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Title	**A New Stream Mapping Rule for Vertically-Encoded STC System in IEEE 802.16m**
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Re:	IEEE 802.16m-07/040 - Responds to Call for Contributions on Project 802.16m System Description Document (SDD)
Abstract	A new stream mapping rule is proposed for the vertically-encoded STC framework adopted in IEEE 802.16 to enhance the link quality performance. The basic idea is to properly allocating the relatively more important systematic part of the coded bits to the better channel. Simulation results show that the new scheme can significantly outperform the mapping rule currently being used in IEEE 802.16 especially for the case of low coding rate.
Purpose	For 802.16m discussion and adoption
Notice	
Release	
Patent Policy	

A New Stream Mapping Rule for Vertically Encoded STC System in IEEE 802.16m

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1. Summary

This contribution introduces a block-wise stream mapping to enhance the error rate performance for IEEE 802.16m. Simulation results show that the new scheme provides a significant gain over the demux-based mapping currently used in IEEE 802. 16 system especially for a low coding rate. The method is simple and is easy to fit in the vertically-encoded STC framework adopted in IEEE 802.16.

Proposed Text

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X.X X. STC Data Stream Mapping for IEEE 802.16m

<note: the block-wise stream mapping rules for vertically encoded STC should treated as an alternative to the conventional stream mapping rules. Our study shows that the performance gain using a block-wise stream mapping rules, which is listed in Table 2, was observed to be better than conventional demux-wise stream mapping rules shown in Table 1 [1].>

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2. Introduction

This contribution describes a block-wise stream mapping rule for the vertically-encoded STC system based on the channel condition to enhance the error rate performance. The new scheme provides an attractive gain over the demux-wise mapping method currently used in the IEEE 802.16 OFDMA system. The new method can co-exist with the vertically-encoded STC framework adopted in the IEEE 802.16 OFDMA system.

3. Vertically Encoded STC System

Fig. 1 is the vertically-encoded STC system with MIMO precoding adopted in the IEEE 802.16 system. The convolutional turbo code (CTC) [1] using a double binary circular recursive systematic convolutional code, as is shown in Fig. 2. The input information bits (A, B) are first encoded via CTC as the systematic bits (A, B) and parity bits (Y1, Y2, W1, W2), each of which is then individually interleaved by the interleaver shown in Fig. 3. Next, the coded sequences (i.e., systematic part and parity part) are aggregated (A, B, Y1, Y2, W1, W2) and punctured to match the desired coding rate. After puncturing, all the coded bits are modulated as complex-valued symbols. The modulated symbols are then converted to multiple transmission streams via a stream mapper. Finally, these streams are precoded by a pre-designed matrix and transmitted from the multiple antennas.

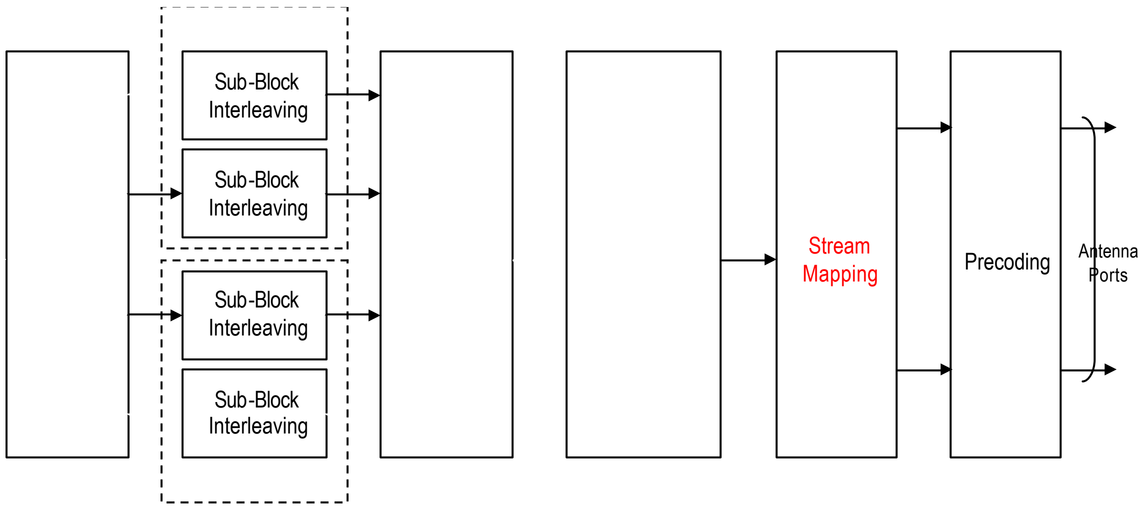

Fig. 1: A block diagram for vertically encoded STC systems with MIMO precoding.

