Directive Antenna – Way of RF Pollution Control
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Abstract: Directive Response method optimizes resource utility. Power is one of the rare commodity and creates RF pollution, hence it is to be spent very carefully. It is truly said that “power saved is power generated and non radiation direction is RF pollution free”. To avoid RF pollution & power wastage while radiating and to improve the power utility, it is proposed assigned signal delivery against demand only, meaning radiation is Responds against demand. To optimize power radiation, it is proposed to control the width of beam and steer the beam in the direction of demand. Controlled beam width and steering of it, leads to a Digital Beam-steering System (DBS) along with antenna array. Also can be called as smart antenna. The function is achieved by phase controlled array. The array ensures, also interference free radiation by verifying non radiated direction as well as radiation only in required direction with optimum gain

Keywords: Directive response, Optimize power, Controlled beam, Beam steering and Digital Beam-steering system, smart antenna

1 INTRODUCTION

Antenna can be defined as “The bidirectional metallic device (or transducer) which can transmit and/or receive electromagnetic energy into/from space”. Antenna is very important part of any electronic/communication system which is an interface between the electronic system and external world.

Multiple number of antenna elements used to radiate the signal is called antenna array [2]. Antenna is an arrangement of one or more conductors, called elements. For a transmission, RF energy is fed to antenna terminals, which creates time varying current in the elements, causing the elements to radiate an electromagnetic field into the space. For a reception, the inverse occurs: an electromagnetic field through space (from another source) induces time varying current in the elements and a corresponding voltage at the antenna’s terminals

Its working principle is: An accelerated/decelerated current results into electromagnetic field radiation or time varying current results into radiation of electromagnetic field[1]. The above wording can be express in a simple mathematics as

\[ I \times L = q \times v \]  

Here the term in bracket [] indicates accelerated or decelerated value [1][2]. The Maxwell has given first prediction of radiation. The term L is a dimension of an antenna and for the optimum value of antenna length is half wave length for the maximum power transfer.

The antenna performance is judged by several parameters. These parameters should be within acceptable limit whether single antenna or antenna array. Importance and criticality may vary little, from application to application, however each one has, one or the other way, their own importance for the overall performance. The critical parameters, on which the performance based, can be adjusted during the design process [2]. These parameters are the reciprocity, frequency of operation, impedance, gain, radiation pattern, polarization, efficiency and bandwidth. Transmitting antenna may also have additionally, maximum power handling capacity, and receiving antenna differs in terms of noise rejection capability

When antenna used in array, provided higher gain and narrow beam width [1][2]. Width of beam can be controlled either by increasing number of antenna or varying phase of feed signal for each antenna element.
2 HYPOTHESIS

1) Isotropic antenna (Hypothetical antenna) radiates equal amount of energy in all the direction.
2) Each antenna in an array are spaced at an equal distance.
3) Phase of Transmitting antenna can be controlled by external means

3 ARRAY

Let us consider two elements Array.

Let, there be a, two simple dipoles (mounted horizontally) on X-axis, spaced by one wavelength and fed with in-phase signal. Signal radiated by both the dipoles, added in a space in a horizontal plane, along the array axes. At the point P in a space on Off-axes, the radiation is addition of two dipole radiation as shown below.

\[ E_{\phi} = A \cos \left( \frac{\lambda}{2} \sin \theta \right) \]  

Where, A is amplitude of received signal
\( \lambda \) is the wavelength of operating frequency
\( \theta \) is angle between array axes and line joining from centre of array to point P

The single element antenna radiates in Omni direction, hence its beam width 360 degree. Two element antennae as mentioned above creates beam width of about 40 degree. The radiation pattern of such an array in a quadrant is shown in Figure 1 below.

![Figure 1. Two Element Array Radiation](image)

Now, if number of elements increased in same plane and created array of 12-element or even further goes up to 36 elements, the pattern is as shown in Figure 2 and Figure 3 respectively.
The beam width achieved in 12-element array is about 10° and in 36 element array, about 3° [3]. The power re-distribution or re-arranged in the field is being created by increasing no of elements. The power is concentrated or focused in small aperture area. The rise in a gain due to array is directly proportional to the beam width. With 10 degree beam width, it will have rise in a gain of about 19 dB and with 3 degree beam width gain rises to about 24 dB [3]

4 PHASE CONTROL

The radiation pattern discussed in previous section for two or more elements, the energy fed to each element is in-phase. Now let us discuss the effect of phase variation (in input) to the radiation pattern.

Consider a case of paragraph 3 for two elements array and input has a phase difference of , its peak value of pattern moves on left or right side of centre depending on phase lead or lag. Figure 4 below, shows the radiation pattern with =20°.
Compare the radiation pattern of Figure 1 and Figure 4, the peak of radiation is moved toward left from centre.

4.1 Phase Control System

The microcontroller or digital signal controller based system can be developed which can adjust the phase of antenna array (lead or lag) very precisely and accurately. This is called Digital Beam-steering System (DBS) or digital Beam-controlling System[1]. The system function is to generate and adjust array feed phase as per requirement. System can have capability to readjust phase dynamically. The system can be considered as Automatic Phase Array Controller (APAC). The system allows radiation only in required direction and within just required beam width. Thus, it avoids RF pollution in other direction.

Such system, if used as a receiving system, it can also survey and detect in coming signal direction, in turn, any point in time it can detect the RF pollution free direction.

During non-demand period, system goes to sleep mode and only pager channel (Very low power consumption) is on. Sleep mode power consumption is almost NIL or negligible.

5 CONCLUSION

1) Array of an antenna can concentrate power within limited area. It is clear from Figure 1, 2, 3 that as number of elements increases, the beam of power becomes narrower and narrower (Like pencil beam). This avoids RF power radiation from the non utility area.

2) Using array configuration, power can be diverted in a desired direction and wastage of power (in undesired direction) can be avoided. With highly directive characteristic, in turn, RF pollution is avoided.

Controlling the phase of the array antenna, beam can be steered in the space as required and thus, radiation can be accomplish in the desired direction as well as at any point in time, it can be radiated in any direction of demand and avoided in other direction. On event of non-utility period, system radiation is stopped & to avoids RF pollution.
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