SPACE-TIME TRELLIS CODES FOR ULTRA-WIDEBAND MULTIPLE-INPUT MULTIPLE-OUTPUT (MIMO) COMMUNICATIONS

by

ANSHUL TYAGI

DEPARTMENT OF ELECTRICAL ENGINEERING

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1. Wireless C

2 MIMO Communication

Dedicated to my beloved parents

Certificate

This is to certify that the thesis titled **"Space-Time Trellis Codes for Ultra-wideband Multiple-Input Multiple-Output (MIMO) Communications"** being submitted by Anshul Tyagi to the Department of Electrical Engineering, Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy, is a record of *bona-fide* research work carried out by him under my guidance and supervision. In my opinion, the thesis has reached the standards fulfilling the requirements of the regulations relating to the degree.

The results contained in this thesis have not been submitted either in part or in full to any other university or institute for the award of any degree or diploma.

Ranjan Bose

Dr. Ranjan Bose

Associate Professor

Department of

Electrical Engineering

Indian Institute of Technology

New Delhi-110 016

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Tyagi

New Delhi

Anshul Tyagi

Abstract

Wireless systems continue to pursue even higher data rates and better quality. Ultra-wideband (UWB) and multiple-input multiple-output (MIMO) systems are two promising techniques to achieve this objective. Because of their unique advantages, like, low power, high rate, immunity to multipath propagation, less complex transceiver hardware and low interference, UWB systems have been considered as a physical layer solution for very high rate, short range wireless personal area networks (WPANs). Similarly, MIMO systems with space-time (ST) coding have made large performance gains possible in practical wireless systems.

Under the coexistence principle, UWB systems face severe restrictions on the peak transmitted power. In order to boost the error performance of UWB systems, the use of space-time coded MIMO systems in combination with UWB systems has recently attracted the attention of researchers in wireless communications.

Space-time coding, a new coding paradigm, aims at extracting the total available spatial diversity in the MIMO channel. Of the two kinds of space-time coding schemes, namely, space-time block codes (STBC) and space-time trellis codes (STTC), STTC hold the potential of much better performance than STBC.

In this thesis, we investigate the design and performance of STTC for UWB MIMO systems. More specifically, we derive the design criteria for optimal STTC for UWB MIMO systems for three different modulation schemes, viz. M-PAM (pulse amplitude modulation), M-PPM (pulse position modulation) and MN-ary PPAM (pulse position amplitude modulation: a combination of M-PAM and N-PPM). The

design criteria are deduced from upper bounds on average pairwise error probability, obtained through performance analysis. For *M*-PPM and *MN*-ary PPAM, new communication distance notions are introduced and novel design criteria are developed.

Based on the design criteria, an optimal STTC is handcrafted for binary-PAM and binary-PPM. For 2,2-ary PPAM, an STTC is constructed using set partitioning based on the new distance notion introduced.

Simulations of the handcrafted STTC are carried out in a UWB communication system for both slow fading and fast fading multipath channels. Significant improvement in BER performance of the handcrafted STTC is observed vis-à-vis uncoded SISO system and also vis-à-vis previous ST coding schemes for UWB.

Contents