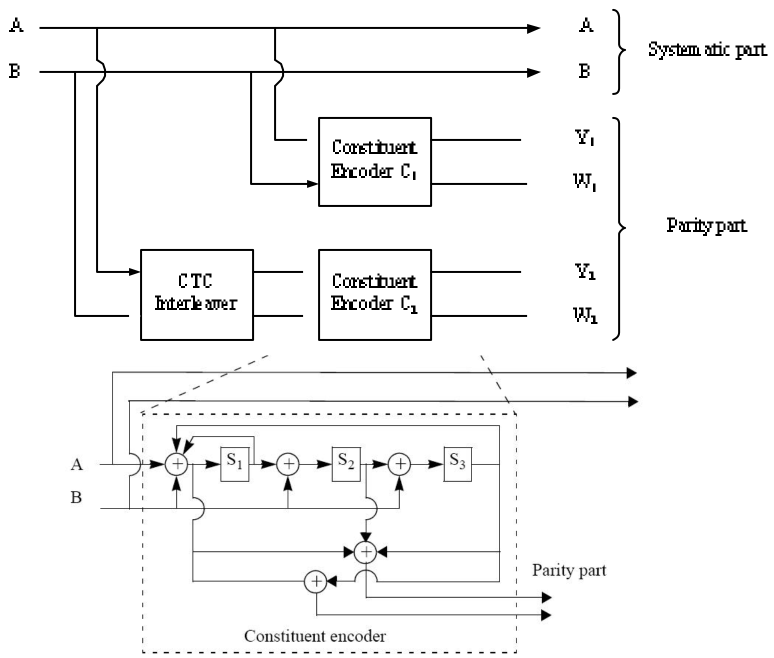

Fig. 2: CTC encoder [1].

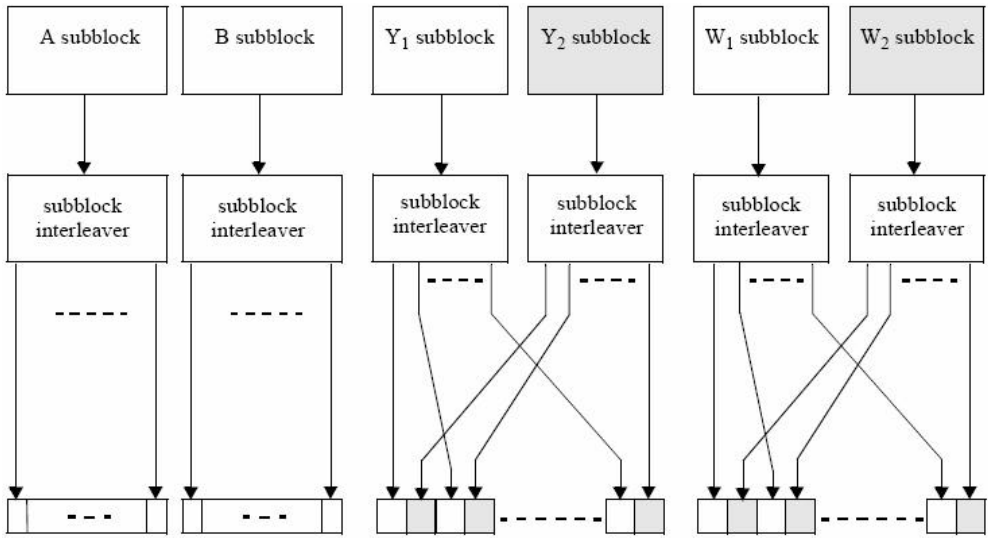

Fig. 3: Block diagram of the interleaving scheme [1].

