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Application Of Extended Matrix Pencil Method In Dual Directive Beamformer

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Abstract - *The designing and synthesis of antenna array application has been become popular in wireless communication system. The extended matrix pencil method and the forward-backward matrix pencil method have been used to reduce the number of antenna elements in the multiple pattern arrays. These methods also applied for the synthesis of dual directive antenna array beam former to acquire smaller number of elements. These method organizes the data into a composite Hankel matrix from which has minimum number of elements has been obtained. It performs a complete optimization of the common element positions for the desired pattern, and finally gets reduced number of elements considerably.*

***Key Words*: Delay and Sum algorithm, Extended Matrix Pencil Method, Forward Backward Matrix Pencil Method.**

1. INTRODUCTION

Antenna array is an arrangement of multiple antennas (elements) to achieve a given radiation pattern. In an antenna a single element provides wide radiation and low directivity (gain).Since in many applications it is necessary to design antennas with very directive characteristics to meet the requirements for long distance communication. It is because array antenna is very good to use in wireless communication especially for point to point communication application. In fact, array antennas also give high gain and directivity, narrow beam compared to single antenna (elements). The cost, complexity and size of an array are proportional to the number of elements. This work reduces the number of elements dual directive array with the matrix pencil method. This provides a comparable array pattern reconstruction between the two arrays. The algorithm of the proposed method has been represented in flow chart as given in the fig - 1.

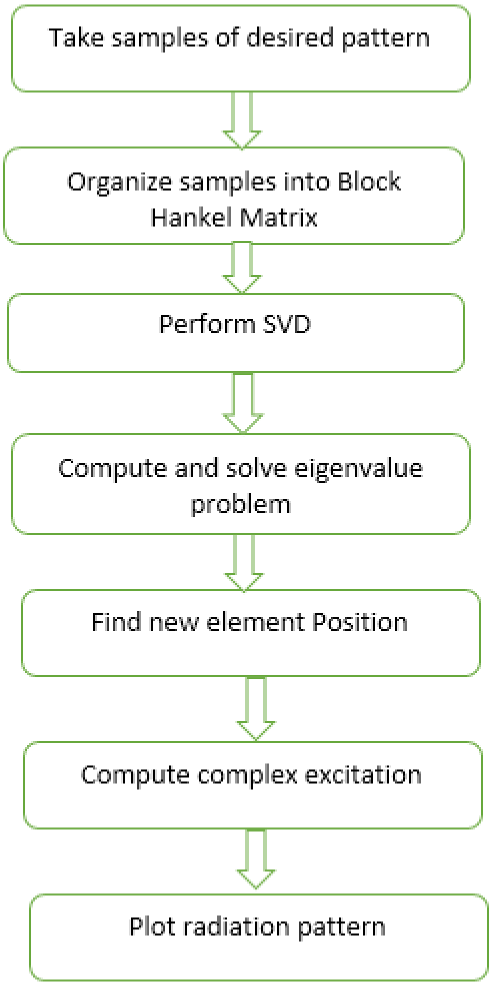

Fig -1: Algorithm for extended Matrix pencil method

There are many synthesis techniques for antenna array are conducted in past years which includes the extension of the aperture length of an equally spaced linear array with a spacing of half wave length in which author give a new limit to improve the resolution and aperture length [2]. The genetic algorithm Modified woodward-lawson technique [6-8], particle swarm optimization [5], projection approach [3, 4] and many other techniques have been formulated for solving the antenna designing problem. But in those techniques, multiple patterns have been generated by only governing the excitation phases of a single array with pre-determined or optimized common amplitudes. Such type of synthesis can make simpler the designing of feeding network without adjusting the amplitudes. Also those methods have based on postulation that elements are equally spaced with a uniform distribution thus a large number of antenna elements are obtained.

The array factor is a function of the number of elements, its geometrical arrangement, relative magnitudes, relative phases, and spacing. The radiation of the antenna is characterized with the parameters such as amplitude of the array elements, phase of the array elements, distances between individual antenna elements, number of elements and radiation pattern of individual elements. Directivity has the ability to focus on the energy in the particular point in the antenna array.

