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5G Phased-Array Beamforming Antenna Design for Future Communication Technologies

Girish M[1], Manjunath K[2], Harshitha N[3]

[1-3]Department of ECE, ATME College of Engineering, Mysuru, India

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Abstract- *In the era of advancement in communication standards, the design of underlying antennas are play a vital role. Beamforming antennas or phased-array antennas make use of series of antenna elements to control the beams electronically instead of human intervevntion as in conventional antennas. This feature is very important in non-fixed systems such as aircraft and satellite systems. Addition to it radiation diagram can also be adjusted therefore antennas can receive more information or able to emit the more energy in specific direction than other. This paper presents the implementation of massive MIMO phased array design and this Eliminate design problems before building hardware also addresses the challenges in the designing of antennas for 5G like increased bandwidth, flexible air interface and small*

Index terms- massive MIMO, Beamforming antenna, non-fixed system, electronically controlled, 5G.

I. Introduction:

Hybrid beamforming is a technique that uses the partition between RF and Digital beamforming. In order to meet the required performance parameters antenna engineers shall implement the hybrid beamforming to stability between the tradeoffs namely flexibility and cost of the design. Hybrid beamforming consitutes the subarray modules by cascading multiple array elements. Range of steering angles need to precisely selected by the transmitter and receiver modules in the subarray and few are necessary in the system along with the number of elements and positioning of the elements within each subarray. RF domain will have applied with phase shift directly on each element inside the subarray as discussed with our first instance, although complex weighting vectors shall be applied on the signals that feed each subarray in digital beamforming techniques. Signal attributes namely the amplitude and phase at subarray level will be controlled in the digital beamforming. RF control with phase shift for each element is leads to the cost and complexity reasons.

In this particular era of emerging applications connected vehicles, Internet of Things, Remote medicine and virtual reality are at the top edge of the technologies which addresses the propagation challenges signal attenuation, wideband performance and scatter rich propagation.

This paper describes overall design of phased arrays addressed the challenges of future communication.

II. 5G Waveform Generation

As 5G principles remain to develop, the goals like achieving bandwidth rate, latency must be very less and efficient implementation.

Beamforming antenna design to accomplish these requirements the following architecture helps to build an efficient antenna as shown in the figure 1.

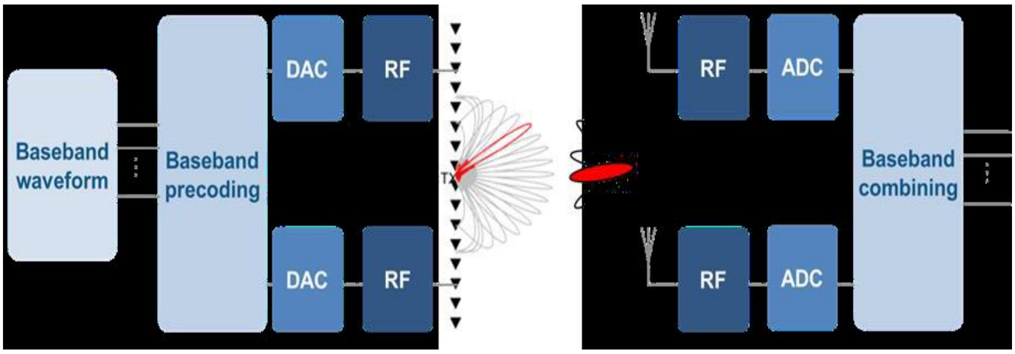

Figure 1. Hybrid beamforming architecture.

Hybrid beamforming is done in two stages:

First stage is Subcarrier spacing can be a power of two multiple of 15KHz and the later one is different subcarrier spacing in different bandwidth parts.

This table shows the typical values of subcarriers spacing.

m	Df = 2^m * 15kHz	Slots / ms	Max BW (MHz)
0	15	1	49.5
1	30	2	99
2	60	4	198
3	120	8	396
4	240	16	397

Using the Matlab 5G toolbox can design the fully parametrizable synchronization signal bursts and multiple bandwidth parts can be achieved through a design of the array. While designing the antenna array several factors need to be considered such as element tapering, lattice structure, element spacing and geometry of the elements.

To start the array design process, the Sensor Array Analyzer app, which is available with Phased Array System Toolbox, can be launched from the MATLAB prompt ***sensorArrayAnalyzer*** **through this prompt you ca also edit all the design parameters at the left side of the window presented in figure 2.**

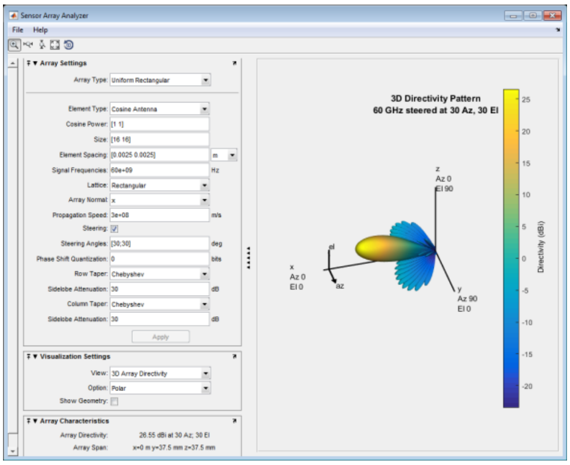

Figure 2: SensorArrayAnalyzer app for array design.

