

Development of IP core for Trellis Coded Spatial Modulation Scheme

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Abstract - In this paper, VHDL coding of Trellis coded spatial modulation (TCSM) scheme is presented. Here the concept of a novel multiple antenna transmission technique, called Spatial Modulation (SM) is used. SM entirely avoids the inter channel interference (ICI) at receiver, requires no synchronization between the transmitting antenna and avoids correlation between them. It also increase the spectral efficiency. SM maps a block of information bits into a constellation point in the signal as well as spatial domain. The spatial domain corresponds to a particular antenna number. In SM at a time only single antenna transmit a data. The receiver estimate both transmitted data and antenna number and use this information to reconstruct the transmitted data. Also the concept of Trellis coded modulation (TCM) applied to SM which is known as Trellis coded spatial modulation is used. In TCM only certain sequences of successive constellation points are allowed.

KeyWords: Spatial Modulation, Trellis coded modulation.

1. INTRODUCTION

The need to improve the spectral efficiency and reliability of radio communication is driven by ever increasing requirement for higher data rates and improved Quality of Service across wireless links. Higher data rate and better spectral efficiency are most important in next generation mobile communication. Today, Mobile communication faces two main challenges:

1. At a moment total traffic of mobile network doubles every year.

In order to fulfil that we have to allocate more radio frequency spectrums to this network, but we don't have that spectrum available. One way to solve this issue by making this system more efficient i.e. more spectrum efficient which means it transmit more bit/Hz/bw.

2. 2nd challenge is to make this system more energy efficient.

At a moment, about 1.5 million cellular radio base station worldwide and this base station consumes a lot of energy. The amount of energy consume by this base station is a power equivalent to or comparable to entire Air traffic. So we can say that wireless communication system has limited power and bandwidth resources. To increase spectral efficiency MIMO technique is used. In MIMO at a time more than one antenna transmit signals. So there is a possibility of Inter channel interference. Also it requires synchronization between transmitting antenna. So to overcome this a new technology introduced which is known as Spatial Modulation.

In this paper the VHDL coding simulation result of Trellis coded spatial modulation (TCSM) scheme is presented.

2. SPATIAL MODULATION

Spatial modulation is a new modulation technique which is used to transmit extra information bits without transmit that bits. It uses multiple transmit antenna to convey extra information bits. Extra information is encoded into physical location of antenna. In SM, at any particular time instants only one antenna is active. The other antenna radiates zero power. So it required only single RF chain. Therefore, synchronization between transmit antenna is not required. Also the ICI at the receiver is completely avoided. SM maps a block of information bits into a constellation point in the signal as well as the spatial domain. The spatial domain corresponds to a particular antenna location. The basic idea is to map a block of information bits to two information carrying units:

1. A symbol that is chosen from a complex signal constellation diagram,
2. A unique transmit antenna index that is chosen from the set of transmit antenna in the antenna array.

The SM system for two transmit antenna is shown in fig. 1. $Q(k)$ is $n \times m$ binary matrix to be transmitted. Here the bits are partitioned into group of 3. The first bit of vector is used to select antenna and other two bits are transmitted from that antenna. For example an initial three-bit input sequence of 0 1 0 is mapped to ant1 because 1st bit is 0 and other two bits 1 0 transmitted from antenna 1. Here QPSK modulation technique is used. So 1 0 is mapped to symbol $1-i$. Similarly, for bit sequence 1 1 1 ant2 is selected and transmitted symbol is $-1-i$.

