PERFORMANCE OF FIXED BEAMFORMING

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ABSTRACT

In wireless transmission, to improve quality of transmission, MIMO or multiple input and multiple output technology is used to increase the signal to noise ratio. With beamforming technology, by using more antenna at the transmitter, beampattern can steer in desired direction. Then, interference from others signal can be deleted. This research paper is about beamforming technology. In this paper, the objective is to demonstrate using Simulink simulation that fixed beamforming technology is performant with delay and sum beamforming.

Keyword : *interference, antenna, direction, beamforming*

1. INTRODUCTION

The gain of an antenna depends on the direction in which the signal is transmitted or on the direction from which the signal is received. This antenna gain can be observed by its beam. To direct the beam in a direction without mechanical rotation of the antenna, beamforming is used. This technology is used to maximize the signal to interference plus noise ratio to the receiver. Here, simulation of transmission over additive white Gaussian noise channel and interference with beamforming is used by Simulink to improve the performance of beamforming [1].

2. BEAMFORMING

Beamforming also referred as spatial filtering, is a technique used by sensor arrays for a directional signal transmission or reception. Beamforming is used to point an antenna at the signal source to reduce interference and improve communication quality.

This is achieved by combining elements in an antenna array such that signals at specific angles are subject to constructive interference while others are subject to destructive interference.

2.1 Beamformer

Beamformer for transmitter or receiver applies the complex weight to the transmit signal for each element of the antenna array. Beamforming techniques can be subdivided into two main groups as fixed beamforming and adaptive beamforming. In the first case, the interference is mitigated but not suppressed and in the second, pattern is rotating in desired direction to suppress the undesired sources [2].

The output signal y(t) of Beamformer can be expressed as [3]:

$$y(t) = \sum_{k=1}^{N} w_k^* x_k(t) = w^H x(t) \tag{01}$$

Where :

- $x(t) = [x_1(t), \dots, x_N(t)]^T$ is the received signal
- $w(t) = [w_1(t), \dots, w_N(t)]^T$ is complex antenna weight
- * represent the complex conjugate

For Multiple Input Multiple Output (MIMO) channel, with beamforming at the transmitter and the receiver, the output signal is expressed as :

$$y_{BF} = W_r^{\,H} H W_t \; x + W_r^{\,H} \, b \tag{02}$$

Where :

- $W_t = [W_{t_1} \quad \cdots \quad W_{t_{N_T}}]^T$ is the complex antenna weight at the transmitter
- H Is the MIMO channel
- $W_r = [W_{r_1} \quad \cdots \quad W_{r_{N_R}}]^T$ is complex antenna weight at the receiver
- w^H represent the complexe transpose conjugate of w

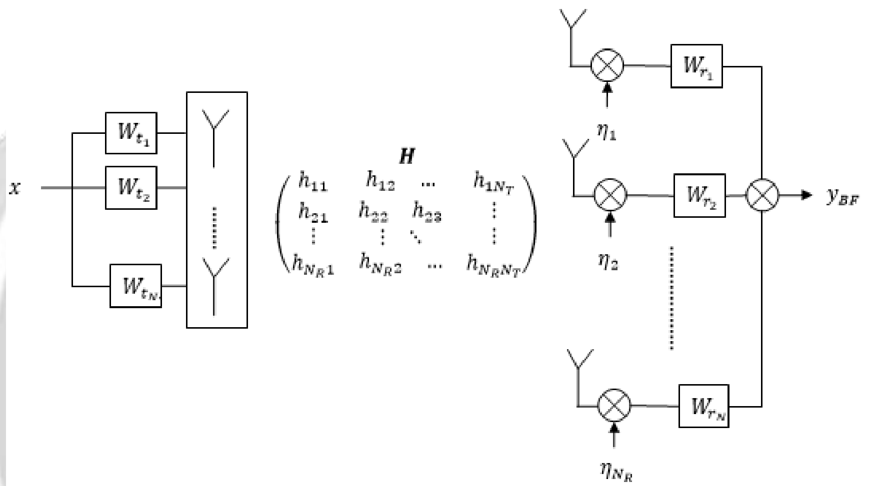

Fig -1: Beamforming process

A. Fixed beamforming

With fix beamforming, antenna systems detect the signal by selecting one of many predetermined, fixed beams. Beam select is depending on the mobility of the mobile across the sector. Fixed beamforming does not perform the amplitude weighting of the received signals.

