BEAMFORMING MICROSTRIP ARRAY ANTENNA USING DIRECTIONAL MODULATION TO IMPROVE WIRELESS SYSTEMS

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Abstract: A novel approach is used to realize the microstrip antenna array with beam forming capability is proposed. This approach utilizes the directional modulation (DM) technique for achieving beam forming concept using phased array theory. The phased array theory is implemented via genetic algorithm (GA). GA is used to adapt the far field pattern in order to receive the desired signal in the desired directions and reject the interference in other directions. In directional modulation technique by phase shifting each element correctly, the desired amplitude and phase of each symbol in a digital modulation scheme can be produced in a given direction. Because this signal is direction-dependent, it also offers security, as the signal can be purposely distorted in other directions. When using an array with driven elements, the phase shifts can be determined from Simple calculations rather than the time-consuming simulations or measurements. Mathematic analysis and experimental results are presented. The results are simulated using MATLAB software.

***Index Terms*---Microstrip antennas, Feed network, Phase shifters, beamforming, Directional modulation, Genetic Algorithm.**

I. INTRODUCTION

Recently, there was rapid development in wireless local area network (WLAN) applications. In order to satisfy 2.4 GHz band of IEEE 802.11b/g and 5.8 GHz band of 802.11a WLAN standard, dual-band operations in the 2.4 GHz (2400–2483 MHz) and5.8 GHz (5725–5825 MHz) bands are demanded in practical WLAN applications. A single antenna is highly desirable if it can operate at these two bands. The antenna should be in the planar form, light weight and compact, so that it can easily be embedded in the cover of communication devices. In addition, a simplified feeding circuit is also an important component, because it can reduce the transmission line length and the radiation losses. To make mobile WLAN devices work with all these standards, multi-band antennas and wide-band antennas have been developed.

II. BASIC CHARACTERISTICS OF MICROSTRIP ANTENNAS

Microstrip antennas, as shown in Figure 1, consist of a very thin ($t \ll \lambda_0$, where λ_0 is the free-space wavelength) metallic strip (i.e. Patch) placed a small fraction of a wavelength ($h \ll \lambda_0$, usually $0.003\lambda_0 \leq h \leq 0.05\lambda_0$) above a ground plane. The microstrip patch is designed so its pattern maximum is normal to the patch (broadside radiator).This is accomplished by properly choosing the mode (field configuration) of excitation beneath the patch. End-fire radiation can also be accomplished by judicious mode selection.

For a rectangular patch, the length L of the element is usually $\lambda_0/3 < L < \lambda_0/2$.The strip (patch) and the ground plane are separated by a dielectric sheet (referred to as substrate), as shown in Figure 1.

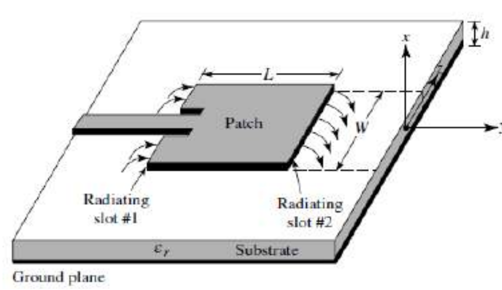

Figure.1 Microstrip antenna

Often microstrip antennas are also referred to as *patch* antennas. The radiating elements and the feed lines are usually photo etched on the dielectric substrate. The radiating patch may be square, rectangular, thin strip (dipole), circular, elliptical, triangular, or any other configuration. Even though rectangular and square patches are widely used Square, rectangular, dipole (strip), and circular are the most common because of ease of analysis and fabrication, and their attractive radiation characteristics, especially low cross-polarization radiation. Linear and circular polarizations can be achieved with either single elements or arrays of microstrip antennas. Arrays of microstrip elements, with single or multiple feeds may also be used to introduce beamforming capabilities and achieve greater directivities.

