Enhance Performance Analysis for DoA estimation using MVDR Capon Algorithm for MIMO

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Abstract: In this paper we performing adaptive beamforming algorithm MVDR (Minimum Variance Distortionless Response) for MIMO (Multiple-Input-Multiple-output). A phase array antenna generating signal processing that can be improve the system and resolve the direction of arrival (DoA). For better performance of incoming waves direction, we use the high resolution technique. And the main object of their technique is that that identify the direction of signals source amplitude. In this paper we perform the DoA algorithm MVDR on uniform linear array (ULA). By using this algorithm, we improve the parameters like signal-to-noise ratio (SNR), beamwidth of the signal, separation of the angles between two signal at different angles.

***Index Terms* - Phase array antenna, ULA, DoA, MVDR algorithm, Massive MIMO**

I. INTRODUCTION

In resect years the popularity of smart phones and social network has increase wireless data traffic. That the motivated of the various innovation in communication technology. Users wants to communicate to each other with same frequency resource and also increase the speed of data transmission. The most common way to increase the data transmission is that to frequency bandwidth or increase the power of the signals. A frequency bandwidth does not increase because it's fixed so we just improve the signal power at base station (BS). For this problem apply the numbers of array antennas at the BS so easily increase the transmit power.

When apply number of array antennas interference of signal must be increase so resolving this problem in wireless communication using beamforming techniques. A beamforming techniques use smart antennas for transmitting signals. The main aim of the beamforming is direction of arrival (DoA). A benefit of this techniques that identify the users' direction and transmit the signal at that. For identifying user angle at BS sensor array to estimate the direction of signal from the user and also knowing the interference signal source. [1]

DoA helps in changing the weight vector of adaptive beamforming. That is improve system and radiation power of whole users. By using DoA estimation the radiation nulls in specific direction remove it and decrease interference of signal source.

Bartlett, Capon, Min-Norn, MUSIC, and ESPRIT are many algorithms of DoA estimation. MUSIC and ESPRIT are most popular for their accuracy and high resolution. In this paper we focus on applications of estimating DoA for multi signals of users. We also focus on MVDR which is known as Capon algorithm. All results programs are simulating in MTLAB. [1]

II. DoA Algorithm Estimation

DoA is classified into two parts one is quadratic and second is subspace. MVDR is one of them. MVDR is dependent on physical size of array, and this method has poor resolution and accuracy. [8]

In this algorithm we focus on performance of number of elements, space distribution, and signal-to-noise ratio, separation of angles between two signals at different angles.

DoA mealy focus on received data of array which are estimate by DoA to signal. A phase array antenna system shown in fig.1. in this system antenna transmit beam and that is come to internal feedback control. [8]

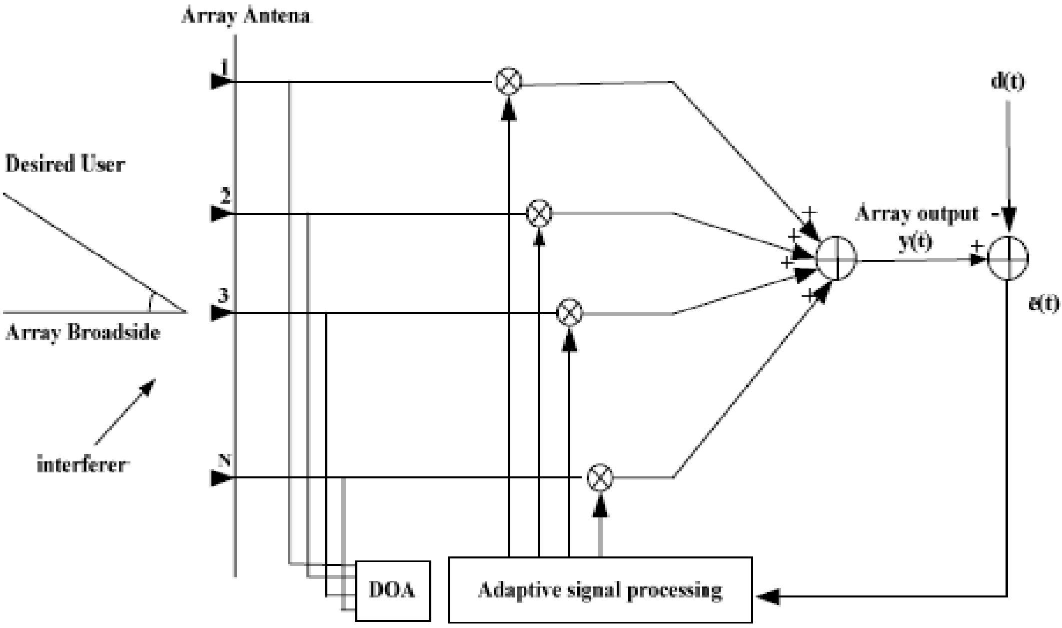

Fig.1 A function block diagram of array antenna system [8]