By using a beam-steerable antenna can overcome the problem related to the WSN such as it robust even if it has enough energy efficient. As reported in earlier researches the method of weighting (DAS) has been used in this project. This method has been giving a significant impact on the output of antenna array. The aim or objective of this paper is to acquire reduced radiation pattern for a prefixed dual directive antenna array pattern by using the technique Extended Matrix Pencil Method. So the weights or delay of the array will be optimized in order to get reduced element.

2. EXTENDED MATRIX PENCIL METHOD

The minimization of elements in an antenna array has very critical in some of the practical engineering applications such as satellite, WSNs and mobile communications. However, due to the complexity in the synthesis of an antenna array, the available techniques have been not successful for reducing the element number of an antenna array with as few elements as possible with better efficiency. In this paper presented a novel method for antenna synthesis: extended Matrix pencil method [23]. This algorithm has been applied to dual directive beam former.

Suppose that the antenna array is composed of M identical antenna element. The antenna factor is given by

$$F^{(k)}(u) = \sum_{i=1}^{M} R_i^{(k)} e^{j\omega_i u} \qquad [1]$$

Where R_i is the complex excitation of the i-th element, $j=\sqrt{-1}$, u= cos (θ), $\omega_i = 2\pi d_i/\lambda$ and k=1,2,.........,K where K is the total number of the desired pattern k is the wave number in free space. And d_i is the position of i-th element, $R_i^{(k)}$ represents complex excitation of k-th pattern.

Similar to the original MPM based synthesis [19] the extended MPM samples the desired pattern in the space u =-1 to 1. The condition of Nyquist sampling theorem must be satisfied, and the condition is $\Delta \le \lambda / (2d_{max})$ where d_{max} = max $\{d_i\}$. For M element array with a uniform spacing of λ/2 must have samples of N ≥ 2M-1. Thus

$$f^{(k)}(n) = F^{(k)}(n\Delta) = \sum_{i=1}^{M} R_i^{(k)} z_i \qquad [2]$$

Where $z_i = e^{j\omega_i u}$. Then in next step the extended MPM organized the sampled pattern data information as in the form of Hankel matrix as given below

$$Y^{Ext.MP} = \begin{bmatrix} y_0^{(1)} y_1^{(1)} \cdots y_L^{(1)} \\ y_0^{(2)} y_1^{(2)} \cdots y_L^{(2)} \\ \cdot^{\cdot^{\cdot}} \ldots\ldots\ldots \ldots\ldots \ddots \\ y_0^{(K)} y_1^{(K)} \cdots y_L^{(K)} \end{bmatrix} \qquad [3]$$

where L is called as the pencil parameter, which is chosen as M < L< N -M [23] and the above matrix consist of K Hankel matrices. Then splitting it into two matrices as $Y_f^{Ext.MP}$ and $Y_l^{Ext.MP}$ which have obtained from $Y^{Ext.MP}$. These matrices have been obtained by deleting the first column and last column of $Y^{Ext.MP}$ respectively. The poles z_i has been generalized [24] from the equation as given below i.e,

$$Y_f^{Ext.MP} - zY_l^{Ext.MP} = 0 \qquad [4]$$

The singular value decomposition of a matrix is usually mentioned as the SVD. This is the final and best factorization of a matrix. To reduce the numbers of elements in array the extended MPM perform the singular value decomposition (SVD) of the matrix $Y^{Ext.MP}$ [13] i.e,

$$Y^{Ext.MP} = [U][\Sigma][V] \qquad [5]$$

where *U* is orthogonal, Σ is diagonal, and *V* is orthogonal. The minimum number of or lower rank matrix can be obtained by solving the eigenvalue problem given by [19]

$$\{[V_{Q,b}]^H [V_{Q,b}]\}^{-1} [V_{Q,b}]^H [V_{Q,t}] - z' [I] = 0 \qquad [6]$$

Where $[V_{Q,b}]$ and $[V_{Q,t}]$ is obtained by removing the bottom and top row of $[V_Q]$ which contain only principal right singular vectors of [V]. The new element position [21] is obtained as following