The antenna array pattern is obtained from fixed element weights that do not depend on the signal environment. In Fixed Weight Beamforming, multiple fixed beams in predetermined directions are used to serve the users [4] [5].

One of the most popular beamforming technic is the conventional Beamformer, also known as the Bartlett Beamformer, or delay-and-sum (DAS) beamforming. The DAS Beamformer applies a delay and an amplitude weight to the output of each sensor, and then sums the resulting signals. The delays are chosen to maximize the array's sensitivity to incoming waves from a particular direction. [6].

B. Adaptive beamforming

With adaptive beamforming, the radiation pattern is dynamically controlled to perform the electrical beam steering in a desired direction, and null steering to reject interfering signals for others direction.

Adaptive antennas can be subdivided into three groups as spatial reference, temporal reference and blind techniques. For spatial reference techniques, the Direction of arrival (DOA) of the incoming signals is use. The temporal reference techniques employ a reference signal and blind techniques exploit some characteristics of the desired signal [4] [5].

3. Simulation with fixed Beamforming

3.2 Transmission with 8 Phase Shift Keying over additive white Gaussian noise and Beamforming

Parameters of simulation are:

- To improve performance, Signal to Noise Ratio over AWGN channel are SNR = 20 dB and SNR = 60 dB
- Noise power at the Receiver preamp bloc Noise = 0,1 Watt
- At the transmitter, Azimuth Angle of Arrival = 120°
- The Phase Shift Beamformer block performs delay-and-sum beamforming

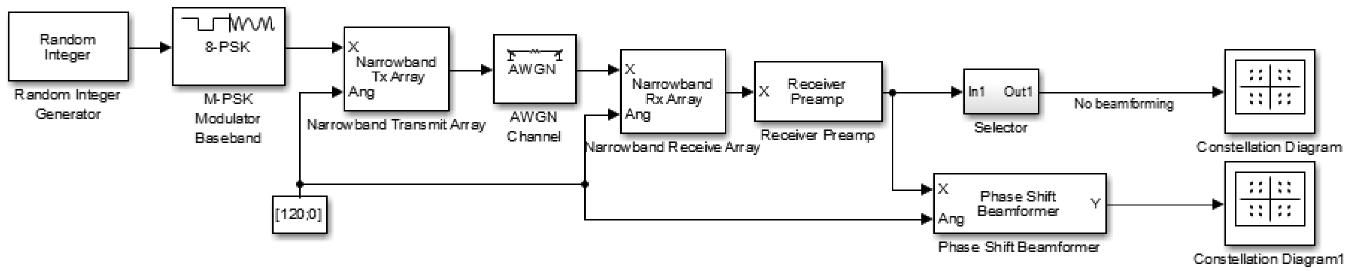

Fig -2: Simulink simulation of transmission with noise over AWGN channel

3.2 Transmission with 8 Phase Shift Keying over interference and noise with Beamforming

Parameters of simulation are:

- Noise power at the Receiver preamp bloc Noise = 0,5 Watt
- At the transmitter, Azimuth Angle = 160°
- For interference, at the transmitter, Azimuth Angle = 80°