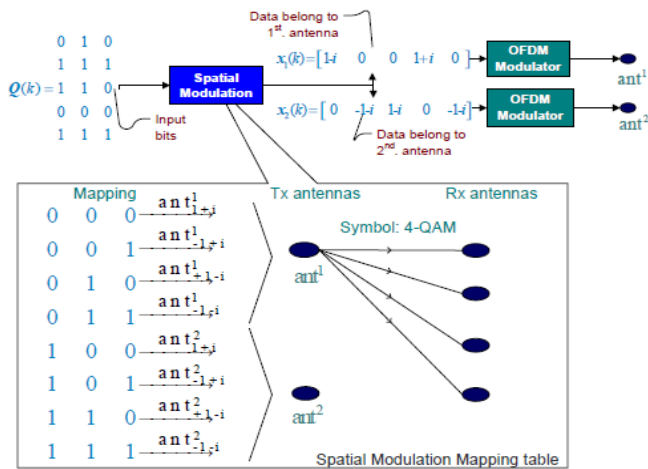


Fig -1: SM mapping table for 2-Tx antenna

2.1 TCSM System Model

TCM is a modulation scheme which allows highly efficient and reliable digital transmission without bandwidth expansion or data rate reduction. TCM combines the function of convolutional encoder of rate $R = k/(k + 1)$ and M-ary signal mapper that maps $M = 2(k+1)$ constellation points. In TCM, unlike conventional coding only certain sequences of constellation points are allowed. The key idea is to group symbols into sets of equal sizes where each set maximizes the free distance between its symbols. The key idea of TCM is applied to antenna constellation point of SM. This novel concept is known as "Trellis Coded Spatial Modulation" (TCSM). In TCSM, the transmit antennas are partitioned into sub-sets in such a way that the spatial spacing between antennas in the same sub-set is maximized. Therefore, the effect of correlated channels on the performance of SM is reduced. The performance of the proposed idea is analyzed in the presence of Rician fading and spatial correlation (SC) channels and major enhancements in BER is reported as compared to SM and V-BLAST with the same spectral efficiency.

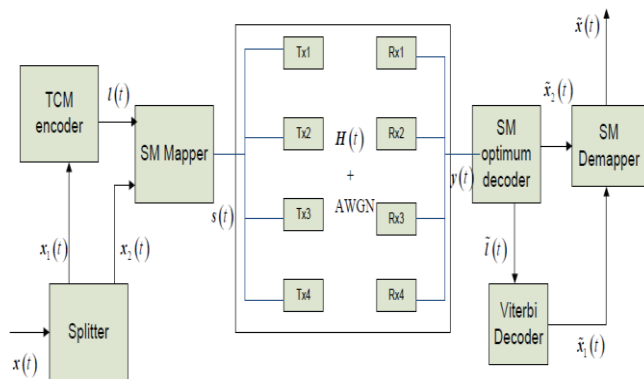


Fig -2: TCSM system model

Fig. 2 describes the TCSM system model having 4 transmit antenna. At a time only single antenna transmit a signal. The model contains splitter, encoder and mapper at both sides. The working of each block is as follows:

1. Splitter:

Splitter splits the data i.e. it divides the bits into two parts. Then one is given to TCM encoder and other is given to SM mapper.

2. TCM encoder:

TCM encoder encodes the data that coming from splitter using convolution encoder of rate $R = 1/2$. The block diagram of convolution encoder is shown in fig. 3.

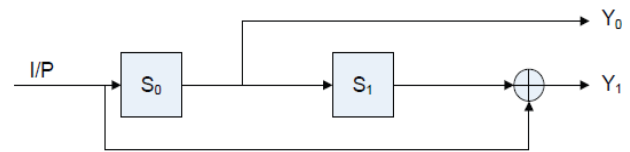


Fig - 3: Convolution encoder of rate R=1/2.

3. SM mapper:

The output of both TCM encoder and splitter is applied to SM mapper. Now first according to output of TCM encoder it selects the transmitting antenna and then transmits the bits coming from splitter from that antenna.

4. SM Optimum Decoder:

SM decoder decodes the received bits and also finds the transmitting antenna from which data bits are transmitted. Then the decoded bits are given to SM demapper and antenna number is given to viterbi decoder.

5. Viterbi Decoder:

Viterbi decoder used to decode the bits that are encoded using convolution encoder. Viterbi decoder use the concept of minimum hamming distance to find the information bits. The output is given to SM demapper.