4. Demux-Wise Stream Mapping

According to the current IEEE 802.16 standard, all the modulated symbols are serial-to-parallel converted to multiple streams by a demux-wise mapping (see Fig. 324 of [1]). Fig. 4 illustrates a demux-wise stream mapping example with $1/2$ coding rate over a 2×2 MIMO channel. It is noticed that in the demux-wise stream mapping, the modulated symbols are alternately mapped to the two streams as listed in Table 1 [1], each of which is passed through different channel. As shown in Fig. 4 and Table 1, the systematic part of the coded bits is distributed evenly over the two channels, where one channel could be much worse the other. If this is case, the performance will be dominated by the worse one, especially half of the relatively more important systematic part of coded bits is placed on it.

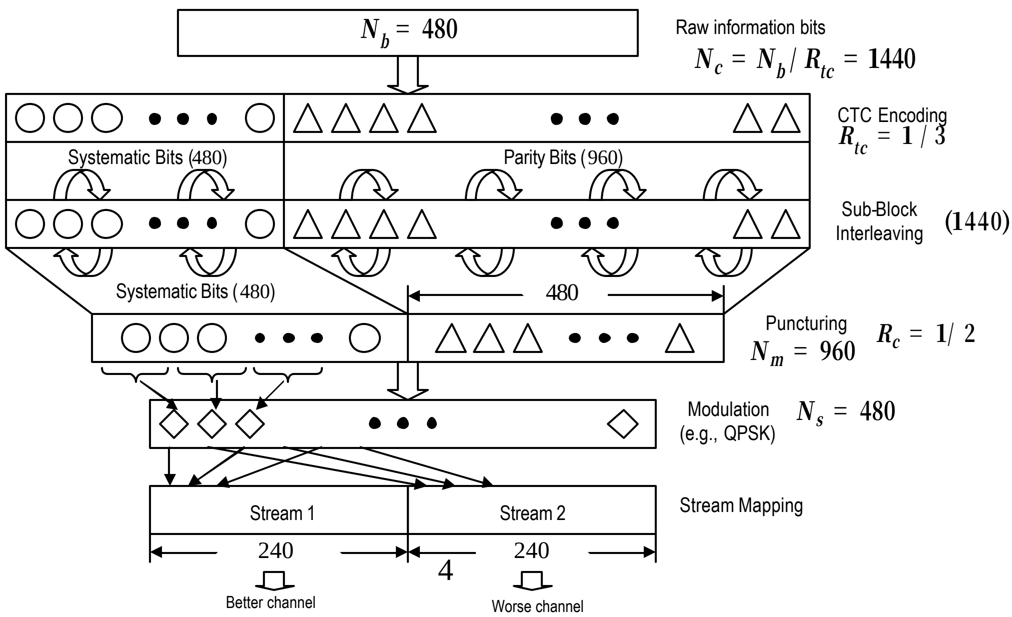

Fig. 4: A demux-wise stream mapping example for vertically encoded STC system in current IEEE 802.16 standard.

Table 1: Symbol allocation for vertically encoded STC system with two transmit antennas in current IEEE 802.16 standard [1]

	Antenna 0		Antenna 1	
	Even Symbol	Odd Symbol	Even Symbol	Odd Symbol
Subcarrier 0	S0	S48	S1	S49
Subcarrier 1	S2	S50	S3	S51
Subcarrier 2	S4	S52	S5	S53
Subcarrier 3	S6	S54	S7	S55
Subcarrier 4	S8	S56	S9	S57
Subcarrier 5	S10	S58	S11	S59
Subcarrier 6	S12	S60	S13	S61
Subcarrier 7	S14	S62	S15	S63
Subcarrier 8	S16	S64	S17	S65
Subcarrier 9	S18	S66	S19	S67
Subcarrier 10	S20	S68	S21	S69
Subcarrier 11	S22	S70	S23	S71
Subcarrier 12	S24	S72	S25	S73
Subcarrier 13	S26	S74	S27	S75
Subcarrier 14	S28	S76	S29	S77
Subcarrier 15	S30	S78	S31	S79
Subcarrier 16	S32	S80	S33	S81
Subcarrier 17	S34	S82	S35	S83
Subcarrier 18	S36	S84	S37	S85
Subcarrier 19	S38	S86	S39	S87
Subcarrier 20	S40	S88	S41	S89
Subcarrier 21	S42	S90	S43	S91
Subcarrier 22	S44	S92	S45	S93
Subcarrier 23	S46	S94	S47	S95

