The Impact of Noise Label on Beampattern and SINR of MVDR Beamformer

Suhail Najm Shahab[1], Ayib Rosdi Zainun[1], Izzeldin Ibrahim Mohamed[1], and Nurul Hazlina Noordin[1]

***Abstract*—**Minimum Variance Distortionless Response (MVDR) is basically a unity gain adaptive beamformer which is suffered from performance degradation due to the presence of interference and noise. Also, MVDR is sensitive to errors such as the steering vector errors, and the nulling level. MVDR combined with a linear antenna array (LAA) is used to acquire desired signals and suppress the interference and noise. This paper examines the impact of the noise variance label (σn2) and the number of interference sources by using Signal to Interference plus Noise Ratio (SINR) and array beampattern as two different Figure-of-Merits to measure the performance of the MVDR beamformer with a fixed number of array elements (L). The findings of this study indicate that the MVDR have successfully placed nulls in the nonlook angle with average SINR of 99.6, 49.6, 24.9 dB dB for σn2.of -50, 0, 50 dB, respectively. Also, the MVDR provides accurate majorlobe to the real user direction, even the σn2 are bigger than desired signal power. The proposed method was found to perform better than some existing techniques. Based on this analysis, the beampattern is not heavily relies on the σn2. Moreover, the SINR strongly depends on the σn2 and the number of SNOIs.

***Keywords*—**Beamforming, Linear antenna array, Minimum variance distortionless response, SINR, Smart antenna.

I. Introduction

CURRENTLY, the mobile cellular networks are experiencing a massive evolution of data traffic, because of multi-media and internet applications that are used by a vast number of devices such as smartphones, mobile PC and tablets [1], [2]. Most beamforming techniques have been considered for use at the base station (BS) since anten-na arrays are not feasible at mobile terminals due to space limitations [3]. The Long Term Evolution (LTE), as introduced by the 3rd Generation Partnership Project (3GPP), is an extremely flexible radio interface, the first LTE deployment was in 2011. LTE is the evolution of 3GPP Universal Mobile Telecommunication System (UMTS) towards an all-IP network to ensure the competitiveness of UMTS for the next ten years and beyond. LTE was developed in Release 8 and 9 of the 3GPP specification. Maravedis, anticipates that 3 LTE–TDD and 59 LTE–FDD networks will be running worldwide by the end of 2011. By 2016, there will be 305 million LTE subscribers, which means about 44 million (14%) will be LTE–TDD clients and the remaining 261 million (86%) will be LTE–FDD [4].

[1]Faculty of Electrical and Electronics Engineering, Universiti Malaysia Pahang, 26600, Pahang, Malaysia.

Interference is one of the significant obstacles in the wireless networks. It can be caused by other users or by the signal itself [5]. The signal can interfere with itself due to multipath components, where the signal is gathere-d with another version of the signal that is delayed because of another propagation path [6]. The fundamental pr-inciple of the Adaptive beamforming (ABF) algorithm is to track the statistics of the surrounding interference and noise field as well as adaptively placing nulls that decrease dramatically the interference and noise under the restriction that the look angle is not distorted at the beamformer's output [7]. The basic idea of the Minimum Va-riance Distortionless Response (MVDR) algorithm is to estimate the beamforming excitation coefficients in an adaptive way by minimizing the variance of the residual interference and noise whilst enforcing a set of linear constraints to ensure that the real user signal are not distorted [7].

The authors in [8] proposed an enhanced model of MVDR algorithm by replace the position of the reference element in steering vector to be in the central of the array and the number of elements must be odd. Simulation results show that modified MVDR has a realistic behavior especially for detecting the incoming signals direction and outperforms the conventional MVDR. One of the popular approaches to improve the classic Capon beamfor-mer in the presence of finite sample effect and steering vector errors is the diagonal loading, which was studied by [9]. The idea behind diagonal loading is to adapt a covariance matrix by adding a displacement value to the diagonal elements of the estimated covariance matrix. Nevertheless, how to select an appropriate diagonal loadi-ng level is a challenging task. [10] mentioned that the element spacing must be $d \leq \lambda/2$ to prevent spatial aliasin-g. In [11], the author presents a comparative study of MVDR algorithm and LMS algorithm, where results show that LMS is the better performer. The SINR maximization is another criterion employed in the joint transmitter and receiver beamforming algorithms [12], [13], [14]. In an analysis of [15], the mixing of differential algorithm based LAA is applied to deepen nulls and lower side lobe levels (SLLs) in the unwanted direction, and they fou-nd the max null depth of -63 dB by using 20 element. The statistic numerical algorithm was proposed to obtain the requirement for the amplitude and phase error of multibeam active phased array antenna [16]. The radiation beampattern is simulated from the value of the random amplitude and phase errors of phase shifter. From the results, it is found that the only way to meet the requirement of the sidelobe level is to use digital