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# Digital Beamforming For OFDM 3D Radar

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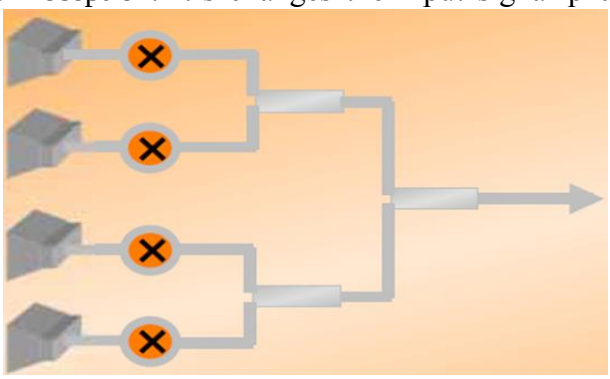
**Abstract:** Digital beamforming allows to analyze the all beams simultaneously. The implementation of digital signal processing for this challenge we used the FPGA, because the FPGAs can proceed parallel processing. We have created the 8 beams and 3 modes for 3D OFDM Radar. The mode names are Normal, Offset and Mono, which are used for different Radar applications. For DBF (Digital Beam Formation) we have used 4 antennas and each of that has 5 rectangular patch elements. The type of feeding for these antennas is serial. To achieve better side lobe level the rectangular patch sizes are modified by Dolph-Chebishev function. The receiver antenna array beam-width in azimuth plane is 25° and in elevation plane is 60°.

**Keywords:** Digital beamforming, directional transmission, discreet phase shifter.

## 1. Introduction

The beamforming is the signal processing technique which used for directional transmission or reception. It's changes the input signal phase for every antenna which force to move the beam direction. There is two methods of Beamforming that are realized for modern Radars.

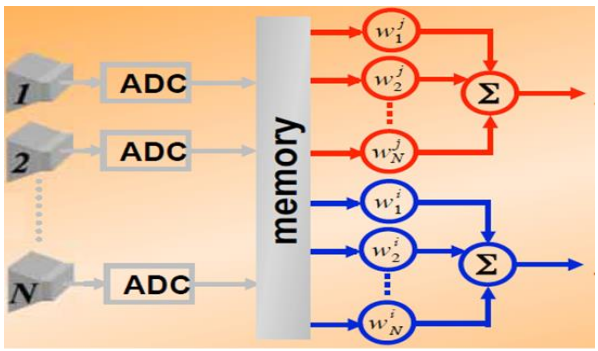


1) First method is the analog Beamforming (Figure1):

In this case the signal phase controlled by discreet phase shifters. This technic has a lot of disadvantages. It cannot reach fast scanning rate because the beam formation proceed by the serial way. Antenna array feeding line becomes massy, which cause to the complexity. The phase shifters with good accuracy is so expensive and that increase the system cost, additionally, they adds the noises in RF tract, which cause to loss of information.

**Figure 1:** Analog Beamforming

2) Second method is the digital Beamforming (Figure 2):




This technique performs the space filtering by using the DSP. In this case, the signal processing is realizing in digital world and that means we can use the parallel signal processing and scan all beam positions simultaneously. In the analog beamforming, we had discrete beam positions but in this technic, the DSP allows to change the input signal phases continuously.

**Figure 2:** Digital Beamforming

In the Radar systems we have the strongly fixed time period to scan elevation and azimuth. The energy equation is:

$$E = Pt$$

where $E$ is energy, $P$ is power, $t$ is time.

Front this equation clearly shown that we can win in the energy by decreasing the processing time.