5. Reliable Stream Mapping Rule: Block-Wise Mapping

As mentioned previously, IEEE 802.16 CTC generates a block of coded sequence {A, B, Y1, Y2, W1, W2}, in which A and B are the systematic part and Y1, Y2, W1 and W2 are the parity part. This sequence imposes an important structure: the systematic part always occupies the leading part of the sequence followed by the parity part. Moreover, after the sub-block interleaving and puncturing, the coded sequence still keeps the same structure.

The basic idea of the proposed block-wise mapping rule is that to allocate as many as possible the relatively more important systematic part of coded bits to the well-conditioned channel to against the destructive fading and hence enhance the error correction capability. Fortunately, the distinctive structure of the coded bits described above facilitates the development of the proposed mapping rule. With this distinctive structure, the reliable stream mapping can be easily done by directly equal-length block segmenting the punctured sequence into multiple blocks, each of which (in "block-wise") is then individually passed through the different channel, according to the channel condition. The overall design flow for the coding rate $R_c = 1/2$ is shown in Fig. 5 and the corresponding symbol allocation is modified in Table 2. Compared with Table 1, the label "antenna" has been generalized to "stream" in Table 2. From this example, we can see that all the systematic part indeed can be transmitted through the better channel. However, with the coding rate R_c

increased, the performance gain provided by the block-wise mapping mechanism diminishes. This is because that more systematic bits will be allocated into the worse channel due to equal-length block segmentation. It is evidenced by Fig. 5 that the proposed mapping rule is easily realized without significant change from the existing framework (Fig. 1); therefore, it is very suitable for use in the vertically encoded STC system (especially for MIMO precoding) adopted in the IEEE 802.16 system, if the channel state information (CSI) is available at the transmitter. Note that CSI is already available at the transmitter side for precoded system. For the non-precoded systems, only $\log_2 N$ bits are needed for CSI reporting, where N is the bit-stream number. In addition, the demux-wise stream mapping will be used if no CSI is available at the transmitter.

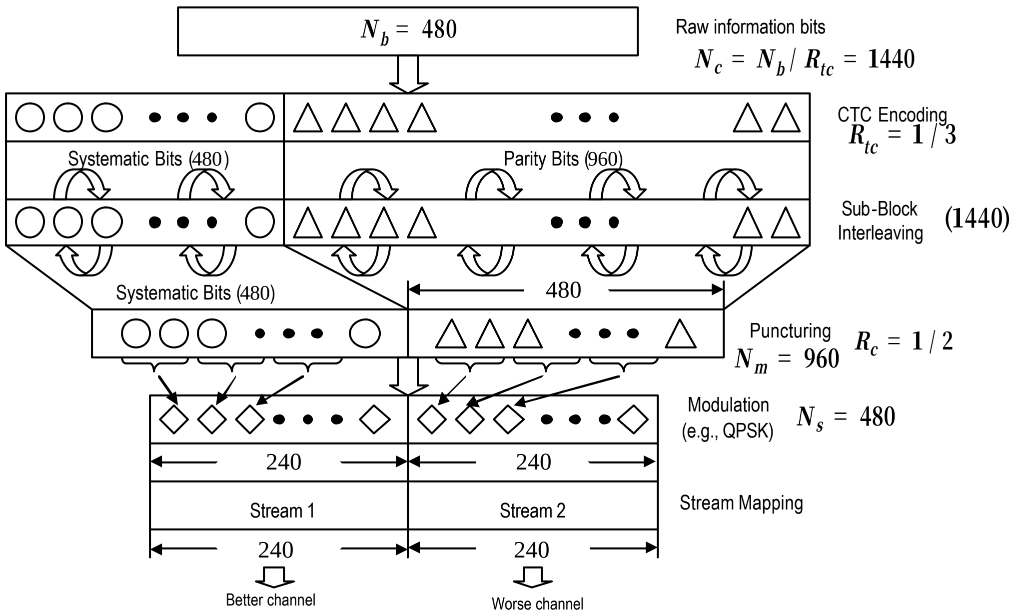

Fig. 5: A block-wise stream mapping example for vertically encoded STC system.