In radio communication for better performance we use an adaptive beamformer. DoA is depends on may parameters like array elements, SNR, angles between two users, signal spacing etc.

A. Signal Model:

Assume that number of M plane wave forms implemented at different angles θ_i where i = 1, 2, 3, …, M which are implemented in ULA N equi-spaced sensor like show in fig. 2. For particular time t where t = 1, 2, 3, …., k here k is total number of snapshot of array output. The signal vector x(t) is defined as: [8]

$$\mathbf{x(t)} = \sum_{m=1}^{M} a(\theta_m) \cdot s_m(t) \qquad (1)$$

where s(t) is M × 1 vector of source waveform, a(θ) is an N × 1 vector of array reuse to that origin or that array steering vector for that particular direction. That is given by:

$$a(\theta) = [1\ e^{-j\phi} \ldots e - j^{-j(N-1)\phi}]^T \qquad (2)$$

here T is transposition operation and ϕ is use for electric phase shifter for element to element. That can be written as:

$$\phi = (\frac{2\pi}{\lambda})\ d \cos(\theta) \qquad (3)$$

here d is used for interval betwixt two array element, λ is used for electromagnetic wave of accepted signal. So the x(t) signal vector of size N × 1 is defined as:

$$x(t) = A(\theta_m)\ s_m(t) \qquad (4)$$

here $A(\theta_m) = [a(\theta_1), \ldots, a(\theta_M)]$ is N × M matrix of steering vector, $s_m(t) = [s(t_1), \ldots, s(t_M)]$ is M × N matrix for input vector. Now add the noise in array output signal it can be define as:

$$x_m(t) = A_m(\theta_m)\ s_m(t) + w_m(t) \qquad (5)$$

here $x_m(t)$ and $w_m(t)$ are uncorrelated which assumed and $w_m(t)$ type of as short-term white and eq. (5) show that zero mean for complex Gaussian noise and its define as in matrix from of size N×M as:

$$X_m = A_m\ S_m + W_m \qquad (6)$$

Here $S_m = [s_m(1), \ldots, s_m(k)]$ is M × N matrix for source waveforms, $W_m = [w_m(1), \ldots, w_m(K)]$ is N × K matrix for signal detector noise. A correlation matrix for R_{xx} of the observed signal vector x(t) is written as:

$$R_{xx} = [x_m(t) x_m(t)^H] \qquad (7)$$

$$\mathbf{R_{xx} = A(\theta).R_{ss}.\ A^H(\theta) + \sigma_{n2\ I}} \qquad \textbf{(8)}$$

Here σ_{n2} is variance of noise, I is identity matrix:

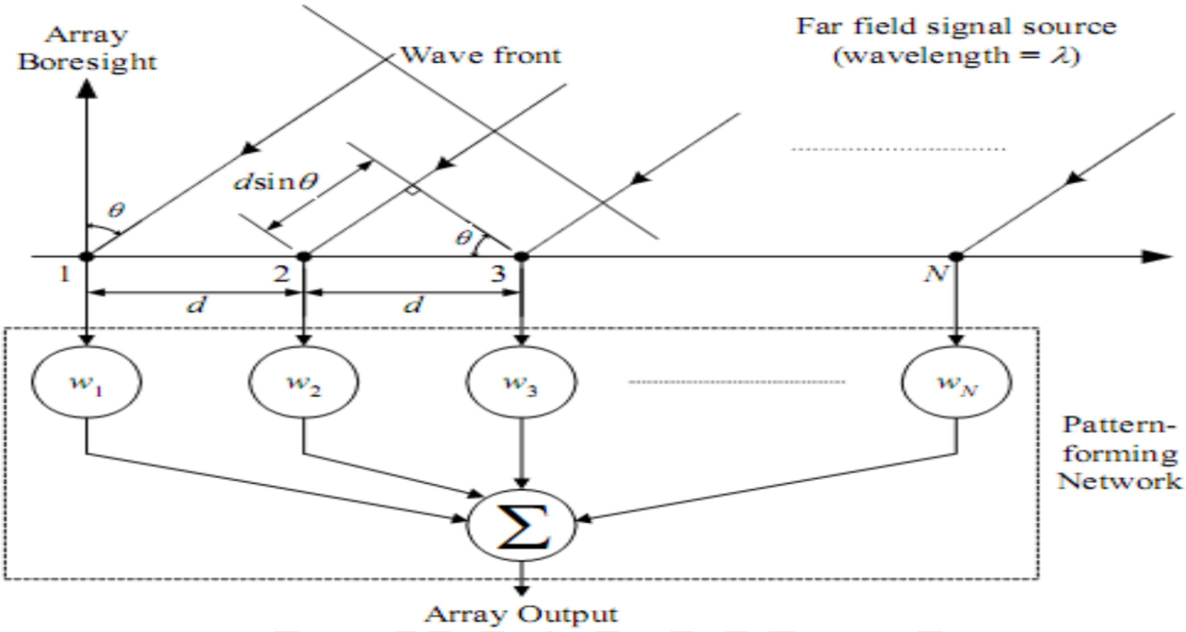

Fig. 2 A plane wave implemented on ULA of N equi-spaced sensor [8]

The spatial correlation matrix by R. In this matrix expression of its eigenvector and their eigenvalues. The correlation matrix vector y(t) can be defied in the form of:

$$\mathbf{R = E[u(t)u(t)^H]} \qquad \textbf{(9)}$$

B. DOA ESTIMATION USING MVDR ALGORITHM

A MVDR algorithm implicated estimate the noise subspace from the correlation matrix for M array steering vector. A steering vector also known as direction vector. That present ideal array to signal source. A signal source derived by the steering vector and they are orthogonal to noise subspace. [1]

E [] and ^{H} are present as expectation and conjugate transpose operators. The array output equation u(t) put into (9). The used correlation matrix (R) can be defined as: [8]

$$\mathbf{R = E\ [A\ s(t)s(t)^H\ a^H] + E[w(t)w(t)^H]} \quad \textbf{(10)}$$

The correlation matrix (R) contains M signal eigenvalues. (N, M) is the noise eigenvalue which is exist. The matrix build of the M signal eigenvalue E_s is represent as:

$$\mathbf{E_s = [e_1\ e_2\ \dots\ e_M]} \qquad \textbf{(11)}$$

the matrix has the remaining (N, M) are noise eigenvectors and it's indicated by En:

$$\mathbf{E_n = [e_{M+1}\ e_{M+2}\ \dots\ e_N]} \qquad \textbf{(12)}$$

Equation (12) may happened when the direction vector E(θ) is orthogonal with outcry subspace the MVDR amplitude. This algorithm minimized the interferences from outer sources. When we get the gain output power is decrease. That means the side of look up direction we assume as constant and it must be unity.

$$\mathbf{\min E[|y(\theta)|^2] = \min w^H R_{xx} w,\ w^H A(\theta) = 1} \quad \textbf{(13)}$$

The weight vector equation for MVDR Capon is define as:

$$\mathbf{W_{cap}} = \frac{\mathbf{R^{-1}A(\theta)}}{\mathbf{A^H R_{xx}^{-1} A(\theta)}} \qquad \textbf{(14)}$$

The power equation for MVDR Capon is as define as:

$$\mathbf{P_{cap}} = \frac{\mathbf{1}}{\mathbf{A^H R_{xx}^{-1} A(\theta)}} \qquad \mathbf{(15)}$$

The angles of arrival are estimated by detecting the peaks in this angular spectrum.

III. SIMULATION RESULT

The MVDR methods for DoA estimating simulation using MATLAB tools. When we performing this algorithm observed many parameters which are effected from this method as well as sensor array. [8]

A ULA with 80 elements are consider in our simulation. When focus on one parameter other are fixed and observed the changing. The distance between the elements is λ/8, angular range is $\theta_1 = 180$ and $\theta_2 = -180$, and observed SNR, array elements. Here we assume two signal to have equal amplitude. [8]

A. MVDR Algorithm

The MVDR method is inversely to the autocorrelation matrix of R_{xx} when this method simulates. When input parameters performing that time other parameters should be constant and observer the main parameter. [8]

Case 1 MVDR spectrum for various value of SNR

Fig.3,4,5 show SNR effect for this algorithm. To increase the SNR spectrum of system is effect. For estimating DoA of two signals which are located at -20 and 30, use the 10 elements using algorithm. There are three different values of the (10, 20, and 30). Show the results it's clear that SNR effect when preforming this algorithm.