With the help of 5G NR test modules anad frequency ranges is mentioned to generate the waveforms with subcarrier spacing and duplexing mode.Hybrid beam forming system and its precoding using Simulink can be viewed as in the figure 3.

As is the instance with all design selections, the higher antenna gains achieved with narrower beams must be balanced with the statistic that MIMO systems are created on scattering surroundings that also depend on wider beam patterns to exploit channel capacity.

Basic idea behind the massive MIMO hybrid structure that can mitigate the problem of power density dissipation.

III. Channel Modeling and Precoding

MIMO Channel modeling is an integral part of the design process. Hence it is very essential to examine and comprehend current *MIMO channel models*.

Precoding is a method that exploits transmit diversity by weighting the information stream, that is the transmitter sends the coded information to the receiver to achieve pre-knowledge of the channel. The receiver is a simple detector, such as a matched filter, and does not have to know the channel state information

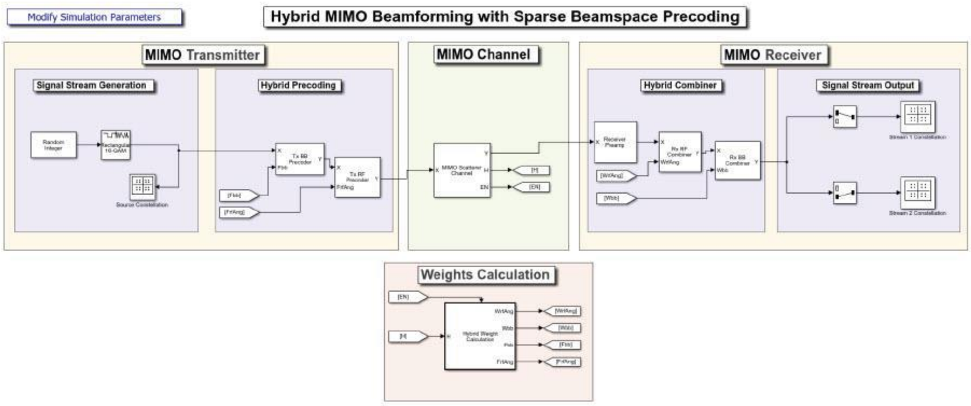

Figure 3. Hybrid beamforming architecture.

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IV. Antenna Arrays Design

In order to design the phased array antenna design is about to start with number of microstrip antennas with characteristics. Later the uniform linear array which consist of min 8 elements in the deisgn. Phased array toolbox in the Matlab which support to build the larger arrays.

Design of antenna element resonant at the desired frequency. Spacing between the elements of an array to minimize the coupling and grating lobes. The resulting structure along with radiation pattern can be depicted as follows:

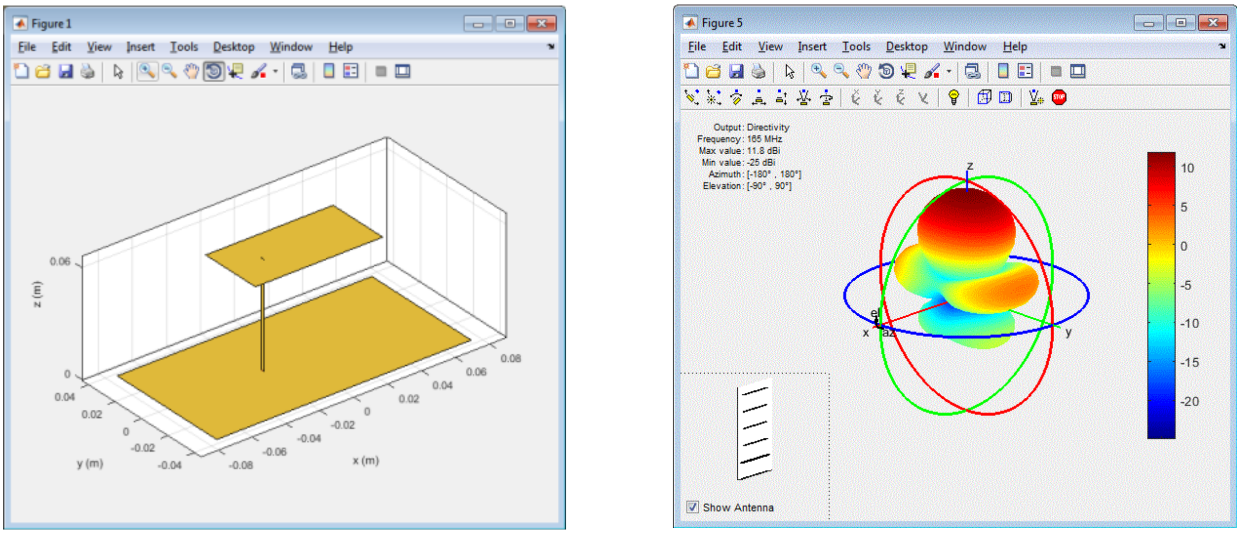

Figure 4: Array Element and Radiation pattern.

