# Sub Array Effect on MUSIC for Partial Adaptive Array Radar

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***Abstract* - Eigen Sub space methods like Multiple Signal Classification (MUSIC) has drawn much attention in the field of Direction of Arrival estimation with antenna arrays because of super resolution properties. In order to reduce the complexity and the computational load, designers are choosing the partial adaptive arrays i.e. total antenna array is divided in to sub array and sub array outputs are processed instead of element outputs. In this paper we discuss the limitation of the MUSIC algorithm for linear sub arrays with the simulation results.**

***Keywords* - MUSIC, Super Resolution.**

## I. Introduction

Angular super resolution has become one of the important research topic. Super resolution in angular domain provides the solution of some problems but needs much computational power. Super resolution algorithms needs the knowledge of the array structure for efficient results and array calibration is needed. Most of the super resolution algorithms give efficient results at element level but it needs knowledge about the antenna element positions and requires high computational power. In order to reduce the complexity and computational load designers combines few elements and provides the sub array output.

Spectrum estimation using the sub-array outputs, need not have the knowledge of the complete array, only gains and the phase centres of the sub arrays are enough to compute the array manifold vector and subsequent spectrum[2]. The above method can provide the super resolution only around the look-direction, named as Spotlight MUSIC by U. Nickel [1].

In this paper the MUSIC spectrum estimation for linear array at sub array level with regular sub arrays are presented. Due to sampling the effect of grating lobe on the main lobe for MUSIC has been discussed with simulations. The grating lobe can be minimized by using the irregular sub array shapes.

The structure of the paper as follows: explanation of the MUSIC spectrum estimation by using sub arrays, Antenna element position and sub array configurations for simulations and lastly discussions on the simulation results followed by conclusion.

## II. MUSIC Spectrum At Sub Array Level

One dimensional linear array has been considered, which can steer the beam by using the phase changes. The inter element distance is considered as half wavelength. Assume that there are $N$ narrow-band sources impinging on array from far-field direction of $(\theta_n)$ where the bore-sight of the array is $(\theta_0)$.The output of the $l^{th}$ $(l = 1, 2.....L)$ element, here we considered first element as reference is

$$x_l(t) = g_l \sum_{n=1}^{N} s_n(t)\, exp\left\{-j\frac{2*\pi}{\lambda}[(x_l - x_1)(\alpha_n - \alpha_0)]\right\} + n_l(t) \quad (1)$$

Where

$$\alpha_n = sin\theta_n$$

$$\alpha_0 = sin\theta_0$$

$g_l$ is the gain of the element. Each element is assumed as Omni-directional elements and without tapering. The antenna is divided in to P number of non-overlapped sub arrays. $s_n(t)$ is the nth incident signal, $n_l(t)$ is the white Gaussian noise in the lth element.

Now we construct a Transformation matrix (T-matrix) from element level to sub array level. It has a dimension of $P\ X\ L$, where P is the number of sub arrays. Matrix will have zeros and ones. Ones are present in a particular row (sub array) for a given column (element).
From (1) we can obtain sub array output vector as

$$X(t) = Tx(t) \quad (2)$$

Where

$$X(t) = [X_1(t)\ , X_2(t), \ldots\ldots\ldots . X_P(t)\,] \quad (3)$$

The sub array phase centers are $\gamma_x$ and gain of the $p^{th}$ sub array are given by (4), (5) and (6) respectively.

$$\gamma_x = \frac{\sum_{l\in U_p} g_l\, x_l}{\sum_{l\in U_p} g_l} \quad (4)$$

$$G_p = \sum_{l\in U_p} g_l \quad (5)$$

Since tapering is not applied and each element is a Omni-directional element, gain will be unity, then the above equations (4),(5) can be replaced with (6) and (7)

$$\gamma_x = \frac{\sum_{l\in U_p} x_l}{Q} \quad (6)$$