distributions of the array antenna element in both azimuth and elevation directions and different feed phase shift angles between different array elements in azimuth direction. Numerically, it has been shown that beam steering of ß 22 has been achieved at phase shift difference of 60 without any grating lobes at (3.5GHz). The gain is saved with ranges between 22.628and 8.65 dBi such that; the mutual coupling dos not changed and lies between--58.141dB and14.022 dB at different feeding phase shift angles, which lies between degrees 0 and 60without any grating lobes.

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