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Research Article

Design of Phase Array Antenna Using Least Mean Square Algorithm: The Use of Point Sources and Micro-strip Patch Antennas

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Abstract: In this study, a phased array antenna was designed using modified Least Mean Square algorithm, to adaptively track incident signals from satellite. The algorithms would form the beam perfectly and the main beam will be centered at the location of the desired signal and the nulls will be located at exactly the direction of the unwanted signals. The main beam and nulls would be steered toward incident signals automatically during adaptation process. The phased linear array using both point sources and micro-strip rectangular patch was designed. 8-elements with 0.5 wavelength separation were used. It was found that with micro-strip antenna sources placed along one of the axis, the algorithm gives a lower side lobe which gives best cancellation of interferers from other satellites with higher directivity and lower half-power beam widths.

Keywords: Phase array antenna, satellite

INTRODUCTION

Phased array antennas have wide applications in business and other services such as radars, base transceiver stations and anti-collision radars (Liu *et al*., 2009). Electronically scanned phased array antennas has several advantages when compared to the conventional ones such as fast scanning, wider operating bandwidth and the ability to host multiple antenna beams on the same array and eliminating mechanical complexity and reliability issues (Ali, 2005). The scanning advantage of a phased array antenna is usually realized using 'forced excitation', in which the antenna elements are energized with signals of the same amplitude other than the progressive phase, needed to steer the antenna beam within certain directions (Balanis, 2006). This study presents a comparative analysis of the use of both point sources and microstrip antennas for phased arrays. The essential desired characteristics were considered in both cases and therefore this study considers the use of the system for satellite communication.

Antennas for satellite communication: Antenna subsystem is an important parameter of a satellite system. Four basic antennas are identified (Balanis, 2005). These are the monopoles/dipoles, horn antennas, array antennas and reflector antennas. The dipoles are applied for high frequency communications while the horn antennas and suitable for microwave frequencies. The array antennas sometimes called the phased array antennas are applied on satellites to make several beams from one aperture. The reflector antennas are usually applied for earth station antennas.

The essential thing in satellite communications is to make sure that satellite is in perfect contact with ground antenna. Dish reflector antennas as widely applied are bulky and their performance deteriorate with age. There is need for antenna with simpler installation mechanism having less degradation to wind. Phased array antennas are definitely the solution.

The phase array antennas have several merits and demerits (Garg *et al*., 2001; Pozar, 1996). The beam can be adjusted using digital signal where no physical movement is needed. They have small size and weight. They can be used with computers to cancel unwanted beam for satellites. Their major disadvantage is that their look angles may be narrowed to certain areas when compared with conventional scanning.

BEAM-FORMING ALGORITHMS

The literature has proposed certain beam forming algorithms based on stability and cost of implementation (Balanis, 2006; Dawoud *et al*., 1993). These are the Direct Null Steering techniques, Indirect Null steering Methods (or the search algorithms), Least Mean Square algorithm. The later is the easiest and more reliable search algorithm i.e. by knowing the desired signal, the algorithm can modify its complex weightings of single elements to get the best radiation pattern. They also don't need prior direction information.

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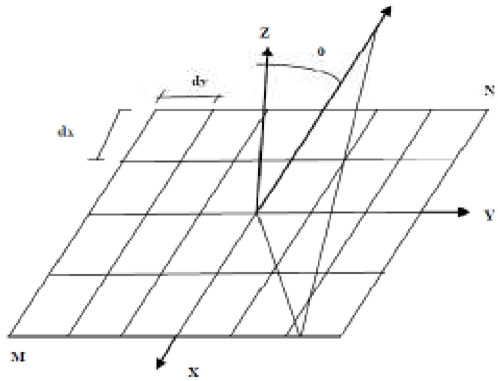

Fig. 1: Phased array antenna using point sources (Balanis, 2005)

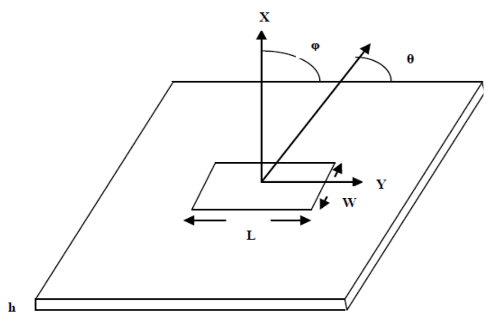

Fig. 2: Directions of radiations for both E-plane and H-plane

In this study, the modified Least Mean Square Algorithm (LMS) will be applied adaptively with the phased array to get the required radiation patterns. Using these techniques, this study compares the phase array antennas using point sources and micro-strip antennas.