Table 2: A Modified symbol allocation for vertically encoded STC system with two streams if CSI is available at the transmitter (assume that transmission chain of stream 0 is more reliable).

	Stream 0		Stream 1	
	Even Symbol	Odd Symbol	Even Symbol	Odd Symbol
Subcarrier 0	S0	S24	S48	S72
Subcarrier 1	S1	S25	S49	S73
Subcarrier 2	S2	S26	S50	S74
Subcarrier 3	S3	S27	S51	S75
Subcarrier 4	S4	S28	S52	S76
Subcarrier 5	S5	S29	S53	S77
Subcarrier 6	S6	S30	S54	S78
Subcarrier 7	S7	S31	S55	S79
Subcarrier 8	S8	S332	S56	S80
Subcarrier 9	S9	S33	S57	S81
Subcarrier 10	S10	S34	S58	S82
Subcarrier 11	S11	S35	S59	S83
Subcarrier 12	S12	S36	S60	S84
Subcarrier 13	S13	S37	S61	S85
Subcarrier 14	S14	S38	S62	S86
Subcarrier 15	S15	S39	S63	S87
Subcarrier 16	S16	S40	S64	S88
Subcarrier 17	S17	S41	S65	S89
Subcarrier 18	S18	S42	S66	S90
Subcarrier 19	S19	S43	S67	S91
Subcarrier 20	S20	S44	S68	S92
Subcarrier 21	S21	S43	S69	S93
Subcarrier 22	S22	S44	S70	S94
Subcarrier 23	S23	S45	S71	S95

6. Simulation Results

In this section, the proposed stream mapping rule is evaluated via the computer simulations. We consider the vertically encoded STC system in Fig. 1. The simulation parameters are given in Table 3.

Table 3: Simulation parameters

Parameters	**Value**
Channel model	Fixed Rayleigh flat-fading channel
Channel estimation	Perfect estimation at TX and RX
MIMO configuration	4×2
Number of streams	2
Precoding scheme	Eigen-based IEEE 16e codebook-based [1]
MIMO detector	LMMSE

MCS sets	QPSK-1/2, 2/3, 3/4, 5/6 16QAM-1/2, 2/3, 3/4, 5/6
Channel coding scheme	Code rate 1/3 CTC [1]
Decoding scheme	MAX Log-MAP algorithm
Number of bits per coding block	480

The first set of simulation examines the bit error rate (BER) performance of the two stream mapping schemes for eigen-based precoding (i.e., the precoding matrix is of the right singular matrix of the MIMO channel matrix) and the results are shown in Fig. 6 and Fig. 7 respectively for QPSK and 16QAM modulations with the coding rate being a control parameter. From Figs 6 and 7, we can see that the proposed mapping rule provides significant gain over the demux-based mappin for coding rate of 1/2. The improvement becomes smaller when coding rate becomes higher. Similar results are observed for the 16e vector codebook-based precoding scheme, as shown in Figs 8 and 9.

7. Conclusion

This contribution introduces a block-wise stream mapping to enhance the error rate performance for IEEE 802.16m. Simulation results show that the new scheme provides a significant gain over the demux-based mapping currently used in IEEE 802. 16 system especially for a low coding rate. The method is simple and is easy to fit in the vertically-encoded STC framework adopted in IEEE 802.16.

References

[1] IEEE DRAFT P802.16Rev2/D1, "Part 16: Air interface for broadband wireless access systems," October, 2007.