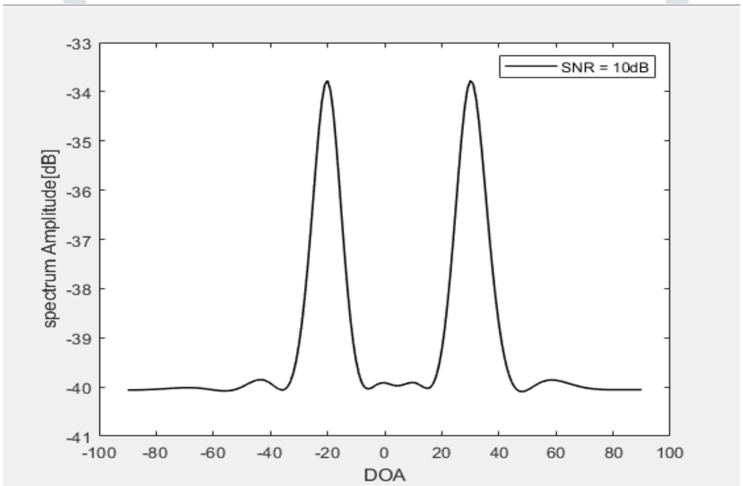

Fig. 3

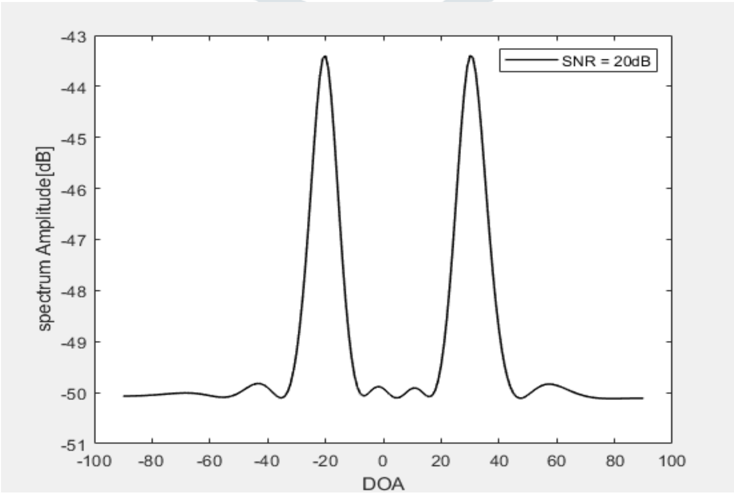

Fig. 4

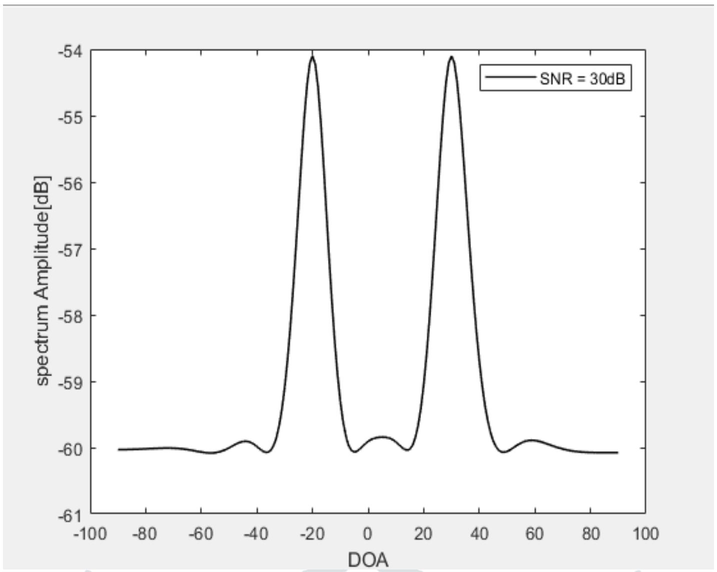

Fig. 5

Case 2 MVDR spectrum for various number of array elements

Fig. 6,7,8 show the MVDR angular spectrum using N = 10, 20, and 30. The beamwidth is decrease when number of elements are increase. For better resolution MVDR algorithm it performs as angular width become sharp at peak point. SNR is constant at 10 db.

