Available online at www.elixirpublishers.com (Elixir International Journal)

Electrical Engineering

Elixir Elec. Engg. 98 (2016) 42730-42734

ISSN: 2229-712X

Generation of Beams from Conventional and Non-Conventional Antennas using Phase Control

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ARTICLE INFO

Article history:
Received: 19 August 2016;
Received in revised form:
19 September 2016;
Accepted: 29 September 2016;

Keywords
Sector Beams,
Tschebychev,
Binomial,
Patch Antenna Arrays.

ABSTRACT

Antenna arrays are particularly preferred as they provide flexibility in design, excellent gain and high directivity. They allow optimization via the tapering of amplitude, the special distribution, the phase distribution or their combination providing also the option to generate specific sector and cosec beams for advanced radar applications. The narrow beams obtained from parabolic antennas or from an array of radiators are used to achieve high gain, precise direction finding and high degree of resolution of complex targets. But these narrow beams require multi scans which is highly involved and time consuming. These difficulties can be overcome by providing flat beams which are broad basically. The phase only control allows a fast scanning of the beam without moving the antenna structure. In this paper an attempt is made to design an array of antennas to produce shaped beams like sectors by introducing an optimally designed phase distribution. The results of this paper are extremely useful for designers of antenna arrays for scanning and non-scanning radar and communication applications.

Introduction

Antennas have been important tools in communication technologies from the days of electromagnetic radiation. Their applications are extremely diverse, as are the physical designs that have evolved from wire. The term wire represents a metallic highly conducting structure. Its structure can be constructed from a given number of wire segments and which may in principle be straight or curved. In fact, a dipole can be a wire or a rod of conducting material. The directional pattern of the array of the dipoles has the characteristics limited by some constraints.

These imitations will be considered in terms of side lobe levels and beam widths. Although several structures exist in the literature, their arrays are considered in this paper to produce controlled and well defined beam shapes. In this paper an attempt is made to design an array of antennas to produce shaped beams like sectors by introducing an optimally designed phase distribution. In this paper several attempts are made to produce sector shaped beams from an array of antennas, which includes Tschebychev, Binomial and Patch antenna arrays.

Problem Definition

Generally antenna arrays are used to provide flexibility in design, excellent gain and high directivity. The beams thus produced are with high directivity and gain but with many side lobes and more power dissipation which is a major drawback in the synthesis of antenna arrays. The narrow beams obtained from parabolic antennas or from an array of radiators require multiple scans, which is highly involved and time consuming. For changing the direction of the radiation pattern the entire structure of the antenna has to be change.

These difficulties can be overcome by providing flat beams which are broad basically.

Among all the antenna parameters the phase only control allows a fast scanning of the beam without moving the antenna structure.

Goals

The main goal of the paper is to generate sector beams from an array of antennas. There are so many beams generated from the antenna structure. Those beams are bidirectional, fan, cardioid, pencil and sector beams. Among these beams sector shaped beams are more advantageous.

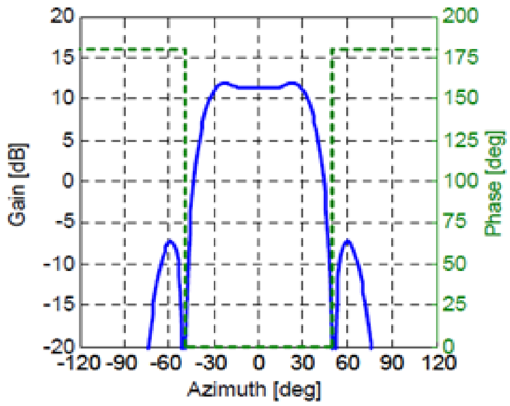

Fig 1. Sector beam.

As shown in the above figure the radiation pattern can be propagated in the bounded region. Antenna arrays allow optimization via the tapering of amplitude, the spatial distribution, the phase distribution or their combination providing also the option to generate specific sector and cosec beams.