Once the design of array with designed properties met the standard then the design can be tested and compared with reference data.

Visualization and Analysis of antenna data can be viewed as shown in the figure 5.

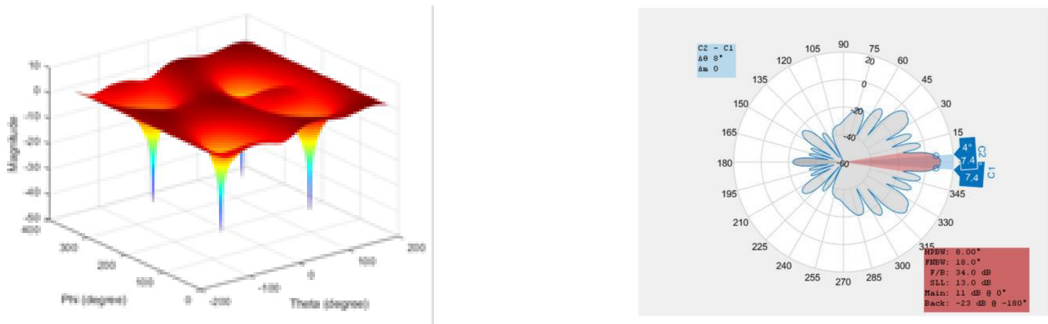

Figure 5: Analysis of the phased array design with its radition pattern

As discussed in the second section Hybrid beamforming can be done at two statges and two types as well one in which the Phase shifters are used at front end known as RF beamforming. Another way is digital beamforming or digital filtering of baseband signal.

V. Design of RF fromt end

Using RF budget analyzer it implements power and noise analytical computations along with it accounts the impedance mismatches. In the toolbox provided by Matlab you can also design the RF circuit envelop and testbenches. The typical design of RF front end to export them as blockset is shown in figure 6.

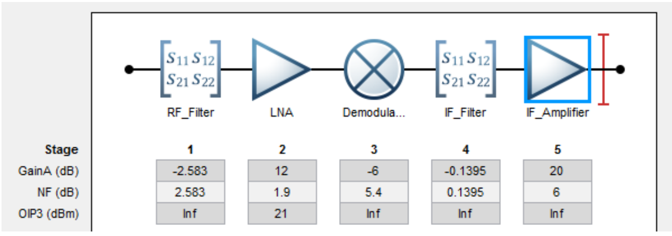

Figure 6. RF front end using RF budget analyzer.

VI. Optimization Techniques to Improve the Beam Pattern

As of now the design is focused only to the specific configuration. Now let realize how the array element tapering and element spacing can be adjusted to achieve the preferred performance for a hybrid beamforming arrangement.

This Process includes following steps as follows:

Step 1: Desired initial beam pattern

Step 2: Build cost function to drive desired pattern attributes

Step 3: Specify the constraints to be considered.

Step 4: Run through optimization toolbox

Step 5: Generate element taper, element positions and subarray partitioning

Step 6: Extend across the steering angles, frequency and phase shift quantization's.

VII. Results

In this section let look into the performance assessment of the phased array system in receiver response and interference along with steer view of the design. There are several methods to imagine the link-level performance, together with the constellation diagrams as depicted in the figure

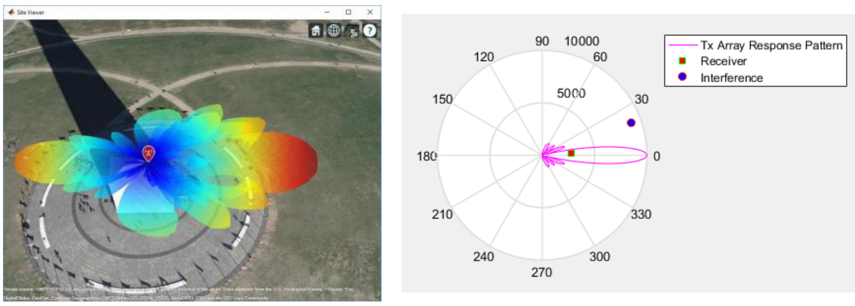

Figure 7: Steer view and Transmitter array response pattern.

VIII. Conclusion:

This work exhibits a thorough investigation of cross breed shaft shaping Massive MIMO situation. Explicitly this paper examines about current situation with the examination and impediments which individuals are looking in the execution of cross breed pillar shaping in mm-wave Massive MIMO framework. In 5G designs the massive MIMO and RF architectural components are considered as critical components. Development of this hybrid beamforming and algorithm evaluation is the very initial stage to meet the requirements of future wireless communication standards. Whatever the performance assessed here is only with the sample values of steer angle and channel combinations. The subsequent element patterns can be directly implemented in advance complex array designs. With the proposed design can cover the radiation pattern upto 4 times of the current antenna designs with more accuracy in reaching the receiving antennas.

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