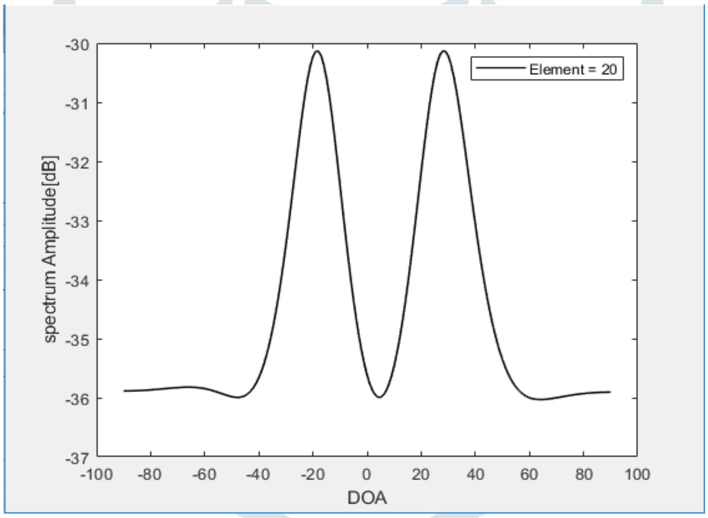

Fig. 6

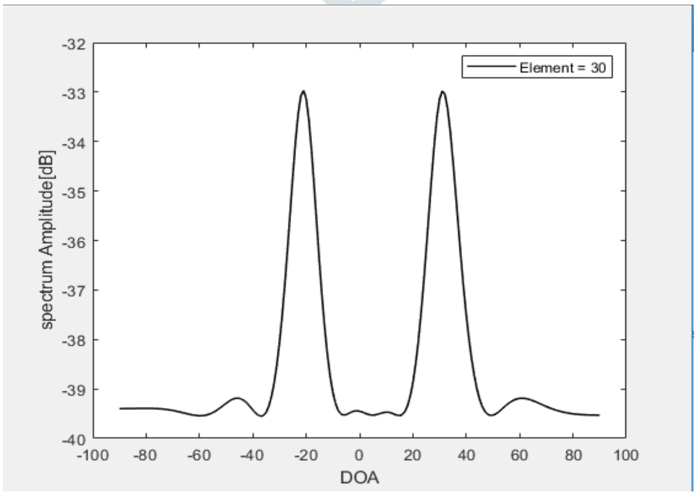

Fig. 7

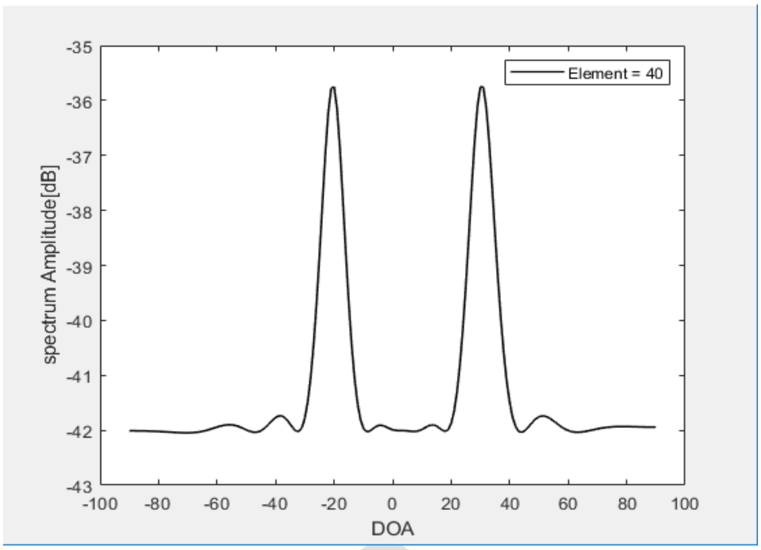

Fig. 8

Case 3 MVDR spectrum for various angular separation

Fig.9,10,11 it's clear that MVDR has better resolution. The MVDR's method may resolve two signals with angular disconnecting at ten degrees. When the users comes as close 2.5° the signals are start failure. SNR is constant at 10 db. The distance between two signals are large than signal resolution is high as shown in fig. 11 the spectrum has sharp peak and lower noise and interferences.