Proposed Methods

Various types of beams can be generated from the antenna arrays.

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In this paper a literature survey is done on different antennas in to understand the characteristics of different beams. Linear array of antennas can produce bidirectional as well as unidirectional beams. By changing the parameters of antenna arrays pencil beams can be produced. These pencil beams are very useful in the detection of targets in defense, in the field of communication. But it is difficult to track the moving objects by pencil beams. So we are moving for sector beams.

Sector beams are needed to implement the access channels of mobile radio standards. Prior to network entry there is no information on the radio channel associated with a particular subscriber, so a sector beam is required to transmit and receive signals over a variety of directions. Another situation when sector beams are necessary is for broadcast operation, where the same signal is transmitted simultaneously to multiple geographically dispersed subscribers. To generate sector beams we chose the micro strip antennas which are also known as patch antennas.

Micro Strip Antennas

In high-performance aircraft, spacecraft, satellite, and missile applications, where size, weight, cost, performance, ease of installation, and aerodynamic profile are constraints, low-profile antennas may be required. Presently there are many other government and commercial applications, such as mobile radio and wireless communications, that have similar specifications to meet these requirements, micro strip antennas can be used. These antennas are low profile, conformable to planar and non-planar surfaces, simple and inexpensive to manufacture using modern printed-circuit technology, mechanically robust when mounted on rigid surfaces, compatible with MMIC designs, and when the particular patch shape and mode are selected, they are versatile in terms of resonant frequency, polarization, pattern, and impedance.

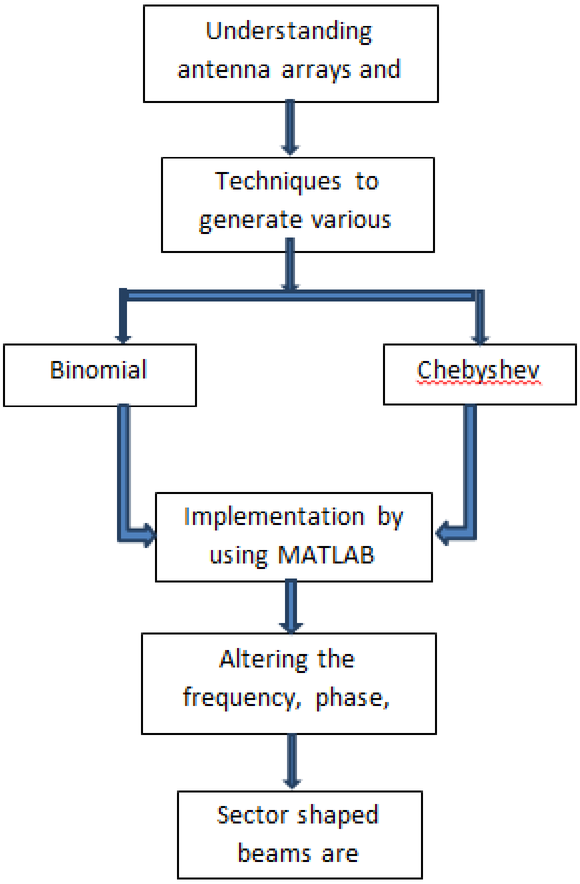


Fig 2. Block Diagram.

In addition, by adding loads between the patch and the ground plane, such as pins and varacter diodes, adaptive elements with variable resonant frequency, impedance, polarization, and pattern can be designed.

Major operational disadvantages of micro strip antennas are their low efficiency, low power, high Q, poor polarization purity, poor scan performance, spurious feed radiation and very narrow frequency bandwidth, which is typically only a fraction of a percent or at most a few percent.

The simulation results can be obtained by changing the parameters of the antenna arrays, spacing between the elements, number of elements in the array, amplitude and phase excitations. The step wise results during the time period of this paper will be discussed below.

Linear Array

The simulation results for the linear array are shown in the following diagrams.