Phased array using point sources: Here the radiators (point sources) are situated along rectangular lattice, thereby providing more parameters to monitor the pattern of the radiation (Lin *et al*., 2012). This is important to give more symmetrical patterns with low side lobes and is more suitable for tracking moving objects e.g., satellite (Fig. 1).
The array factor of N-elements array is given as ( ):

$$AF = \sum_{n=1}^{N} a_n e^{j(n-1)\psi} \tag{1}$$

where,

$$\psi = kd\cos(\theta) + \beta = \frac{2\pi d}{\lambda}\cos(\theta) + \beta$$

where,
K = A wave number
d = The distance between the elements
θ = The angle of the main beam of the array
β = The progressive phase shift
a = The amplitude of each of the individual elements

This study considers varying the number of elements in both the two axis and changing the phase excitations and evaluating the radiation pattern. In phase array antennas, the radiating elements are electronically excited from the same source such that the vector components are constructively added in one direction to form the main beam and destructively cancelling in other direction to form the nulls ( ). This has advantage in tracking satellites where the desired signal is directed towards the main beam and the interferers towards the nulls.

Phased array using micros trip antenna sources: Micro strip Antennas are similar to parallel plate capacitors, with dielectric in between them (Saunders and Aragón-Zavala, 2007). It has radiating patch one side while a ground plane on the other. It radiates because of the fringing fields between patch edge and ground plane. For large bandwidth and better radiation, thick substrate with large dielectric constant provides better efficiency with better radiation**.** In this study, the rectangular micro strip antenna is applied as shown in Fig. 2 above.

The E-plane (principal) is given by, θ = 90, 0 ≤Φ≤ 90, 270 ≤Φ≤360, which is the x-y plane. The E-field radiation is given by the equation (Balanis, 2006):

$$E_\phi^{\ e} = +j\frac{hk_o wE_o e^{-jk_o r}}{\pi r}\left\{\frac{\sin(\frac{k_o h}{2}\cos\phi)}{\frac{k_o h}{2}\cos\phi}\right\}\cos(\frac{k_o L}{2}\sin\phi) \tag{2}$$

The H-plane (principal) is given by, Φ = 0, 0≤θ≤ 180, which is the x-z plane:

The H-field radiation is given by the equation (Balanis, 2006):

$$E_\phi^{\ h} = +j\frac{hk_o wE_o e^{-jk_o r}}{\pi r}\left\{\sin\theta\frac{\sin(\frac{k_o h}{2}\sin\theta)\sin(\frac{k_o w}{2}\cos\theta)}{(\frac{k_o h}{2}\sin\theta)(\frac{k_o w}{2}\cos\theta)}\right\} \tag{3}$$

In this study, it is assumed that the rectangular patch elements are placed along the z-axis and the following parameters are considered in the design:

Frequency = 10GHz
Dielectric constant of the substrate = 2.2
Length (L) = 0.45λ
Width (W) = 0.25λ
Height (H) = 0.005λ
λ represent the wavelength.

RESULTS AND DISCUSSION

It can be observed from Fig. 3 to 6 that using rectangular a patch antenna as the radiating sources gives lower side lobes than applying point sources

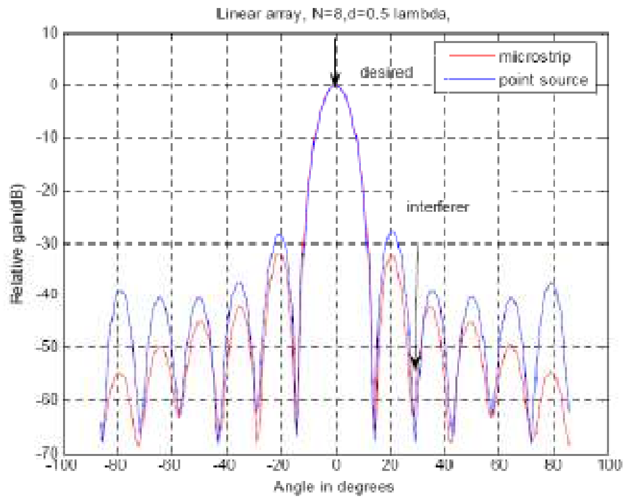

Fig. 3: Array factor for linear array with 8 elements, dx = 0.5 λ, desired signal at = 0, while the interferer is at = 30°

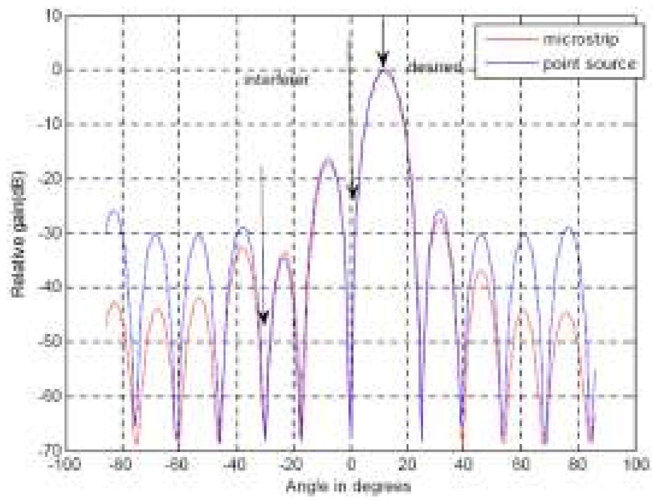

Fig. 4: Array factor for linear array with 8 elements, dx = 0.5 λ, desired signal at = 0, while one interferer is at -30°and the other at = 0