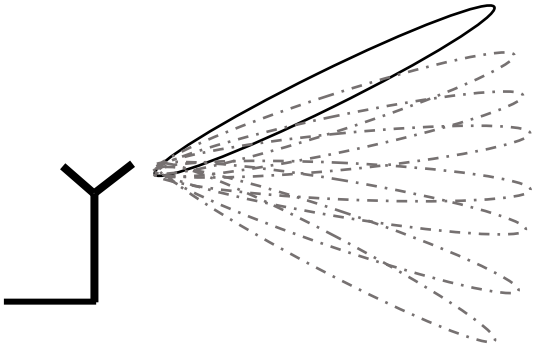


**Figure 4:** Serial processing

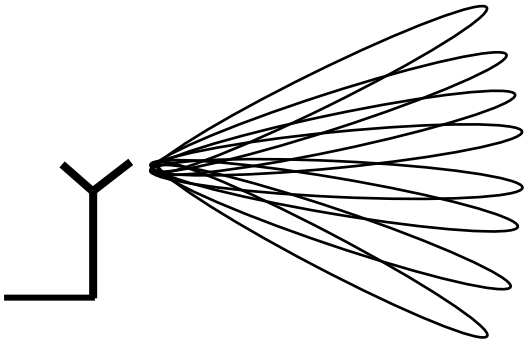


**Figure 3:** Parallel processing

In the Figure 3 and 4 shown the serial and parallel beamforming implementation visualization.

## 2. Implementation

The digital beamforming techniques have implemented for small RADAR prototype. Practically there is need to create several Tx beams which are shown in the Figure 6. The Tx beam is wide and has a fan-shaped pattern. This type of radiation pattern build by using antenna array Figure 5. The antenna spacing is larger then wavelength size.

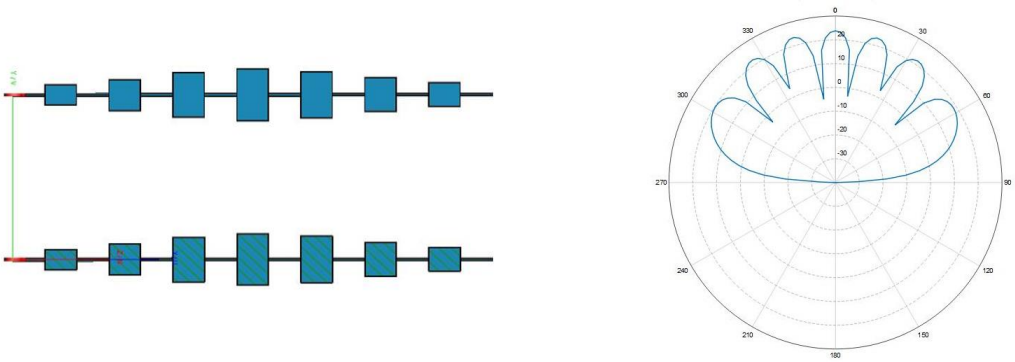


**Figure 5:** Transmitter antenna and radiation pattern

With phase shifters has an opportunity to change radiation pattern form and get different modes. First mode is the Normal mode. This is the default operational mode. Second mode is the High elevation mode. This mode used to detect close and high objects. The third mode cold Long-range mode. The radiation pattern mainly concentrated on front to detect the targets, which are far from RADAR.

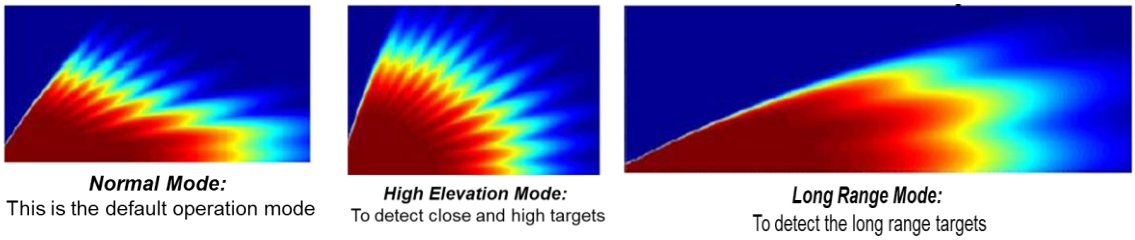



**Figure 6:** Three implemented modes for 3D OFDM Radar

Receiver part consist of 4 antenna array lines. By using Dolph-Chebyshev function for element size, the side lobe level increases. With this way the main lobe level become expressed, and scanning process getting easy. The total gain is $20DBi$, radiation pattern size in $E$ and $H$ plane approximately equal to 26 and 13 degrees (Figure 7).

