Analyze the Effect of Number of Elements on Radiation Pattern of Broadside array and End Fire array

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ABSTRACT
In the smart antenna system, the commonly used Antenna arrays are broadside array, and end fire array. They adapt to radiate their own beam patterns. The antenna arrays with different arrangements may produce the diverse radiation properties. The overall radiation pattern of an array is determined by array factor combined with the radiation pattern of the antenna element. The overall radiation pattern results in a certain directivity and different lobes with different number of elements. Thus in this paper analysis is made on the effect of number of elements on broadside array and end fire array. And the comparative conclusions are drawn

Keywords
Directivity; broadside array; end fire array; radiation pattern

1. INTRODUCTION
Over the last few years, there has been an increasing demand for better quality, increased capacity and new value added services on existing wireless mobile communications network. This demand has brought technological challenges to service providers. In the form of "smart antennas" or "adaptive array antennas", they meet the challenging demand and bring many benefits to the wireless communications services. These benefits include the enhancement of coverage and the channel capacity, lower transmitted power, better signal quality, higher data rate, and provided value-added services such as users' position location. For some applications single element antennas are unable to meet the gain or radiation pattern requirements [1,2]. Combining several single antenna elements in an array can be a possible solution.

When an element is excited, the radiated fields induce currents on nearby elements, which produces an additional contribution to the radiated fields. The equivalent current for an element in an array has a large component on the driven element, and smaller components on the other elements around the driven elements. For elements near the edge of the array, the coupled currents are different because there are fewer nearby elements than is the case for elements in the interior of the array. Even though the elements in the array are identical, the elements in the array are effectively represented by different equivalent currents. This means that the embedded element radiation pattern (including radiation from currents induced on neighboring elements) is different from the radiation pattern of the antenna element in isolation[3,4]. The array factor can be controlled by adjusting the complex excitations. The array radiation pattern is the product of the array factor and the pattern of one element located at the origin. If the array elements are electrically small, then the element pattern is broad and slowly varying with angle, and the array factor dominates in determining the shape of the radiation pattern. If the elements were ideal isotropic radiators, then the radiation pattern is equal to the array factor. The theory of array antenna beamforming provides methods for designing the excitations and locations of the elements in order to achieve various goals for the radiation pattern, such as high gain, electronic beam steering, low sidelobes, or interference nulling [8,9].

2. ANTENNA ARRAY
The phasing of the uniform linear array elements may be chosen such that the main lobe of the array pattern lies along the array axis (end-fire array) or normal to the array axis (broadside array). The maximum of the array factor occurs when the array phase function is zero.

$$\Psi = \alpha + kd\cos\theta = 0$$

For a broadside array, in order for the above equation to be satisfied with $\theta = 90$ degrees, the phase angle α must be zero. In other words, all elements of the array must be driven with the same phase. With $\alpha = 0$ degree, the normalized array factor reduces to

$$(AF)_n = 1/N\,[(Nkd\cos\theta/2) / \sin(kd/2\cos\theta)] \qquad (1)$$

If we plot the array pattern for ϕ = 90degrees, we find that the element pattern is unity and the array pattern is the same as the array factor. Thus, the main beam of the array of *x*-directed short dipoles lies along the *y*-axis. The nulls of the array element pattern along the *x*-axis prevent the array from radiating efficiently in that broadside direction. In fig1 and fig2 showning the phases of elements in case of broadside array and end fire array respectively. End-fire arrays may be designed to focus the main beam of the array factor along the array axis in either the θ = 0degree or θ = 180 degrees directions[2]. Given that the maximum of the array factor occurs when

$$\Psi = \alpha + kd\cos\theta = 0$$

In order for the above equation to be satisfied with $\theta = 0$ degree, the phase angle α must be equal to negative of " kd" as given in equation

$$\alpha = -kd$$

For θ = 180 degree, the phase angle α must be

$$\alpha = +kd$$

The normalized array factor for an end-fire array reduces to

$$(AF)_n = 1/N\ [(Nkd\cos\theta \pm 1)\ /\sin(kd/2\cos\theta \pm 1\ )] \qquad (2)$$

