Implementation of Blind Adaptive Beamforming Algorithms

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Abstract— Beam forming is an array signal processing which increases signal to interference-noise ratio (SINR) by mitigating co-channel interferences present in wireless mobile cellular system. In this paper presents importance of beam forming technique for next generation broadband wireless mobile systems. Beam forming is a powerful means of increasing capacity, data rates and coverage of the cellular system. In beam forming technique, Delay of sum, Minimum variance distortion less response (MVDR) and Generalized Side lobe Canceller are presented. In this paper LMS algorithm can be applied to MVDR application. This is called LMS-MVDR has the capability of interference nulling. The amplitude response of LMS-MVDR will suppress the interfered signal and have the target amplitude held at 0db.Moreover, the amplitude response can be improved by increasing the number of Iterations(snapshot),Increasing the interference to target signal ratio, The spatial power spectrum MVDR shows the power incoming signals but it tries to maximize the interference signal instead of suppressing .The drawback is the target signal can be overpowered by the interference in the MVDR power spectrum.

Key words: Adaptive beam forming, Smart antenna, minimum variance distortion response.

I. INTRODUCTION

In wireless communication, beam forming is a highly used technique that improves antenna gain and eliminates the interferences. . In these circumstances, the needed signals transmit power is reduced. In traditional beam forming method analog devices are used and they require a lot of customized electronics hardware. Thus, the beam forming implementation costs have been high-priced. In case of digital beam forming, the signal processing is performed through software which significantly increases the flexibility. Moreover, since electronics are commercial off-the-shelf, expenses of digital beam forming utilities are insignificant comparing to convention. Although the development of the digital beam forming has been a point of interest for the last 50 years, today we discover its utility in being the solution in many contemporary and forward looking challenges.

Wireless technology is a very dynamic research and innovation field. The 4th generation mobile communication systems are still looking for feasible approaches for a better power control, suitable spectrum access, intra and interbase solution interference cancellation. Also, the satellite communication technology is in progress and with this incredible increased number of users needed better solutions for its goals.

The sonar systems are known for using digital beam formers, but there are still some needs in quantizing time delays, detecting and modeling the target echo in real-ocean environments.

In the military domain, having digital beam forming as one of its features, the new radar systems placed on satellites answer some complaints about military ballistic missile defense systems, or make new spy and environmental monitoring missions possible from orbit.

II. SMART ANTENNA CONCEPT

A smart antenna is a unit of a wireless communication system. The smart antenna concept is defined as an antenna array with a digital signal processing capability to operate in an adaptive approach. Also, smart antennas are known as adaptive array antennas or multiple –input multiple-output (MIMO) system. Their main ability is to determine the direction of arrival (DOA) of the signal, and further on to compute the weights for the digital beam forming process. A smart antenna can automatically modify its radiation pattern as a feedback to the electromagnetic environment. This can improve the performance properties of the wireless system that the smart antenna serves.

Depending on the beam forming strategy, there are switched beam smart antennas and adaptive array smart antenna. Adaptive array is the most advanced smart antenna technology. With proper signal-processing algorithms the antenna is capable to dynamically maximize the desired signal reception by steering the beam to any direction of interest and also by annulling the undesired signals.

III. ADAPTIVE BEAMFORMING

Digital beam forming uses different methods according to multiple criteria. Important criterions are in this case the type of application where beam forming is required, the signal processing speed needed the angle of arrival of the incoming signals, the complexity of the algorithm. Also, considering these criterions, there are multiple theoretical classifications.

Reflecting about the angle of arrival of the incoming signals, the techniques used for the digital beam forming can be group into fixed beam forming approaches and adaptive beam forming algorithms .If the arrival angles don't change with time, the optimum array weights won't need to be adjusted. In this case, for the fixed arrival angle emitters, the fixed beam forming approaches are to be applied. If the desired arrival angles change with time, it is necessary to design an optimization scheme that operates continuously to keep recalculating the optimum array weights. The receiver signal processing algorithm then must allow for the continuous adaptation to a permanently –changing electromagnetic environment ,The fixed beam forming process is out –of -the date and the adaptive

algorithm is embraced for its ability to calculate the continuously updated weights. The adaptation process must satisfy a specified optimization criterion.

Beam forning is a signal processing technique used in sensor arrays for directional signal transmission or reception. This spatial selectivity is achieved by using adaptive or fixed receive/transmit beam patterns. The beam pattern is formed by adjusting complete weights of the antenna elements so that beam is directed in the direction of interest. When receiving, information from different sensors is combined in such a way that the expected pattern of the radiation is preferentially observed. Thus receive beam forming increases the sensitivity in the direction of desired user than that of interferences. When transmitting, a beam former controls the phase and relative amplitude of the signal at each transmitter ,thus produces a high directional beam in the direction of the desired user and null in the direction of interferences , thereby increasing SINR of the desired user and reducing the wastage of the transmitted power in the undesired direction. The receive beam forming is achieved independently at each receive while in transmit beam forming; transmitter has to consider the all receivers to optimize the beam former output.