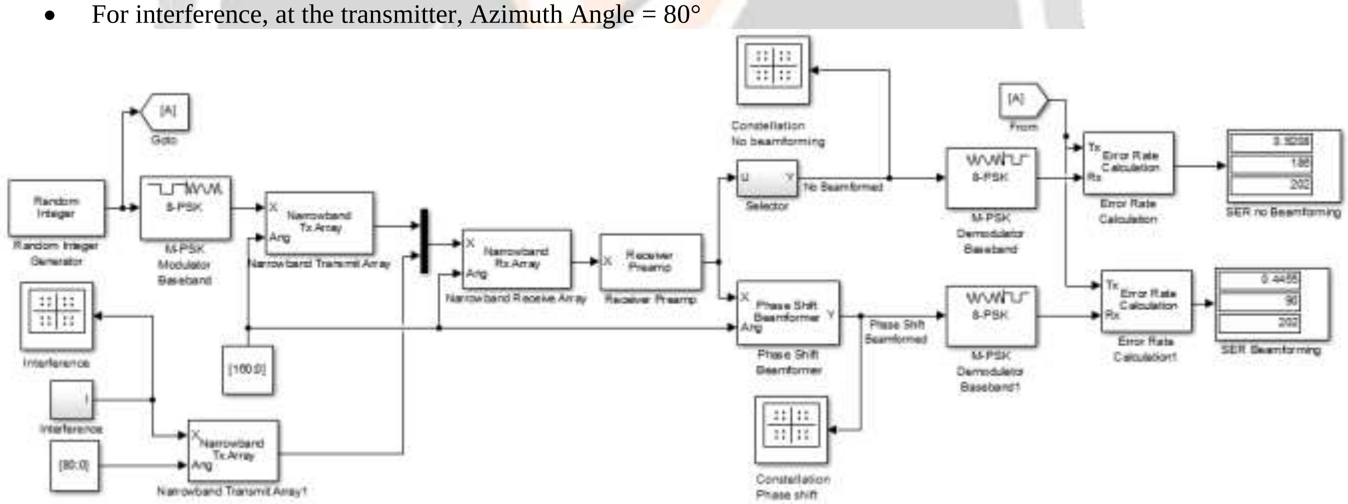

Fig -3: Simulink simulation of transmission with noise and interference.

Interference block is describe by:

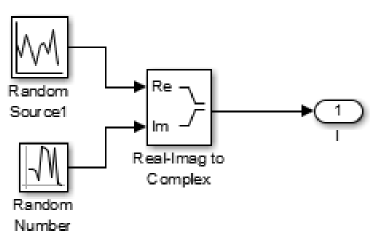

Fig -4: Interference bloc

7. RESULTS

7.1 Results of transmission over additive white Gaussian noise with Beamforming

When the signal to noise ratio of AWGN channel is 20 dB, **Fig -5** and **Fig -6** described outputs.

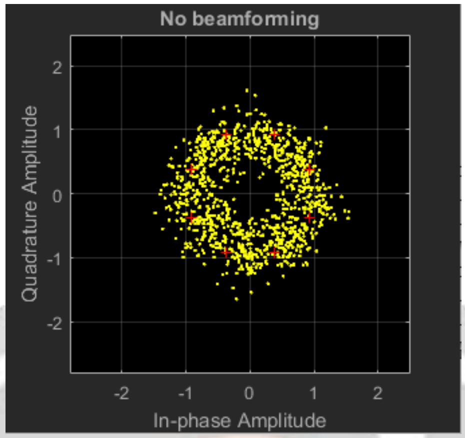

Fig -5: Constellation without beamforming

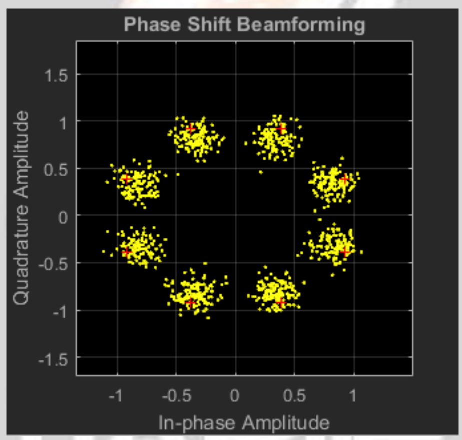

Fig -6: Constellation with beamforming

When the signal to noise ratio of AWGN channel is 60 dB, **Fig -7** and **Fig -8** described outputs.

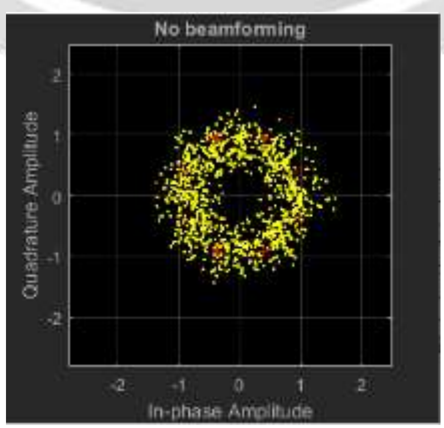

Fig -7: Constellation without beamforming

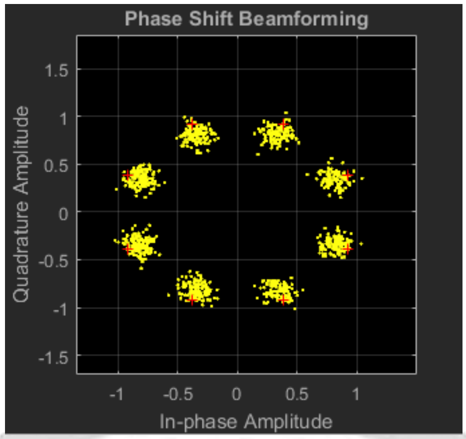

Fig -8: Constellation with beamforming

With **Fig –5**, **Fig -6**, **Fig -7** and **Fig -8** we can see that with beamforming, transmission over AWGN channel is performant.

