SMART ANTENNA DESIGN TECHNIQUES FOR ULTRA-WIDEBAND COMMUNICATIONS

by

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na - Design and construction

Certificate

This is to certify that the thesis titled "**Smart Antenna Design Techniques for Ultra-Wideband Communications**" being submitted by **Mrs. V. V. Mani** for the award of Doctor of Philosophy is a record of bona-fide work carried out by her under my guidance and supervision at the Department of Electrical Engineering, Indian Institute of Technology, Delhi. The work presented in this thesis has not been submitted elsewhere either in part or full, for the award of any other degree or diploma.

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Abstract

Ultra-wideband (UWB) technology, based on transmission of short duration pulses, has gained much interest for its application to wireless communications. Because of the extremely large bandwidth, UWB is currently considered as a physical layer solution for high data rate, short range wireless networks. However, high user density, multipath fading and interference lead to serious issues, resulting in the degradation of bit error rates (BER). To combat these problems and to achieve higher capacity, smart antenna systems with adaptive beamforming capability are very effective.

In this thesis, we have studied the feasibility of using smart antennas at the receiver for UWB communication. We present several novel ways of looking at the problem of UWB Direction of Arrival estimation (DOA) and beamforming via Uniform Linear Array (ULA).

We begin with the preliminary study of UWB communication system and the performance of Rake-Receivers of DS-UWB for the different IEEE channel models. We next examine the problem of UWB impulse beamforming using smart antennas, when the desired signal and several interferences from different directions are received by the antenna array. The proposed UWB smart antenna points its main beam towards presteered direction of the array and suppresses interference and noise coming from other than the look direction of the array. We also analyze the signal to interference noise ratio (SINR) of the array for different interference directions.

We, next look at the problem of the estimation of DOA's of multiple superimposed UWB signals with multipath arrivals in additive white gaussian noise when arrived at ULA. In order to generalize narrowband DOA algorithms to UWB, signals are first decomposed into narrowband signals by using discrete Fourier transform. Then this spatial- temporal data at the output of a ULA is formulated to obtain the exact expression for the Maximum Likelihood (ML) criteria in terms of the prediction polynomial. This polynomial has embedded DOA information. Methods like Iterative Quadratic Maximum Likelihood (IQML) and its modification are suitably applied for obtaining

the coefficients of this polynomial. Rooting of this polynomial yields DOA estimates of coherent UWB signals. Performance of the proposed method is evaluated via computer simulations.

In the remainder of the work we look at the optimum beamforming for the coherent UWB signals. It is shown that ULA space-time data provides an appropriate framework for formulating three different types of optimum beamformers for the UWB sources viz., the optimum combiner beamformer, the optimum notch or null steering beamformer, and the optimum interference-plus-noise rejector beamformer, all based on IQML estimation of the generating polynomial. Simulation results shows that they are able to handle correlated sources and interferences, without the need for pre-processing techniques like spatial smoothing.

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