Antenna Array

The study of a single small antenna indicates that the radiation fields are uniformly distributed and antenna provides wide beam width, but low directivity and gain. For example, the maximum radiation of dipole antenna takes place in the direction normal to its axis and decreases slowly as one moves toward the axis of the antenna. The antennas of such radiation characteristic may be preferred in broadcast services where wide coverage is required but not in point to point communication. Thus to meet the demands of point to point communication, it is necessary to design the narrow beam and high directive antennas, so that the radiation can be released in the preferred direction. The simplest way to achieve this requirement is to increase the size of the antenna, because a larger-size antenna leads to more directive characteristics. But from the practical aspect the method is inconvenient as antenna becomes bulky and it is difficult to change the size later. Another way to improve the performance of the antenna without increasing the size of the antenna is to arrange the antenna in a specific configuration, so spaced and phased that their individual contributions are maximum in desired direction and negligible in other directions. This way particularly, we get greater directive gain. This new arrangement of multi-element is referred to as an array of the antenna. The antenna involved in an array is known as element. The individual element of array may be of any form (wire. dipole. slot, aperture. etc.). Having identical element in an array is often simpler, convenient and practical, but it is not compulsory. The antenna array makes use of wave interference phenomenon that occurs between the radiations from the different elements of the array. Thus, the antenna array is one of the methods of combining the radiation from a group of radiators in such a way that the interference is constructive in the preferred direction and destructive in the remaining directions. The main function of an array is to produce highly directional radiation. The field is a vector quantity with both magnitude and phase. The total field (not power) of the array system at any point away from its centre is the vector sum of the field produced by the individual antennas. The relative phases of individual field components depend on the relative distance of the individual clement and in turn depend on the direction.

ARRAY CONFIGURATIONS

Broadly, array antennas can be classified into four categories:

(a) Broadside array

(b) End-fire array

(c) Collinear array

(d) Parasitic array

Broadside Array- This is a type of array in which the number of identical elements is placedon a supporting line drawn perpendicular to their respective axes.

Elements are equally spaced and fed with a current of equal magnitude and all in same phase. The advantage of this feed technique is that array fires in broad side direction (i.e. perpendicular to the line of array axis, where there are maximum radiation and small radiation in other direction). Hence the radiation pattern of broadside array is bidirectional and the array radiates equally well in either direction of maximum radiation. In Fig. 1 the elements are arranged in horizontal plane with spacing between elements and radiation is perpendicular to the plane of array (i.e. normal to plane of paper.) They may also be arranged in vertical and in this case radiation will be horizontal. Thus, it can be said that broadside array is a geometrical arrangement of elements in which the direction of maximum radiation is perpendicular to the array axis and to the plane containing the array clement. Radiation pattern of a broad side array is shown in Fig. 2. The bidirectional pattern of broadside array can be converted into unidirectional by placing an identical array behind 0 this array at distance of λ/4 fed by current leading in phase by 90 .

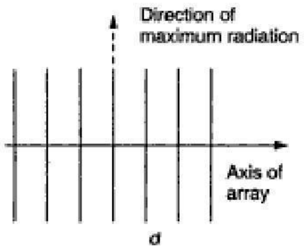

Fig. 1 Geometry of broadside array

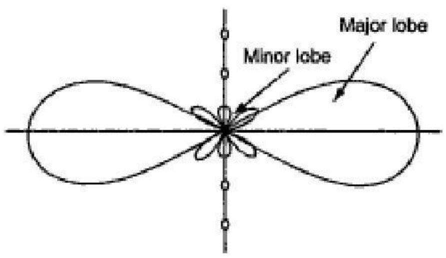

Fig. 2 Radiation pattern of broadside array

End Fire Array-The end fire array is very much similar to the broadside array from thepoint of view of arrangement. But the main difference is in the direction of maximum radiation. In broadside array, the direction of the maximum radiation is perpendicular to the axis of array; while in the end fire array, the direction of the maximum radiation is along the axis of array.

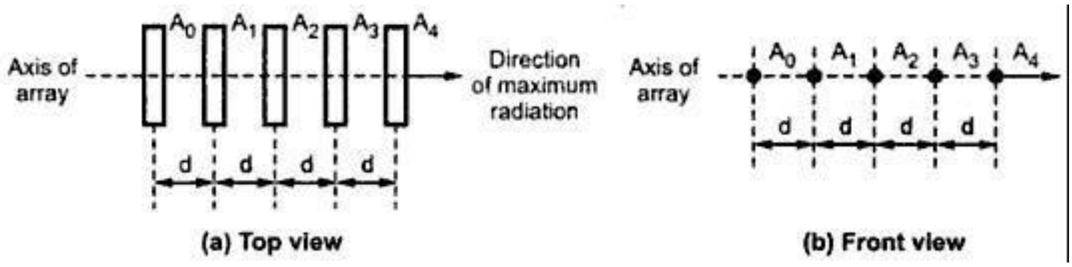

Fig. 3 End fire array

Thus in the end fire array number of identical antennas are spaced equally along a line. All the antennas are fed individually with currents of equal magnitudes but their phases vary progressively along the line to get entire arrangement unidirectional finally. i.e. maximum radiation along the axis of array.