III. ANTENNA ARRAYS

In many applications, it is necessary to design antennas with very directive characteristics (Very high gains) to meet demands for long distance communication. In general, this can only be accomplished by increasing the electrical size of the antenna. Another effective way is to form an assembly of radiating elements in a geometrical and electrical configuration, without necessarily increasing the size of the individual elements. Such a multi element radiation device is defined as an *antenna array*. The total electromagnetic field of an array is determined by vector addition of the fields radiated by the individual elements, combined properly in both amplitude and phase. Antenna arrays can be one, two, and three-dimensional. By using basic array geometries, the analysis and synthesis of their radiation characteristics can be simplified. In an array of identical elements, there are at least five individual controls (degrees of freedom) that can be used to shape the overall pattern of the antenna. These are,

i. Geometrical configuration of the overall array (linear, circular, rectangular, spherical, etc.).
ii. Relative displacement between the elements
iii. Amplitude excitation of the individual elements
iv. Phase excitation of the individual elements
v. Relative pattern of the individual elements

IV. MICROSTRIP ARRAYS

Arrays are very versatile and are used, among other things, to synthesize a required pattern that cannot be achieved with a single element. In addition, they are used to scan the beam of an antenna system, increase the directivity, and perform various other functions which would be difficult with any one single element. The elements can be fed by a single line, as shown in figure.2 or by multiple lines in a feed network arrangement, as shown in figure.3. The first is referred to as a *series-feed network* while the second is referred to as a *corporate-feed network*.

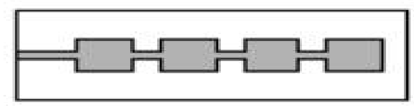

Fig.2 Series fed array

Series-fed arrays can be conveniently fabricated using photolithography for both the radiating elements and the feed network. However, this technique is limited to arrays with a fixed beam or those which are scanned by varying the frequency, but it can be applied to linear and planar arrays with single or dual polarization.Corporate-fed arrays are general and versatile. With this method the designer has more control of the feed of each element (amplitude and phase) and it is ideal for scanning phased arrays, multi beam arrays, or shaped-beam arrays.

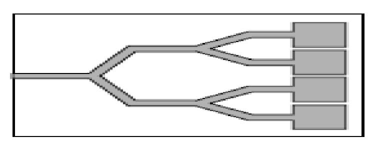

Figure.3 Corporate feed

V.BEAMFORMING USING ANTENNA ARRAYS

Beamforming is the process of steering the radiation pattern of an antenna array in any required direction. It is achieved by changing the phase of the signals applied to the antenna elements. For this purpose phase shifters are used in a beamforming system which is shown in figure.4 and also shows the arrangement for achieving beamforming. Beamforming antenna systems improve wireless network performances such as increased system capacity, improved signal quality, to suppress interference and noise power.

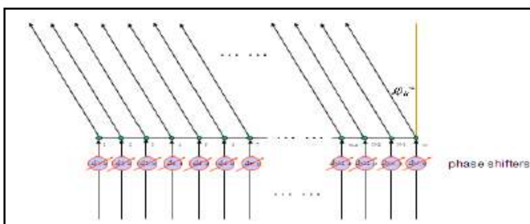

Figure.4 Set-up for beamforming

By varying the signal phases of the elements in a linear array, its main beam can be steered. The simplest way of controlling signal phase is to systematically vary the cable lengths to the elements. Cables delay the signal and so shift the phase. However, this does not allow the antenna to be dynamically steered. In an electronically steered array, programmable electronic phase shifters are used at each element in the array. The antenna is steered by programming the required phase shift value for each element. Figue.5 shows the beam pattern for an 8-element linear array with a progressive phase shift of 0.7 per element. The centralbeam has been steered about 45 degrees to the left.

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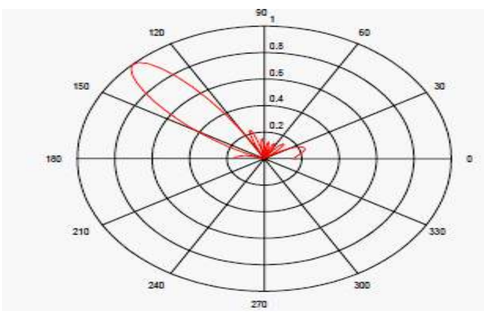

Figue.5 The beam pattern for an 8-element linear array with a progressive phase shift of 0.7 per element

VI. DUAL BAND ANTENNA DESIGN

Today's trend in wireless systems is to integrate more functionality in a single device. For example a wireless receiver can be designed to operate at two or more frequency bands. This can do by incorporating two different antennas for each band in to the device. The other option is to use a wideband antenna. But wideband antennas will have lower gain when compared to narrowband antennas. In this work we propose a dual band antenna design using T-shaped patch. It designed to operate at 2.4 as well as 5.55 GHz.