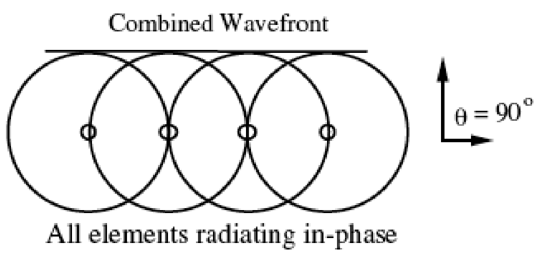


Fig 1: Broadside array

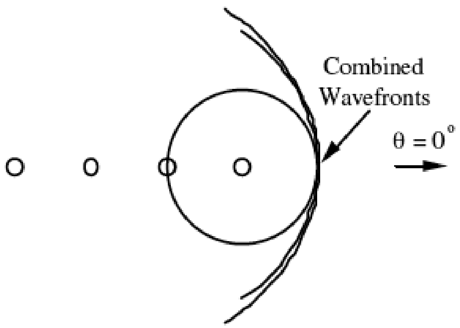


Fig 2: End fire array

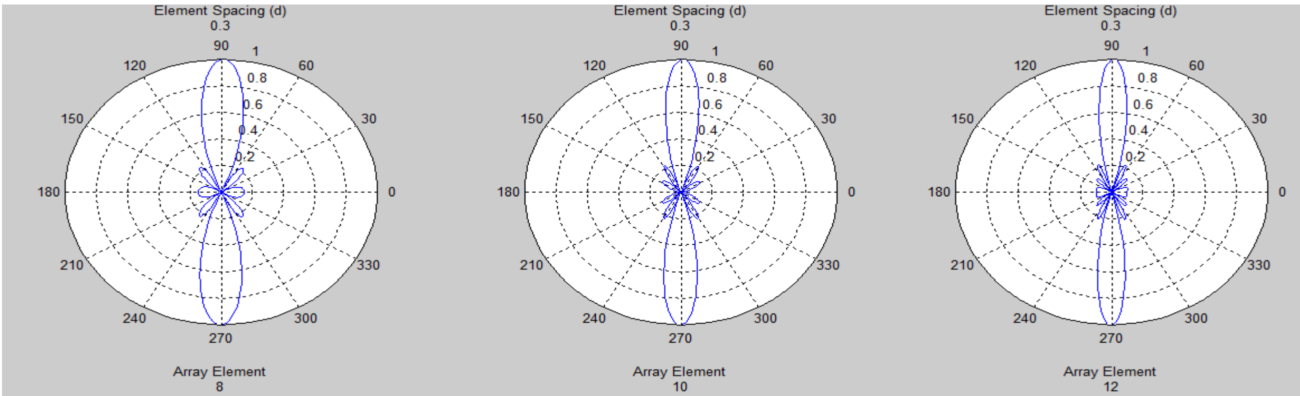
Thus using these equations (1) and (2) radiation pattern can be plotted. It is known that antenna arrays with different structures may radiate the different far-field characters, and generate the diversity of radiation patterns. Therefore, the effect of number of elements are analyzed and a comparison of radiation patterns between these two forms of antenna arrays is done. This work is carried out in this paper and conclusions are drawn.