Thus end fire array can be defined as an array with direction of maximum radiation coincides with the direction of the axis of array to get unidirectional radiation.

Collinear Array-In collinear array the elements are arranged co-axially, i.e., antennas areeither mounted end to end in a single line or stacked over one another. The collinear array is also a broadside array and elements are fed equally in phase currents. But the radiation pattern of a collinear array has circular symmetry with its main lobe everywhere normal to the principal axis. This is reason why this array is called broadcast or Omni-directional arrays. Simple collinear array consists of two elements: however, this array can also have more than two elements (Fig. 4). The performance characteristic of array does not depend directly on the number of elements in the array. For example, the power gain for collinear array of 2, 3, and 4 elements are respectively 2 dB, 3.2 dB and 4.4 dB respectively. The power gain of 4.4 dB obtained by this array is comparatively lower than the gain obtained by other arrays or devices. The collinear array provides maximum gain when spacing between elements is of the order of 0.3λ to 0.5λ; but this much spacing results in constructional and feeding difficulties. The elements are operated with their ends are much close to each other and joined simply by insulator.

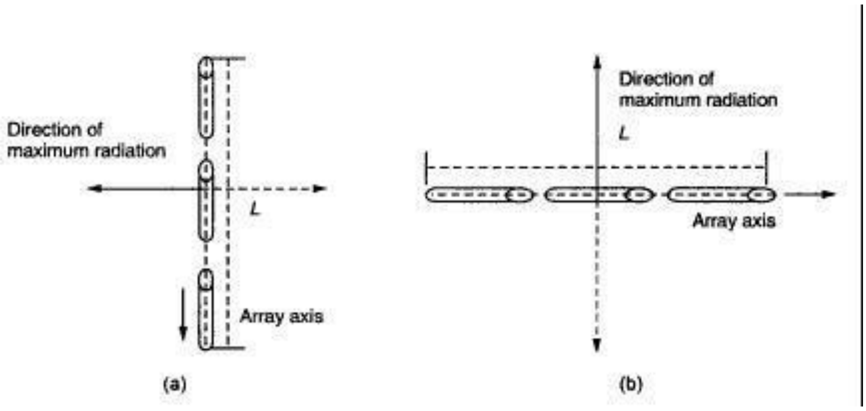

Fig. 4 (a) Vertical collinear antenna array (b) Horizontal collinear antenna array Increase in the length of collinear arrays increases the directivity: however, if the number of elements in an array is more (3 or 4), in order to keep current in phase in all the elements, it is essential to connect phasing stubs between adjacent elements. A collinear array is usually mounted vertically in order to increase overall gain and directivity in the horizontal direction. Stacking of dipole antennas in the fashion of doubling their number with proper phasing produces a 3 dB increase in directive gain.

Parasitic Arrays-In some way it is similar to broad side array, but only one element is feddirectly from source, other element arc electromagnetically coupled because of its proximity to the feed element. Feed element is called driven element while other elements are called parasitic elements. A parasitic element lengthened by 5% to driven element act as reflector and another element shorted by 5% acts as director. Reflector makes the radiation maximum in perpendicular direction toward driven element and direction helps in making maximum radiation perpendicular to next parasitic element. The simplest parasitic array has three elements: reflector, driven element and director, and is used, for example in Yagi-Uda array antenna. The phase and amplitude of the current induced in a parasitic element depends upon its tuning and the spacing between elements and driven element to which it is coupled. Variation in spacing between driven element and parasitic elements changes the relative phases and this proves to be very convenient. It helps in making the radiation pattern unidirectional. A distance of $\lambda/4$ and phase difference of $\pi/2$ radian provides a unidirectional pattern. A properly designed parasitic array with spacing 0.1λ to 0.15λ provides a frequency bandwidth of the order of 2%, gain of the order of 8 dB and FBR of about 20 dB. It is of great practical importance, especially at higher frequencies between 150 and 100 MHz, for Yagi array used for TV reception.

The simplest array configuration is array of two point sources of same polarization and separated by a finite distance. The concept of this array can also be extended to more number of elements and finally an array of isotropic point sources can be formed. Based on amplitude and phase conditions of isotropic point sources, there are three types of arrays:

(a) Array with equal amplitude and phases

(b) Array with equal amplitude and opposite phases

(c) Array with unequal amplitude and opposite phases