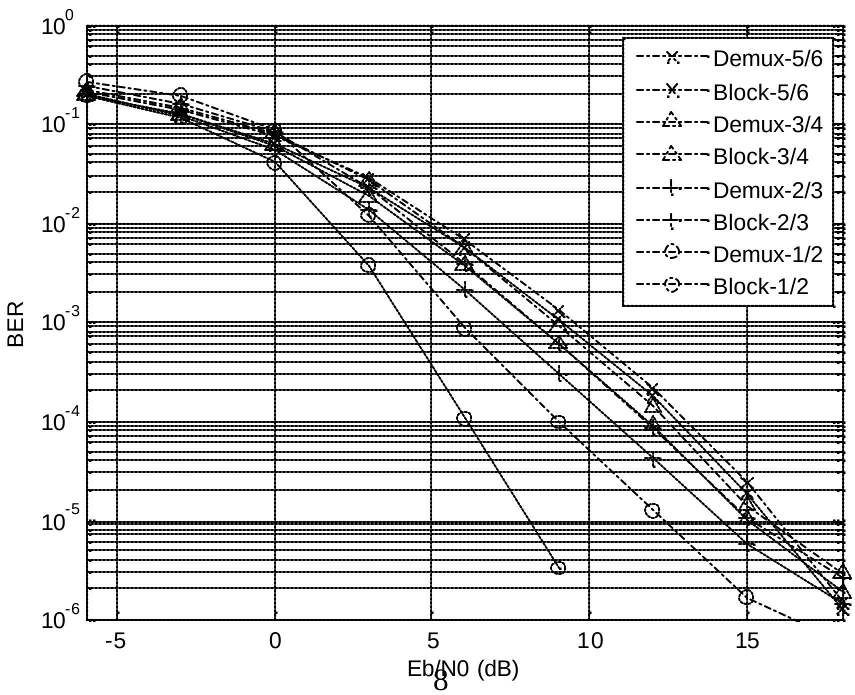

Fig. 6: Bit error rate performance of the two different stream mapping rules with the coding rate being a control parameter. Eigen-based precoding scheme and QPSK modulation are used.

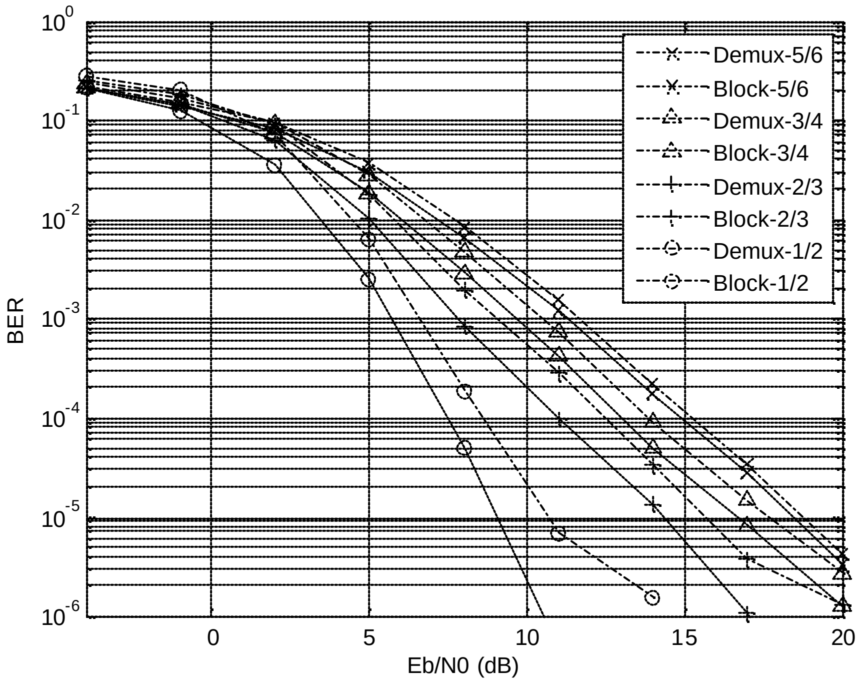

Fig. 7: Bit error rate performance of the two different stream mapping rules with the coding rate being a control parameter. Eigen-based precoding scheme and 16QAM modulation are used.