$$d_i' = \frac{\lambda \ln z_i'}{j2\pi\Delta} \qquad [7]$$

If all the poles and new element positions are computed, next aim is to find the complex excitation for the array. It is given by [21]

$$F = \hat{Z}.\hat{R} \qquad [8]$$

The extended MPM is again improved named as Extended FBMPM, which obtained by combining idea of FBMPM [20]. In Extended FBMPM take the conjugate as shown below [24]

$$Y^{Ext.FBMP} = \begin{bmatrix} \{y_0^{(1)}\}^* & \{y_1^{(1)}\}^* & \cdots & \{y_L^{(1)}\}^* \\ \{y_0^{(2)}\}^* & \{y_1^{(2)}\}^* & \cdots & \{y_L^{(2)}\}^* \\ \vdots & \vdots & \vdots & \vdots \\ \{y_0^{(K)}\}^* & \{y_1^{(K)}\}^* & \cdots & \{y_L^{(K)}\}^* \\ y_L^{(1)} & y_{L-1}^{(1)} & & y_0^{(1)} \\ y_L^{(2)} & y_{L-1}^{(2)} & & y_0^{(2)} \\ \vdots & \vdots & \vdots & \vdots \\ y_L^{(K)} & y_{L-1}^{(K)} & \cdots & y_0^{(K)} \end{bmatrix} \qquad [9]$$

The same algorithm of Extended MPM is followed in extended FBMPM also.

3. DELAY AND SUM WEIGHTING ALGORITHM

The Delay and sum (DAS) algorithm is one of the most common techniques used in antenna synthesis to steer the antenna directivity in a particular direction. It is shown in the fig-2, in which the weightings are applied to give prefixed delay to each element. In DAS beam former, needs to characterize the sensitivity of array into a single frequency from an arbitrary incident angle [25]. In this paper the dual directive beam has been designed by delay and sum (DAS) algorithm in which the signals at particular angles (for example [-30 30] as used in my work) has experiences a constructive interference and some other experiences as destructive interference.

The simple idea in beam forming is to use set of delays to steer the array to different directions in a scanning plane.

The DAS beam former's output in the time domain is

$$Z(t) = \sum_{m=0}^{M-1} w_m . y_m (t - \Delta_m) \qquad [10]$$

Where w_m is the weight and Δ_m is the delay chosen. The delayed signal input to each sensor in terms of phase shift [25] is given as

$$y_m(t - \Delta_m) = y_m(t).e^{-j\omega\Delta_m} \qquad [11]$$

Where $y_m(t)$ is the received signal and $e^{-j\omega\Delta_m}$ is the phase shift. Then the beam former output represented in equation (10) is represented as

$$Z(t) = \sum_{m=0}^{M-1} w_m . y_m(t).e^{-j\omega\Delta_m} \qquad [12]$$

Whenever the steering direction overlaps with a source, observed output power will be maximum. By exclaiming the measured output power from all the scanning points, it is possible to colour the spatial power.