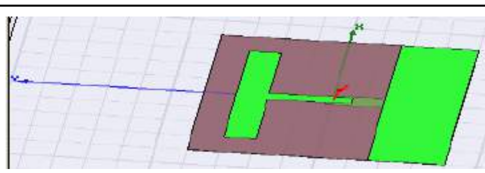

Fig.6 T patch dual band antenna

VII. BEAM FORMING USING DIRECTIONAL MODULATION

Beam forming using directional modulation is a technique used to radiate the signal in the desired directions and suppress the signal in all other directions. It is implemented using phased array theory via genetic algorithm. In previous researches beam forming can be achieved using phase shifters, so separate base band modulation is needed for modulating the signal. Beam forming using Directional modulation performs both modulation and also radiates the signal in the desired direction. In this case no need for separate modulation scheme is required. It radiates the signal in the line of sight channel.

Genetic Algorithm (GA) is the optimization technique that is used to adapt the far field pattern in order to receive the desired signal and reject interference.GA can work with either continuous or binary encoded parameters.

VIII. GENETIC ALGORITHM (GA)

GA is an optimization technique that mimics biological reproduction and natural selection to arrive at an optimum solution. It is used to adapt the far field pattern in order to receive the desired signal and reject interference. The GA can work with either continuous or binary encoded parameter. The GA starts with a matrix of random variables. Each row is a chromosome containing the variables that are passed to the cost function. A binary GA starts with a random population of ones and zeros that must be decoded into continuous values. The continuous values are then sent to the cost function for evaluation. Each chromosome has an associated cost, and the GA searches for a chromosome that minimizes the cost.

The surviving chromosomes serve as potential parents for future population. The best chromosome is not mutated. Consequently, the new population consists of the best chromosome from previous generation, the mutated offspring, and the mutated parents.

IX. SIMULATION RESULTS

1. **BEAM FORMING WITHOUT DM**

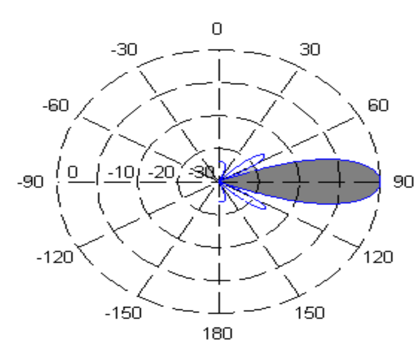

Figure.7 Radiation pattern for beamforming

Beam forming without DM performs modulation at one level and then radiates the signal in another level, so the number of side lobes and the interference from side lobes also reduced. The figure.5 shows that the radiation pattern for four array elements at the desired steer angle of 90 degree with separation distance between the elements are 0.5 at the frequency range of 1to 3 GHz.

2. **BEAMFORMING WITH DM**

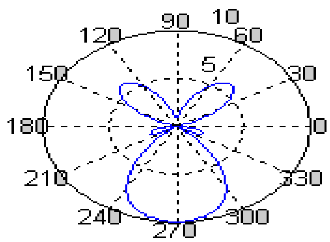

Figure.6 Radiation pattern for Beam forming using DM

It shows that the radiation pattern of beam forming using DM for two array elements. From the look up table, if bit 1 is transmitted with left element at the angle of 20 degree and right element with 33 degree and we will get the output at total phase shift at 270 degree. Otherwise if bit 0 is transmitted with left element at the angle of 340 degree and right element with 140 degree and we will get the output at 270 degree.

X. CONCLUSION

In this paper, beamforming using DM technique has been demonstrated using arrays with driven elements. Unlike previous work similar to DM that used parasitic arrays, using driven elements only requires measurements or simulations for each of the active element patterns instead of every single combination of switch states. Thus, the number of measurements increases linearly with the size of an array instead of exponentially. After these element patterns are known, an efficient GA was shown to either find the phases for transmitting in multiple directions simultaneously or to distort a constellation in all directions except that of the desired receiver. The DM array had a narrower BER beam width compared to a traditional array when both were steered toward broadside. Unlike the traditional array, the DM array's BER beam width did not broaden when it was steered away from broadside. The directional manipulation of constellation points is possible with DM because the modulation is created at the antenna element level. This is in contrast to a traditional phased array in which the modulation is created at baseband and the same copy sent on each antenna element.

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