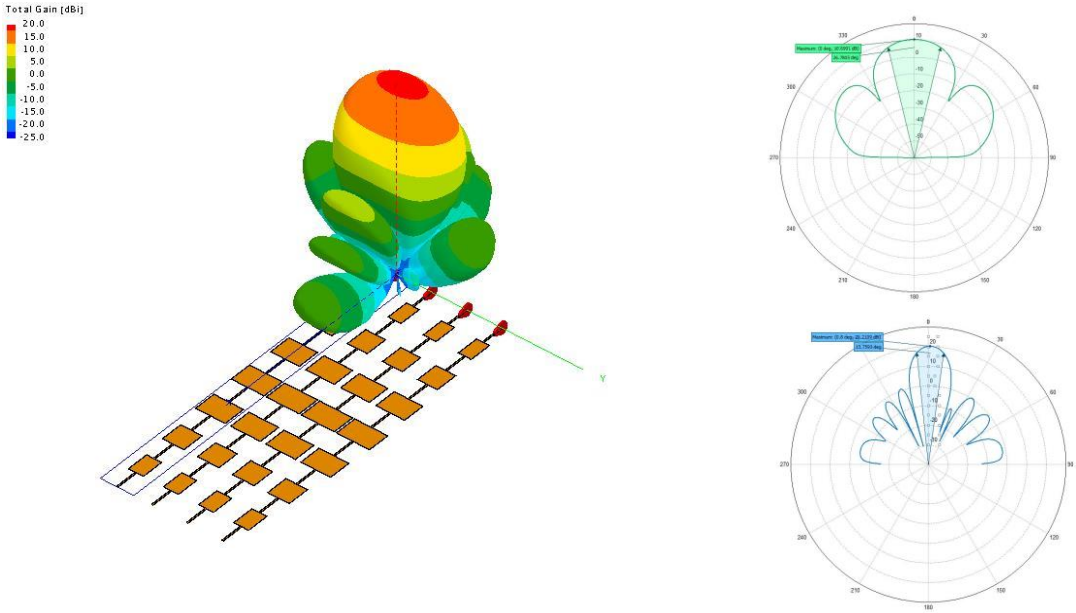



**Figure 7:** Receiver antenna radiation pattern

In the Receiver side, we have created 3 modes. First mode is the "Normal Mode". In this mode beams distributed equal in whole field of view. Second mode is called "Offset Mode". This mode was developed to concentrate beams in one sector of filed of view to achieve more accuracy. Third mode is most valuable mod and called "Mono Mode". This mode used for elevation high accuracy measurements and target tracking.

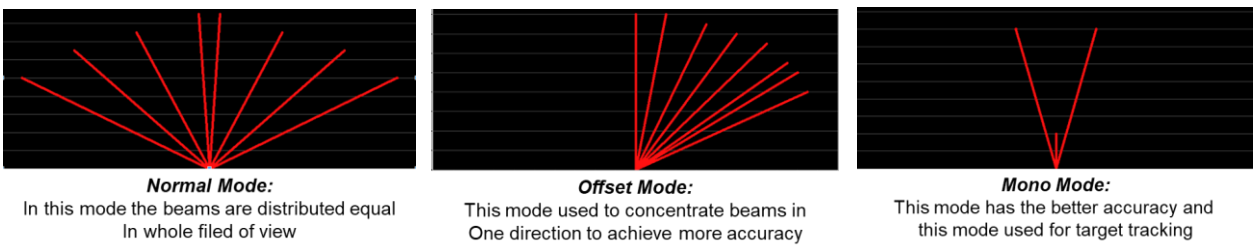



**Figure 8:** Receiver antenna Modes

## 3. Conclusion

- Based on digital Beamforming different type of antenna operation modes has been implemented which allows to use that in different Radar applications.
- Digital Beamforming well suitable for OFDM signals because the both of them based on matrix DSP.

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