3. SIMULATION AND RESULTS

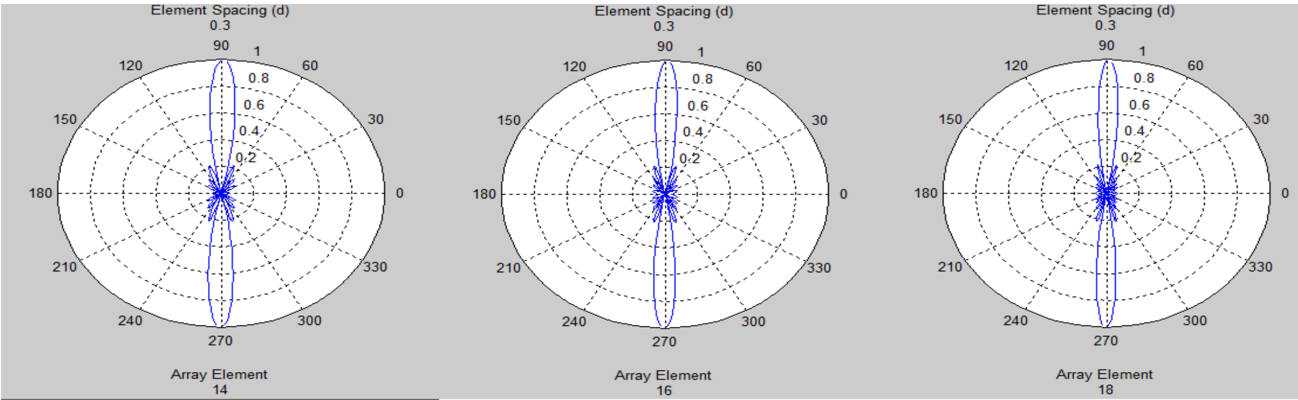
The optimization of directivity and number of minor lobes and main lobes for the various numbers of elements for broadside array and end fire array arrays can be done by varying the number of elements to be placed then the analysis is done. And comparison is done between both. The radiation pattern is obtained using the MATLAB software. Under MATLAB signal processing and data acquisition tools are used, and graphic user interface is used instead of using any antenna tool in getting the radiation pattern. Signal processing tool is a collection of tools on MATLAB numeric computing environment, the tool supports a wide range of signal processing operations from waveform generations to filer design and implementation. The radiation pattern is obtained using polar plots. GUI make easy use for obtaining radiation pattern by directly putting the values of number of elements and spacing between the elements in GUI panel then with the help of data acquisition tool this physical parameters are changed into electrical signal, thus easily we can obtain radiation patterns. The GUI provides an integrated set of interactive tools for performing a wide variety of signal processing tasks. A graphical user interface (GUI) is a pictorial interface to a program. A good GUI can make programs easier to use by providing them with a consistent appearance and with intuitive controls like pushbuttons, list boxes, sliders, menus, and so forth.

3.1 Effect of the number of elements on radiation pattern

In this subsection it is analyze the effect of number of elements on the radiation patterns of both the arrays and then they are compared . In case of end fire array direction of main lobe remain unchanged, as the spacing remain unchanged throughout the results that are obtained But the minor lobes increased and main lobe little bit become narrow as the number of elements increases. In case of broadside array, it is clearly shown in results its directivity is more than end fire array as the main lobe is very much narrow, and also pattern is symmetrical, but the grating lobes appears with increase in number of elements. End fire array is unidirectional as spacing is constant here, only the number of elements are varied, it may be bidirectional if the spacing is increased. The broadside array is bidirectional as it is shown in results, and produces more symmetrical pattern and can be used for long distance communication where directivity needed to be strong. End fire array provide directional radiations and stable unidirectional radiation pattern. Thus to get more directivity size of array has to be more. It can be used in satellite dish antennas, where a very high directivity is needed, because they are to receive signals from a fixed direction.