Thus beam forming antenna produces high directional beam in the direction of intended user, thereby increasing SINR and coverage area. This paper presents the LMS algorithm can be applied the MVDR application. This is called the LMS-MVDR has the capability of interference nulling. The amplitude response of LMS-MVDR will suppress the interfered signal and have the target amplitude held at 0db.

The spatial power spectrum MVDR shows the power incoming signals but it tries to maximize the interference signal instead of suppressing. The drawback is the target signal can be overpowered by the interference in the MVDR power spectrum.

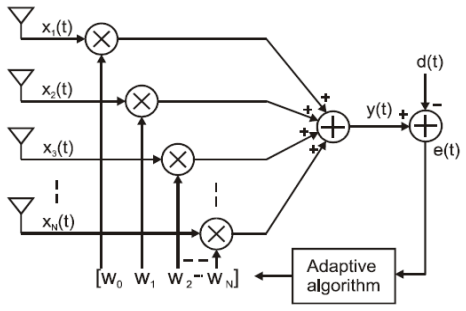

Fig. 1: generic adaptive beam forming system

Usually In wireless communication systems single element antenna like dipole, spiral, horn yagi-uda etc are prevalent. Characteristics of such antennas are fixed for a particular feed current and band of frequency. Although their characteristics change with feed current and operating frequency. To get high directivity, narrow beams, low side-lobes, steerable beams, particular radiation patterns a group of antenna elements called array or simply array is used. Application of array antenna with system with adaptive beam forming provision lies in a mobile cellular and satellite communication to enhance the capacity of wireless link based on space division multiple access technique.

The purpose of beam forming is to form a multiple beams towards desired users while nulling the interferers at the same time, through the adjustment of the beam former's weight vectors. It is the process of altering the complex weight on-the-fly to maximize the quality of the communication channel. Fig.1 shows a generic adaptive beam forming system which requires a reference signal.

The signal x(t) received by multiple antenna elements is multiplied with the coefficients in a weight vector 'w' which adjust the phase and amplitude of the incoming signal accordingly. This weighted signal is summed up, resulting in the array output, y (n). An adaptive algorithm is then employed to minimize the error e(n) between a desired signal d(n) and the array output y(n).The complex weights w for the antenna elements are carefully chosen to give the desired peaks and nulls in the radiation pattern of the array. The weights could then be slowly varied to steer the beam until maximum signal strength occurs and the direction to the signal source is found.

IV. RESULTS

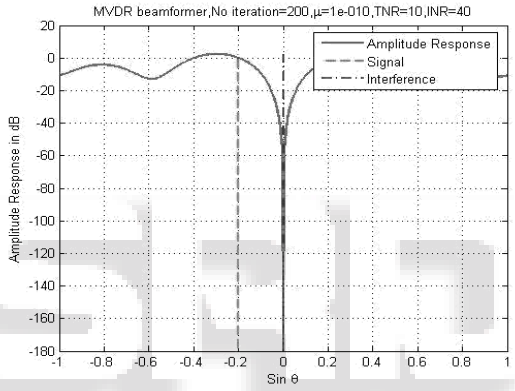

Fig. 2: displays varying number of iterations

Figure2 displays varying number of iterations with all the other parameters remain the same (INR and TNR are help fixed at 20 and 10 db respectively).The interference nulling capability is better as the higher number of iteration.

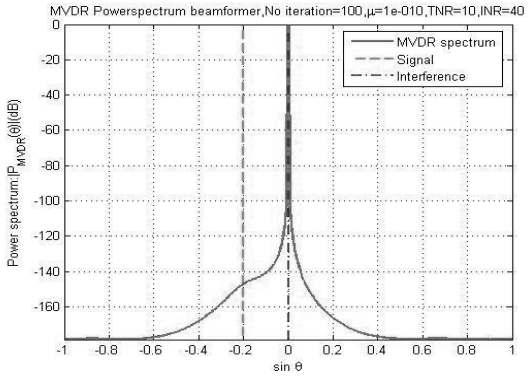

Fig. 3: Graph for MVDR power spectrum

At this point, we can see that if the interference to target ratio increases, the MVDR power spectrum yields the poor response compare to LMS-MVDR amplitude – response. This is become the MVDR power spectrum does not have interference nulling capability like LMS-MVDR .Actually the MVDR power spectrum strongly depends on the target signal –to- noise ratio.

V. CONCLUSION

Depending on the beam forming strategy, there are switched beam smart antennas and adaptive array smart antenna. Adaptive array is the most advanced smart antenna technology. With proper signal-processing algorithms the antenna is capable to dynamically maximize the desired signal reception by steering the beam to any direction of interest and also by annulling the undesired signals.

Moreover, the amplitude response can be improved by:

1) Increasing the number of Iterations(snapshot)
2) Increasing t
3) His interference to target signal ratio.

The Spatial Power spectrum MVDR shows the power incoming signals but it tries to maximize the interference signal instead of suppressing. The drawback is the target signal can be overpowered by the interference in the MVDR power spectrum.

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