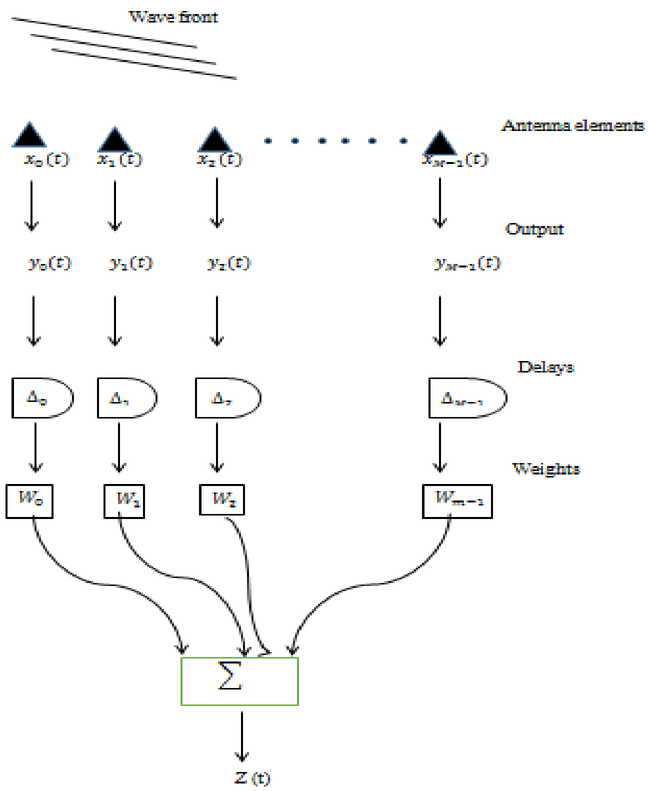

Fig-2: DAS algorithm

4. RESULTS AND DISCUSSION

Using the matrix pencil method conducted a study to reduce the antenna array elements in multiple patterns. The chart below shows the element reconstruction by the proposed method. The improved method of Extended MPM is extended FBMPM which has obtained the zeros in exact in unit circle. The chart-1 shows the original multiple patterns constructed in which elements have been spacing of 0.5 and 0.1.

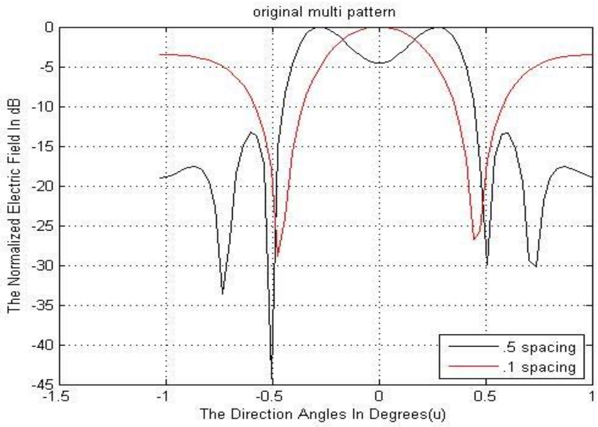

Chart-1: Multiple Patterns constructed

These patterns have been reconstruction with extended MPM and extended FBMPM. The chart-2 and chart-3 shows the pattern reconstruction with Extended MPM and Extended FBMPM for element spacing of 0.5.

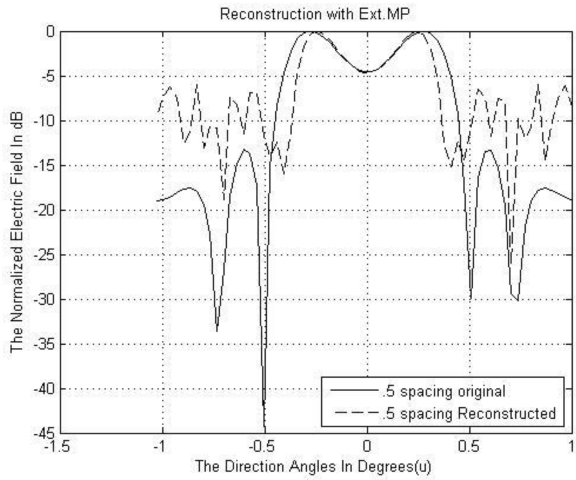

Chart-2: Pattern Reconstructed with Ext.MPM

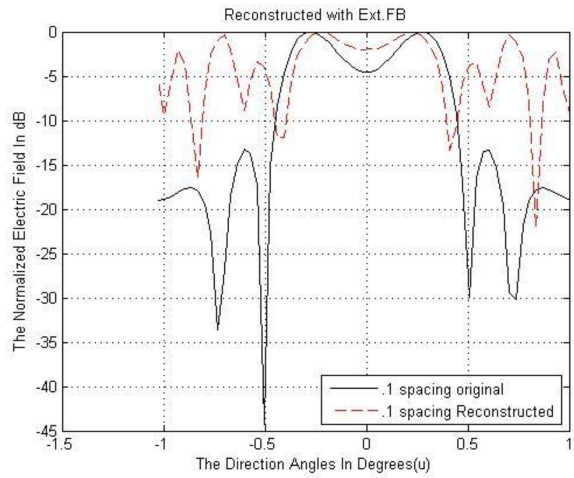

Chart-3: Pattern Reconstructed with Ext.FBMPM

This MPM method is adopted for the reconstruction of dual directive beam former which is applied in DAS beam former.