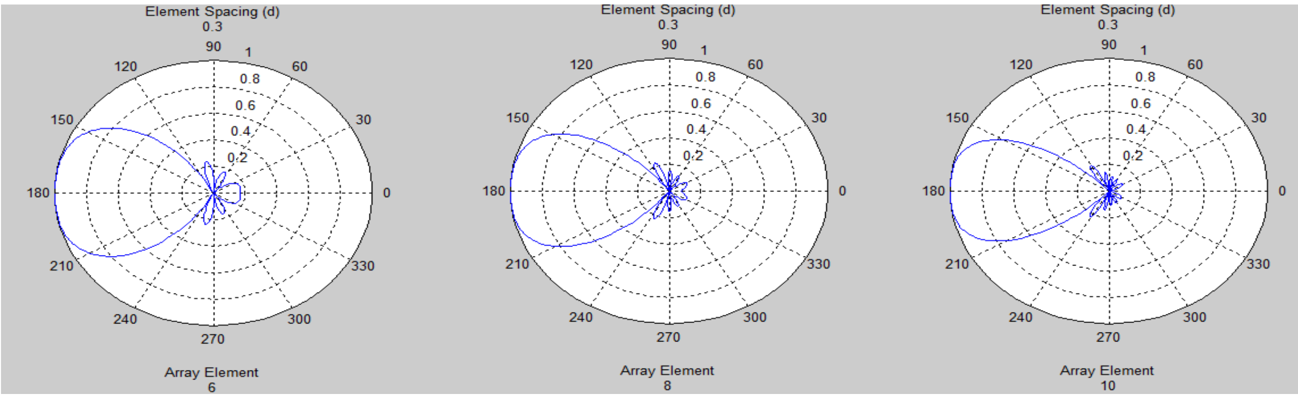


(a) Broadside array for 8, 10, 12 number of elements

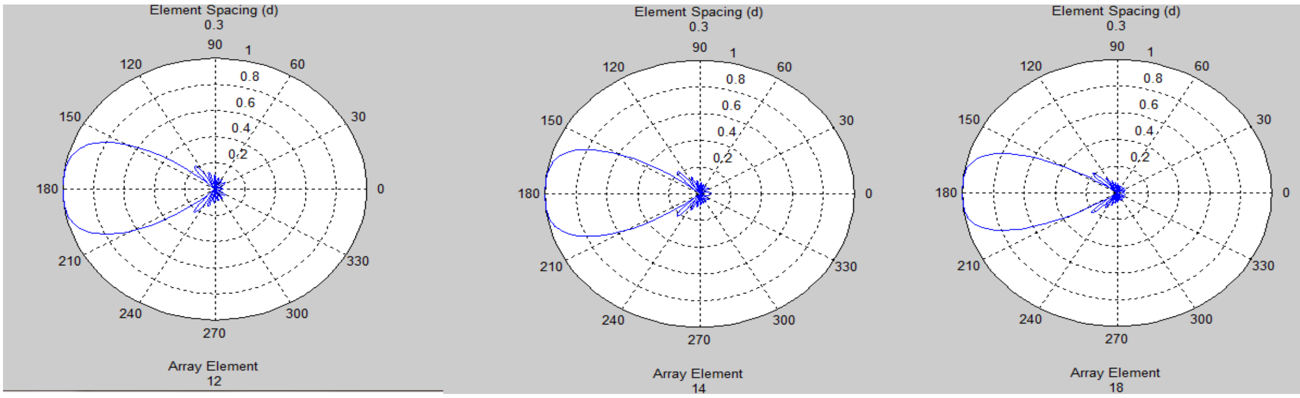


(b) Broadside array for 14, 16, 18 number of elements

Fig 3: Radiation pattern for Broadside array for different number of elements



(a) End fire array for 6, 8, 10 number of elements



(b) End fire array for 12, 14, 16 number of elements

Fig 4: Radiation pattern for end fire array for different number of elements

4. CONCLUSION

The Effect of number of elements on the radiation pattern of broadside array and end fire array are analyzed and compared in present paper. In general the directivity of broadside array is strongest as compared to end fire array, but the end fire produces stable unidirectional radiations. And broadside array give more symmetric pattern as the pattern is bidirectional and can be used for long distance communication as their directivity is strong. The end fire array can be used to construct directional antennas and can be used in satellite dish antenna to receive signal from fixed direction.

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6. REFERENCES

[1] Amanpreet kaur, Amandeep singh, “comparison between the radiation pattern of uniform circular array and uniform planar array.”, International Journal of Computer Networks and Wireless Communications (IJCNWC), ISSN: 2250-3501,Vol.2, No.2, April 2012

[2] Amanpreet kaur, zonunmawii, shakti raj chopra, “comparison between the radiation pattern of broadside array and end fire array”. National conference on challenges in emerging computer technologies(CECT’2012), vol.4, pp 135-137

[3] Michael Chryssomallis, “Smart antennas” IEEE Antennas and Propagation Magazine, vol. 42, no. 3, pp. 129-136, June 2000.

[4] Feng Gao, Qizhong Liu, Runhong Shan, and HouZhang,“Optimal design of smart antenna array,” Journal of Electronics (China), vol. 21, no. 4, pp.342-345, July 2004

[5] Balanis, C.A., “Antenna Theory: Analysis and Design,” John Wiley & Sons, New York, N.Y., 1982

[6] Litva, J., K.Y. Lo, Titus, “Digital Beamforming in Wireless Communications, Artech House, Norwood, MA, 1996.

[7] Stutzman, W. L., and G. A. Thiele, “Antenna Theory and Design,” John Wiley and Sons, 1998

[8] Liu jin, li li , huazhi wang, “ investigation of different types of array structures for smart antennas”, 2008

[9] Yanzhong Yu, “comparison of radiation pattern of smart antenna arrays”, CJMW2011 Proceedings