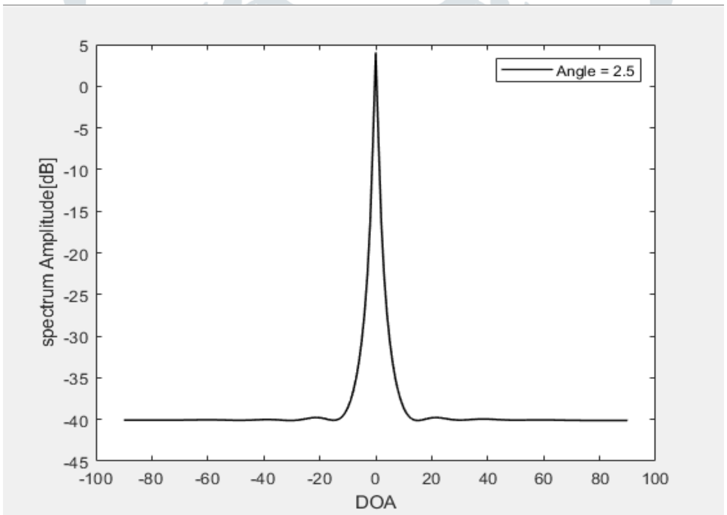

Fig. 9

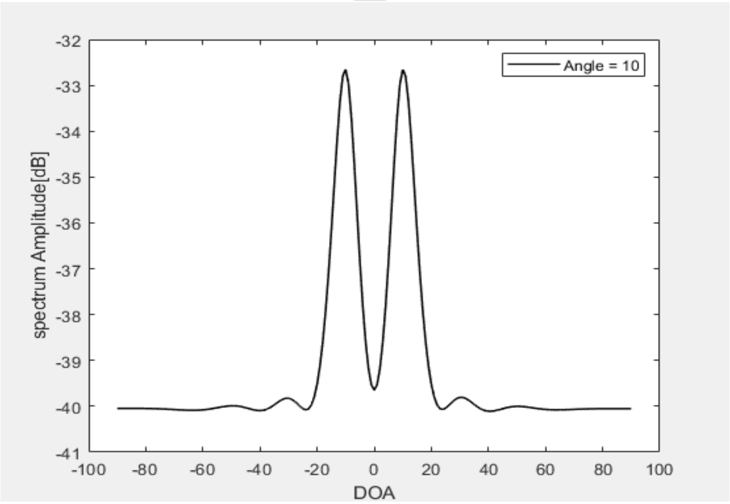

Fig. 10

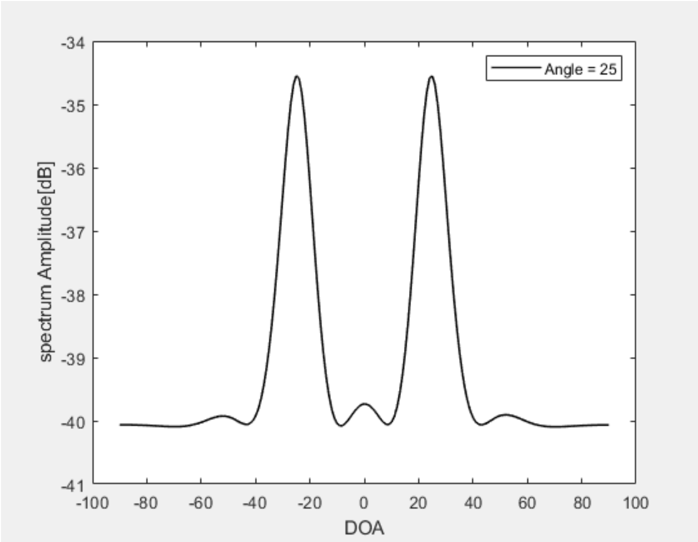

Fig. 11

IV. CONCLUSION

MVDR is useful for optimize the weight vector that is help to minimize the SINR of many array antennas. The number of numerical equations were conducted to find the effect of the MVDR algorithm. It's capable to resolve the incoming signal accuracy. It's prove that MVDR method is effect on signal parameters like SNR, signal spacing, secretion between two angles.

V. REFERENCE

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