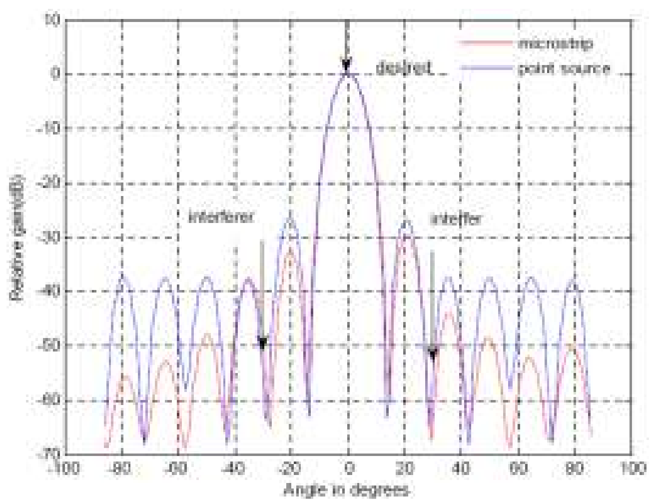

Fig. 5: Array factor for linear array with 8 elements, dx = 0.5 λ, desired signal at = 0, while one interferer is at = -30°and the other at = 30°

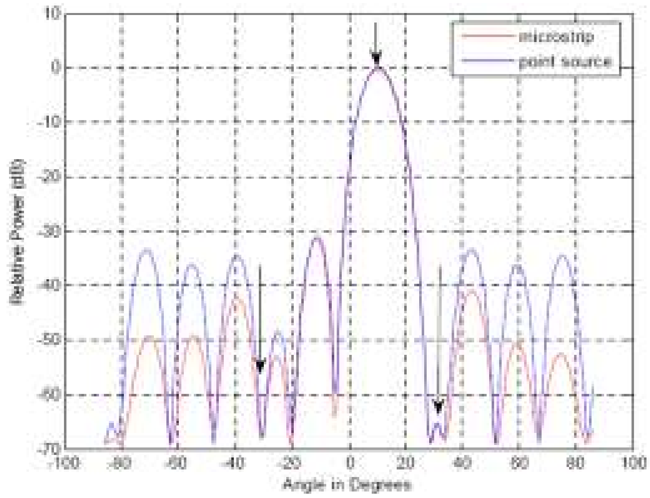

Fig. 6: Array factor for linear array with 8 elements, dx = 0.5 λ, desired signal at = 10, while one interferer is at = -30° and the other at = 30°

which is good for cancelling interfering satellites. This is because micro patch radiates better in only the E and H-planes and the rectangular patch is designed to give radiation vertical to the patch elements.

CONCLUSION

In this study, phased array antenna was designed using the LMS Algorithm to adaptively track incident signals from satellite. The algorithms would form the beam perfectly and the main beam will be centered at the location of the desired signal and the nulls located at exactly the direction of the unwanted signals. The main beam and nulls would be steered toward incident signals automatically during the adaptation process. The phased array using both point sources and micro strip rectangular patch were designed. It was found that with micro strip antenna sources placed along one of the axis, the algorithm gives a lower side lobe for better to cancellation of interferers from other satellites.

REFERENCES

Ali, M.R., 2005. Design of micro-strip antenna linear phase array antenna using integrated array feeder. M.S. Thesis, King Fahd University of Petroleum and Minerals (KFUPM).

Balanis, C.A., 2005. Antenna theory: Analysis and design. 2nd Edn., John Wiley and Sons, New York.

Balanis, C.A., 2006. Smart antennas for future reconfigurable wireless communication networks. Proceeding of IEEE Tropical Conference on Wireless Communication Technology, pp: 181-182.

Dawoud, M.M., T.O. Halawani and R.T. Al-Mushcab, 1993. Design of adaptive arrays based on element position perturbations. Proceeding of 8th International Conference on Antennas and Propagation (ICAP, 1993). Edinburgh, U.K., pp: 504-507.

Garg, R., P. Bhartia, I. Bahl and A. Ittipioon, 2001. Microstrip Antenna Design Handbook. Artech House Inc., MA, England.

Lin, Z., Y. Minli and S. Xiaowei, 2012. Side lobe reduction of the low profile multi-subarray antenna by genetic algorithm. Int. J. Electron. Commun., 66(2): 133-139.

Liu, D., B. Gaucher, U. Pfeiffer and J. Grzyb, 2009. Advanced Millimeter-wave Technologies: Antennas, Packaging and Circuits. Wiley and Sons Ltd., Chichester, U.K., Hoboken, NJ.

Pozar, D.M., 1996. A review of aperture coupled microstrip antennas: History, operation, development and applications. IEEE Letters.

Saunders, S.R. and A. Aragón-Zavala, 2007. Antennas and Propagation for Wireless Communication Systems. John Wiley and Sons, Hoboken, N.J.