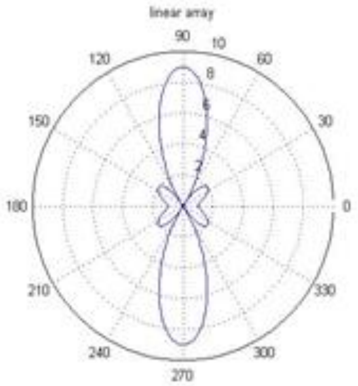


Fig 3. Beam pattern for linear array.

For the spacing between elements=0.2, number of elements=9

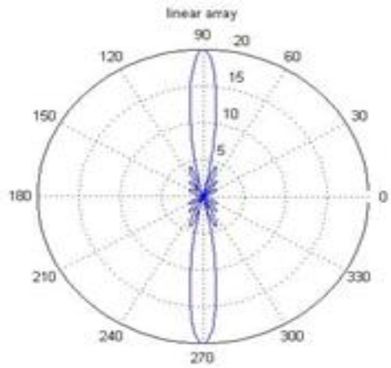


Fig 4. Beam pattern of linear array.

Spacing between elements=0.2, number of elements=20

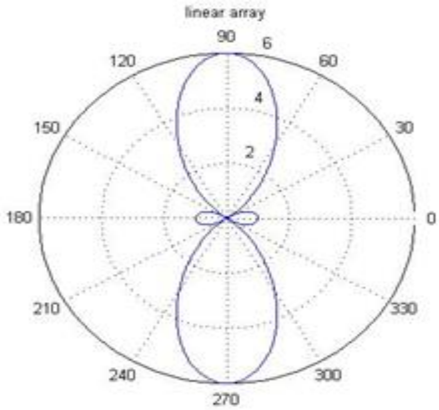


Fig 5.Beam pattern of linear array.

Spacing between the elements =0.2, number of elements=6

Binomial Array

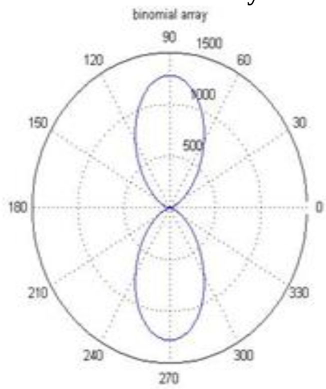


Fig 6. Beam pattern of binomial array

Spacing between elements =0.2, number of elements=9

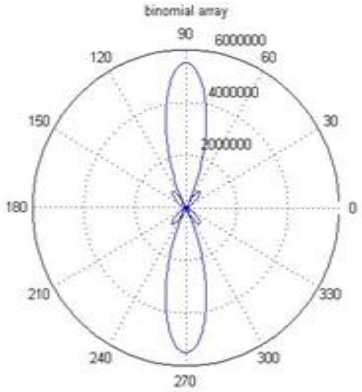


Fig 7. Beam pattern of binomial array.

Spacing between elements =0.2, number of elements=20

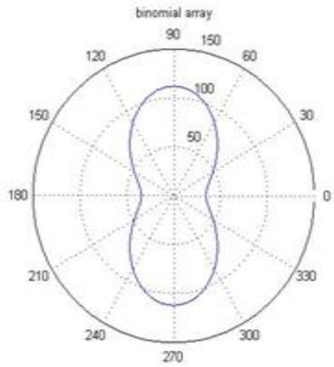


Fig 8. Beam pattern of binomial array.

Spacing between elements =0.2, number of elements=6

Tschebycheff Array

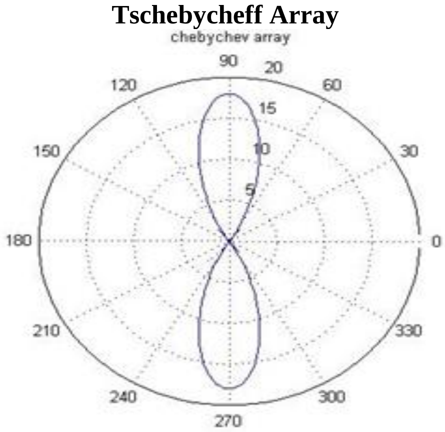


Fig 9. Beam pattern of Tschebbycheff array.