The results show that adopted method is more efficient in reducing the element considerably. The proposed method shows the element reduction in dual direction which can steer to any direction from -90 to +90. The chart-4 shows the reconstructed pattern for the DAS beam former with the Extended MP method.

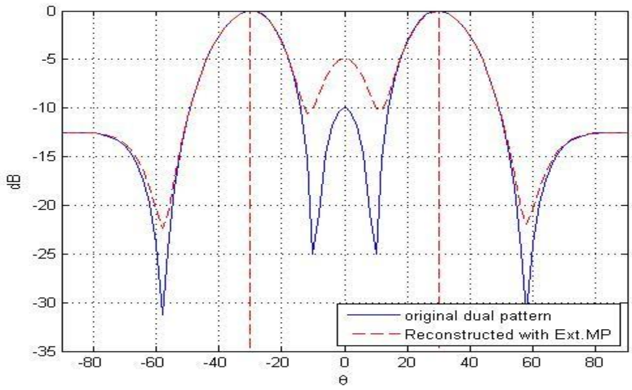

Chart-4: Pattern Reconstructed for dual directive beamformer using Ext.MPM

5. CONCLUSION

Based upon the studies conducted, the extended MPM has great advantage in reducing the elements in antenna array. In previous researches it is applied only to the multiple patterns which have single directivity. These proposed method used in the dual directive beam former. This gives high directivity into pre fixed directions and the direction can be changed by the designer based upon the purpose. The element is considerably reduced by using the proposed method.

REFERENCES

[1] A. Chakraborty, B. N. Das, and G. S. Sanyal, "Beam shaping using nonlinear phase distribution in a uniformly spaced array," *IEEE Trans. Antennas Propag.*, vol. AP-30, no. 5, pp. 1031–1034, May 1982.

[2] Boon Poh Ng, Meng Hwa Ev, and Alex Chi Chung Kot, "A new limit on inter element spacing for a linear array," IEEE Antennas and Propagation Magazine, Vol. 40, No. 4, August 1998

[3] M. Durr, A. Trastoy, and F. Ares, "Multiple-pattern linear antenna arrays with single prefixed amplitude distributions: Modified Woodward- Lawson synthesis," *Electron. Lett.*, vol. 36, no. 16, pp. 1345–1346, 2000.

[4] O.M. Bucci, G.Mazzarella, and G. Panariello, "Reconfigurable arrays by phase-only control," *IEEE Trans. Antennas Propag.*, vol. 39, no. 7, pp. 919–925, Jul. 1991.

[5] R. Vescovo, "Re-configurability and beam scanning with phase-only control for antenna arrays," *IEEE Trans. Antennas Propag.*, vol. 56, no. 6, pp. 1555–1565, Jun. 2008.

[6] D. Gies and Y. Rahmat-samii, "Particle swarm optimization for reconfigurable phase differentiated array design," *Microw. Opt. Technol. Lett.*, vol. 38, pp. 168–175, 2003.

[7] G. K. Mahanti, S. Das, and A. Chakraborty, "Design of phase-differentiated reconfigurable array antennas with minimum dynamic range ratio," *IEEE Antennas Wireless Propag. Lett.*, vol. 5, pp. 262–264, 2006.

[8] G. K. Mahanti and A. Chakraborty, "Phase-only and amplitude-phase synthesis of dual-pattern linear antenna arrays using floating-point genetic algorithms," *Prog. Electromag. Res.*, vol. PIER 68, pp. 247–259, 2007.

[9] S. M. Vaitheeswaran, "Dual beam synthesis using element position perturbations and the G3-GA algorithm," *Prog. Electromag. Res.*, vol. PIER 87, pp. 43–61, 2008.