7.2 Results of transmission over interference and noise with Beamforming

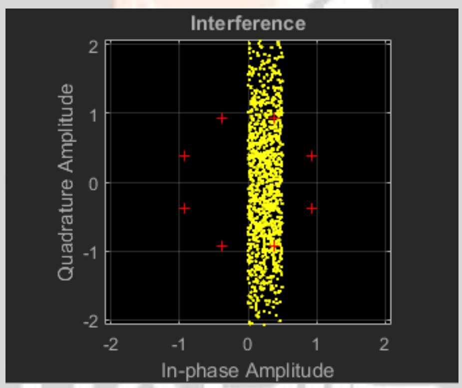

Fig -9: Interference

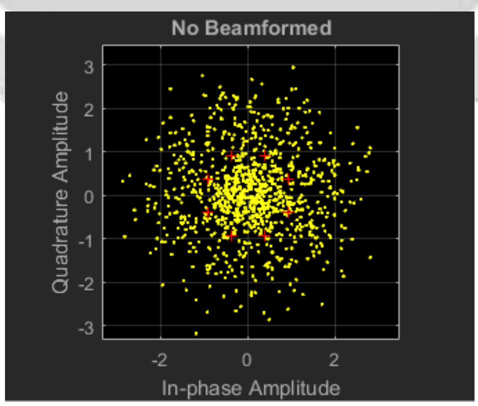

Fig -10: Constellation without beamforming

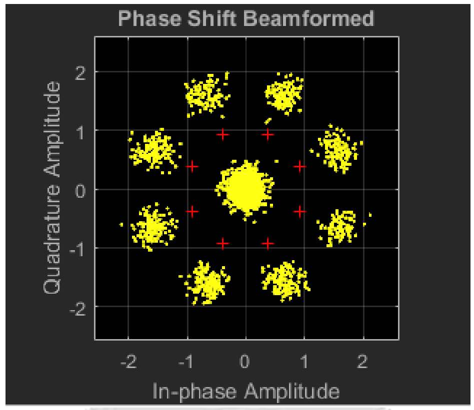

Fig -11: Constellation with beamforming

With **Fig –9**, **Fig -10** and **Fig -11** we can see that beamforming is performant with interference because the signal to noise ratio for transmission without beamforming is SNR= 0,9 but with beamforming SNR = 0,4. The effect of all interference was mitigate by beamforming.

6. CONCLUSION

With beamforming, the signal to interference and noise ratio increase. For fixed beamforming, weight is fixed and do not depend on the signal environment. To produce a common output the signals from the individual sensors are combined. As opposed to adaptive methods, the sensor weights for the delay and sum beamformer are chosen in advance and independently of the received waveform. Fixed Bemforming with delay and sum beamforming is performant.

7. REFERENCES

[1]. I. N. Bhat, E. H. Dogra “Beamforming for 5G Networks”, International Journal of Trend in Scientific Research and Development Journal, v2, 2018.
[2]. M. U. Shahid, A. Rehman, M. Mukhtar, M. Nauman, “Analysis of Fixed Beamforming Algorithms for Smart Antenna Systems simulation”, International Journal of Electronics and Communication Engineering, Vol:14, No:5, 2020.
[3]. J. Litva, T. K.Y. Lo, “Digital beamforming in wireless communications”, Artech House, 1997.
[4]. J. Benesty, I. Cohen, and J. Chen, “Fundamentals of Signal Enhancement and Array Signal Processing”,Wiley-IEEE Press, 2017
[5]. C. A. Balanis, “Antenna theory, analysis and design”, Wiley, 2016.
[6]. J. Grythe, AS Norsonic, Oslo, Norway, “Beamforming algorithms – beamformers”, Norsonic, Technical note, 2015.