Spacing between elements =0.2, number of elements=9

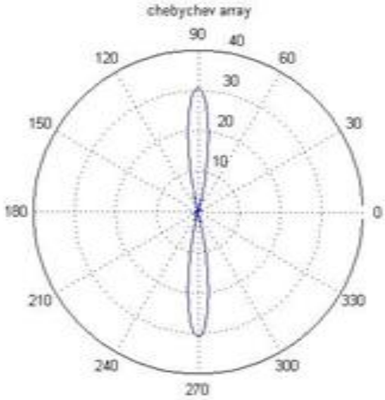


Fig 10. Beam pattern of Tschebbycheff array.

Spacing between elements =0.2, number of elements=20

Results and Discussions

We evaluate our proposed method by using the MATLAB software, the results are displayed in below figures.

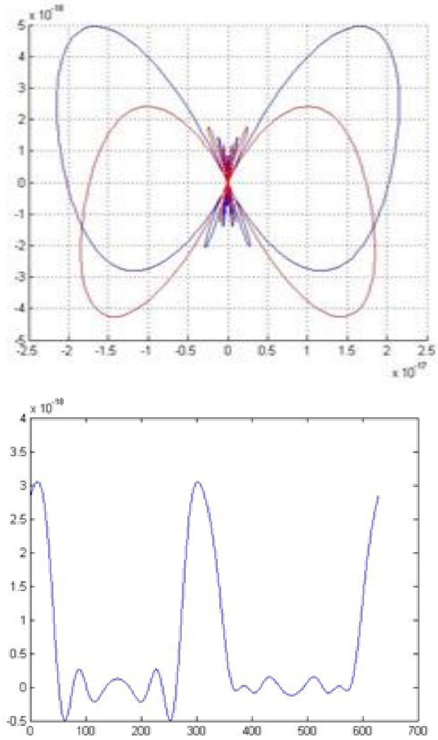
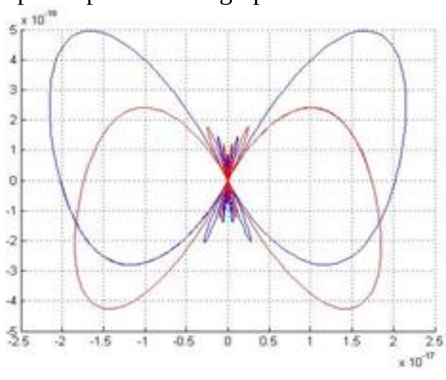


Fig 11. Total electric field for the patch antenna for Theta(θ)=phi($\emptyset$)=2π.

Above figures represents the polar representation of the variation of total electric field with respect to the phase. Here we can observe the sector beams produced are two in number. The second plot represents the graph of sector beams.



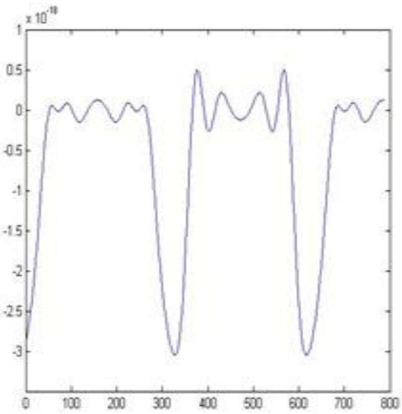
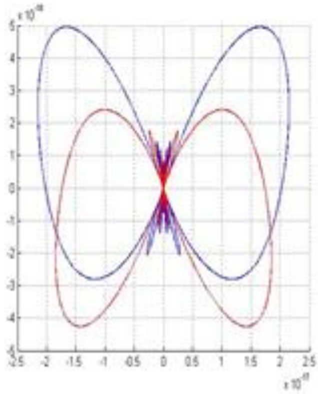


Fig 12. Total electric field for the patch antenna for Theta(θ)=phi($\emptyset$)=2.5π.