[10] A. F. Morabito, A. Massa, P. Rocca, and T. Isernia, "An effective approach to the synthesis of phase-only reconfigurable linear arrays," *IEEE Trans. Antennas Propag.*, vol. 60, no. 8, pp. 3622–3631, Aug. 2012.

[11] M. I. Skolnik, G. Nemhauser, and J. W. Sherman, III, "Dynamic programming applied to unequally spaced arrays," *IEEE Trans. Antennas Propag.*, vol. 12, no. 1, pp. 35–43, Jan. 1964.

[12] B. P. Kumar and G. R. Branner, "Design of unequally spaced arrays for performance improvement," *IEEE Trans. Antennas Propag.*, vol. 47, no. 3, pp. 511–523, Mar. 1999.

[13] O.M. Bucci,M. D. Urso, T. Isernia, P. Angeletti, and G. Toso, "Deterministic synthesis of uniform amplitude sparse arrays via new flexible density taper techniques," *IEEE Trans. Antennas Propag.*, vol. 58, no.6, pp. 1949–1958, Jun. 2010.

[14] G. Oliveri and A. Massa, "Bayesian compressive sampling for pattern synthesis with maximally sparse non-uniform linear arrays," *IEEE Trans. Antennas Propag.*, vol. 59, no. 2, pp. 467–481, Feb. 2011.

[15] G. Oliveri, M. Carlin, and A. Massa, "Complex-weight sparse linear array synthesis by Bayesian compressive sampling," *IEEE Trans. Antennas Propag.*, vol. 60, no. 5, pp. 2309–2326, May 2012.

[16] K. K. Yan and Y. Lu, "Sidelobe reduction in array-pattern synthesis using genetic algorithm," *IEEE Trans. Antennas Propag.*, vol. 45, no. 7, pp. 1117–1122, Jul. 1997.

[17] L. Cen, W. Ser, Z. Yu, S. Rahardja, and W. Cen, "Linear sparse array synthesis with minimum number of sensors," *IEEE Trans. Antennas Propag.*, vol. 58, no. 3, pp. 720–726, Mar. 2010.

[18] D. G. Kurup, M. Himdi, and A. Rydberg, "Synthesis of uniform amplitude unequally spaced antenna arrays using the differential evolution algorithm," *IEEE Trans. Antennas Propag.*, vol. 51, no. 9, pp. 2210–2217, Sep. 2003.

[19] S. L. Ho and S. Yang, "The cross-entropy method and its application to inverse problems," *IEEE Trans. Magn.*, vol. 46, no. 8, pp. 3401–3404, Aug. 2010.

[20] Y. Liu, Z. Nie, and Q. H. Liu, "Reducing the number of elements in a linear antenna array by the matrix pencil method," *IEEE Trans. Antennas Propag.*, vol. 56, no. 9, pp. 2955–2962, Sep. 2008.

[21] T.K. Sarkar, S. Park, J.Koh, and S. M. Rao, "Application of the matrix pencil method for estimating the SEM (singularity expansion method) poles of source-free transient responses from multiple look directions," *IEEE Trans. Antennas Propag.*, vol. 48, no. 4, pp. 48–55, Apr. 2000.

[22] T. K. Sarkar and O. Pereira, "Using the matrix pencil method to estimate the parameters by a sum of complex exponentials," *IEEE Antennas Propag. Mag.*, vol. 37, no. 1, pp. 48–55, Feb. 1995.

[23] Y. Liu, Q. H. Liu, and Z. Nie, "Reducing the number of elements in the synthesis of shaped-beam patterns by the forward-backward matrixpencil method," *IEEE Trans. Antennas Propag.*, vol. 58, no. 2, pp. 604–608, Feb. 2010.

[24] Yanhui Liu, Qing Huo Liu, "Reducing the Number of Elements in Multiple-Pattern Linear Arrays by the Extended Matrix Pencil Methods" *IEEE Trans. ON Antennas And Propagation*, Vol. 62, no 2, February 2014.

[25] Jorgen Grythe, Norsonic AS, Oslo, Norway "Beamforming algorithms – beam formers" August 2015.