6. SM Demapper:

SM demapper combines the output of both optimum decoder and viterbi decoder.

3. Simulation Results

The simulation result of encoder and decoder is shown in fig. 4 and fig. 5. Here first the bit sequence is divided into group of 3. Then only two bits are transmitted from each group and the third bit is retrieve at receiver by finding that data is coming from which antenna. So the efficiency increases linearly according to number of transmit antenna.

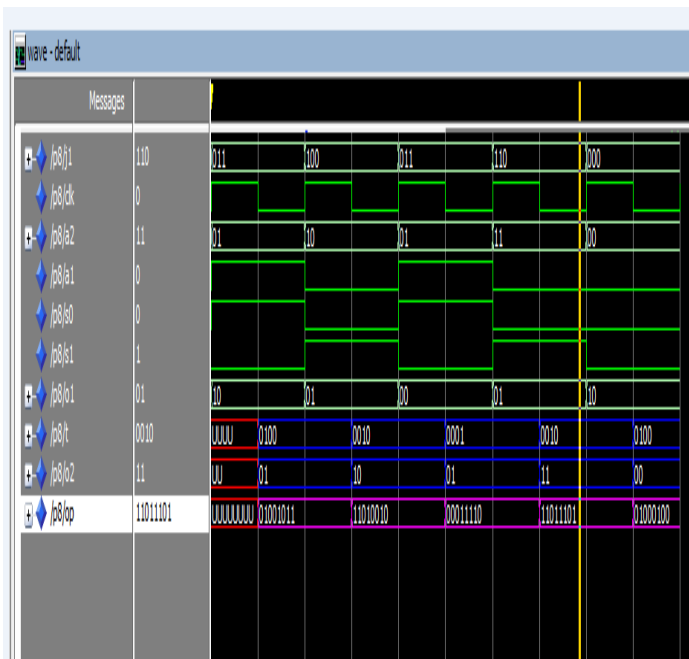


Fig – 4: Simulation result of encoder

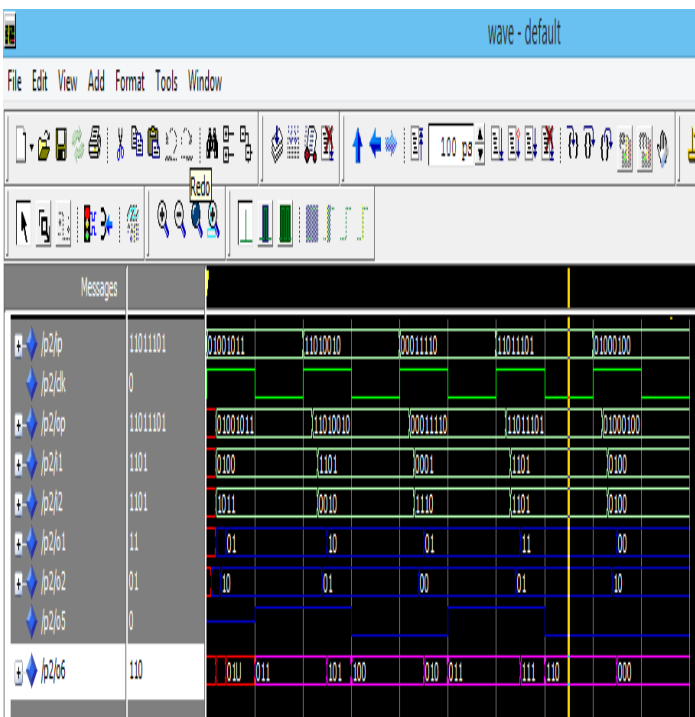


Fig – 5: Simulation result of decoder

4. CONCLUSIONS

Here the concept of SM is used to increase the spectral efficiency. Also the TCM is combined with SM i.e. TCSM is used to increase the system performance. It has been shown that SM increase the system efficiency by base 2 logarithm according to number of transmit antenna. While MIMO system increase spectral efficiency linearly.

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Biography



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