The above fig 12 represents the polar plot of total electric field for the array of patch antennas with respect to the phase change. From the figure we can observe the changes in the real and imaginary parts.



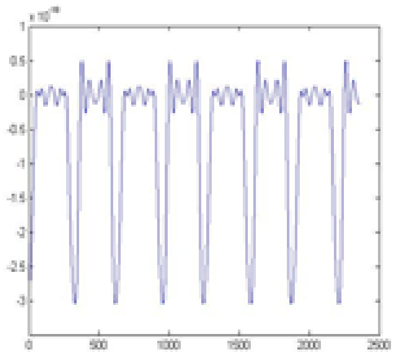
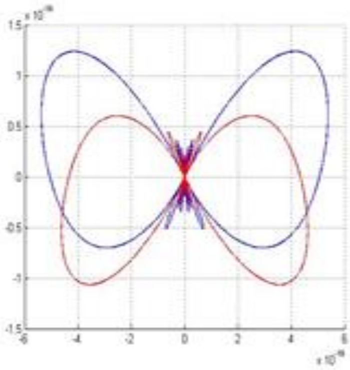


Fig 13. Total electric field for the patch antenna for Theta(θ)=phi($\emptyset$)=$15\pi/2$.

As shown in the above fig 13 the number of sector beams produced is increased by increasing the phase distribution. Here by choosing the phase as 7.5 we attain seven and half sectors.



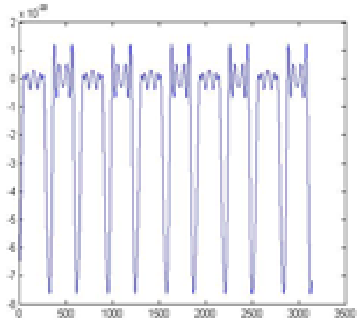
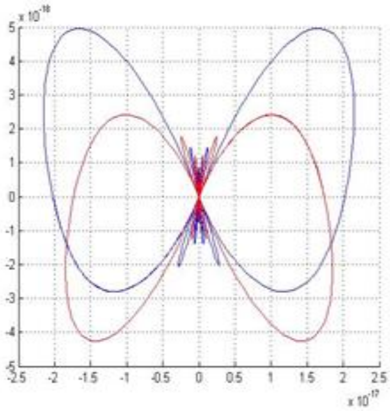


Fig 14. Total electric field for the patch antenna for Theta(θ)=phi($\emptyset$)=10π.

The above fig 14 is indicating the increase in the number of sector beams and also the reduction in the side lobes width.



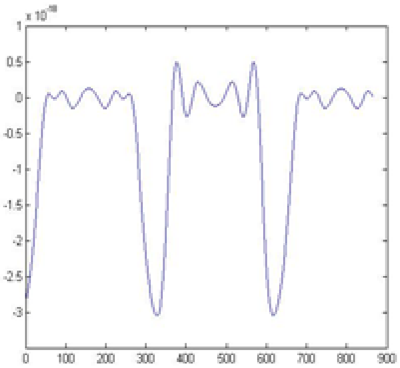


Fig 15. Total electric field for the patch antenna for Theta(θ)=phi($\emptyset$)=$11\pi/4$.

The above fig 15representing the greater increase in the number of sector beams.

Conclusion

By observing the simulation results we can conclude that sector beams are produced by varying the phase distribution of elements. Conversion of narrow beams into sector beams are found to be optimal, as a resultant pattern over the angular widths are very close to the specified one, more over that the converted beams do not have any side lobes in the desired region. The beams are almost flat in the specified angular regions. Thus produced beams are very useful for radar and communication applications. By producing these types of beams, power dissipation would be less in the communicating process.

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