Abstract

In a wireless communication system employing multiple transmit antennas Space-Time Codes (STCs) are used to provide the the receiver with replicas of the transmitted signal with independent fades, in the form of redundancy in the spatial and temporal domain, and thus provide diversity benefits. The spatial redundancy is provided using multiple transmit antennas. The coding gain of a Space-Time Code is defined as the advantage in SNR that we get over an uncoded system offering the same diversity. We have two approaches for designing STCs, the block and trellis coding approach. The STCs so designed are respectively called, Space-Time Block Codes (STBCs) and Space-Time Trellis Codes (STTCs). The coding gain of STBCs are very poor, though they provide diversity benefits. The advantage of STTCs over STBCs is that it achieves both the diversity and coding gain benefits. Thus we need formal techniques to construct STTCs that achieve full-diversity and good coding gain.

By increasing the number of states of an STTC, we can get more coding gains. Many attempts have been made to construct STTCs which achieve full-diversity and good coding gains, though a general method of construction does not exist for a given number of antennas and state complexity. The delay diversity scheme (rate-1), is known to achieve full-diversity, for any number of transmit antennas and any signal constellation, but does not give a good coding gain. It is known that a product distance code based delay diversity scheme enables one to improve the coding gain.

In this work we argue out that a particular kind of trellis called the cyclic trellis is optimal for designing STTCs. We propose a shift register model for a time invariant cyclic trellis. We use this shift register model to construct STTCs. We first derive a sufficient condition for full-diversity of STTCs based on the shift register model, based on the delay diversity scheme. This sufficient condition allows one to construct STTCs, for arbitrary number of antennas, state complexity and signal constellation. Using the sufficient condition derived, we provide a formal rate-1 STTC construction technique, for arbitrary number of transmit antennas and state complexity, over PSK signal sets, which
achieves full-diversity and give a good coding gain. We obtain a class of STTCs from our construction, for a given state complexity. We show that certain STTCs that exist in the literature can be derived as special cases of our construction technique. We finally study the performance of the STTCs over a quasi-static Rayleigh flat-fading channels.