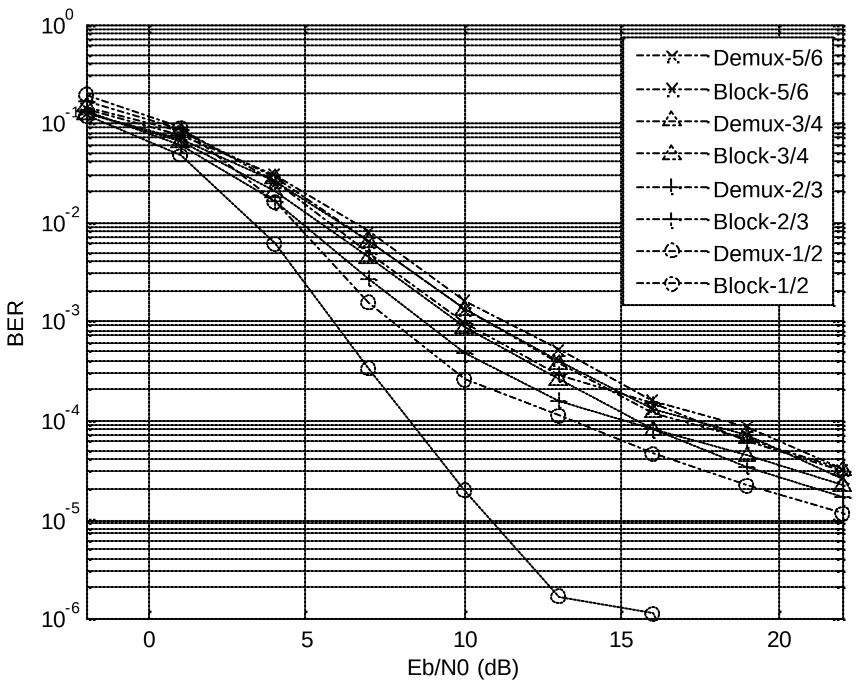

Fig. 8: Bit error rate performance of the two different stream mapping rules with the coding rate being a control parameter. 16e vector codebook-based precoding scheme and QPSK modulation are used.

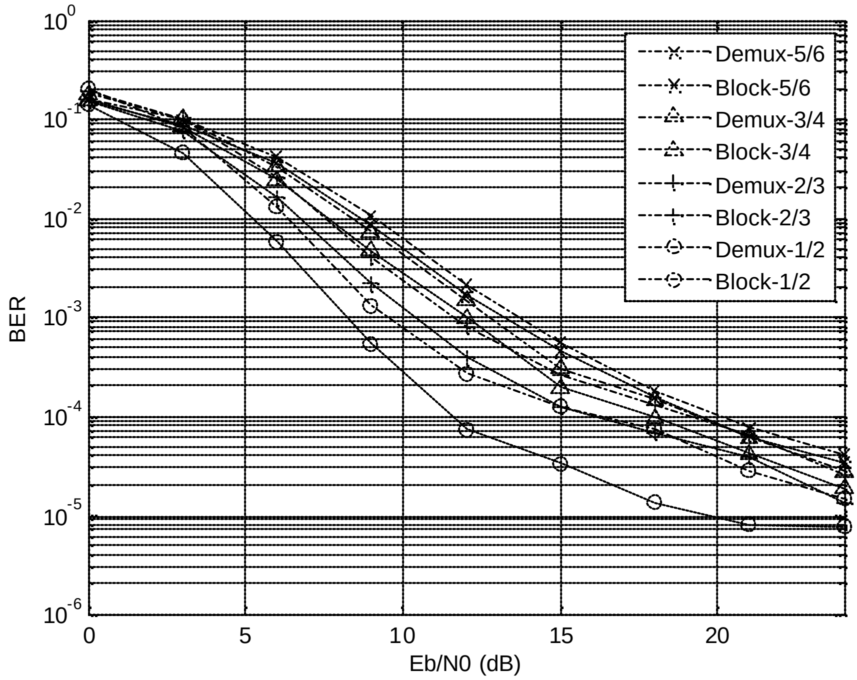

Fig. 9: Bit error rate performance of the two different stream mapping rules with the coding rate being a control parameter. 16e vector codebook-based precoding scheme and 16QAM modulation are used.