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Title	**Enhanced HARQ technique using Constellation Rearrangement**
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Re:	IEEE 802.16m-07/040 - Responds to Call for Contributions on Project 802.16m System Description Document (SDD)
Abstract	New HARQ method using signal constellation rearrangement is presented in this contribution, where different mappings are used for retransmission to improve performance. It is proposed to adopt the technique in the IEEE 802.16m SDD HARQ section for further investigation.
Purpose	For 802.16m discussion and adoption
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Enhanced HARQ technique using Constellation Rearrangement

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Summary

New HARQ method using signal constellation rearrangement is presented in this contribution, where different mappings are used for retransmission and MRC (maximal ratio combining) are employed to combine the received symbols to improve performance. The proposed method has shown significant gain over the conventional schemes [1]. It is proposed to adopt the technique in the IEEE 802.16m SDD HARQ section for further investigation.

Proposed SDD Text

----------*Begin Proposed Text* ----------

X. HARQ

An HARQ method with signal constellation rearrangement for 16-QAM and 64-QAM modulation shall be used.

----------***End of Text Proposal*** ----------

1. Introduction

This contribution proposes a signal constellation rearrangement technique to enhance HARQ performance; Different mappings are used for retransmission and MRC (maximal ratio combining) are employed at the receiver to combine all the received symbols to improve performance . The simulation results show that significant gain is achieved over the traditional Chase Combing.

2. Description of Proposed Method

The inherent different bit reliabilities for different bit positions in Gray labeling, bit reliabilities remain unchanged if identical mappings are used for retransmission in HARQ. To average out the un-even bit reliabilities, we swap the less reliable bits with more reliable bits for retransmission. The averaged bit reliability will enhance the HARQ performance over the Chase Combining.

2.1 Constellation rearrangement for 16 QAM

For Gray labeling in 16QAM as shown in Figure 2.1.1, bit i_1 is more reliable than i_2. If the same labeling is retransmitted for repeated bits, the reliability of bit i_1 will be further higher than i_2 . To resolve the un-even bit reliabilities, we swap bit i_1 with bit i_2 and obtain different mapping for retransmission. Similar argument applies to q_1 and q_2

Transmission No.	Bit mapping order	Figure No.
1	$i_1 q_1 i_2 q_2$	Figure 2.1.1
2	$i_2 q_2 \bar{i}_1 \bar{q}_1$	Figure 2.1.2
3	$i_1 q_1 \bar{i}_2 \bar{q}_2$	Figure 2.1.3
4	$i_2 q_2 i_1 q_1$	Figure 2.1.4
Further transmissions	Repeatedly using constellations from transmissions 1-4	Figure 2.1.1~2.1.4

Figure 2.1.1

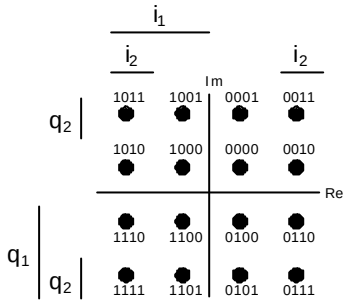

Figure 2.1.2

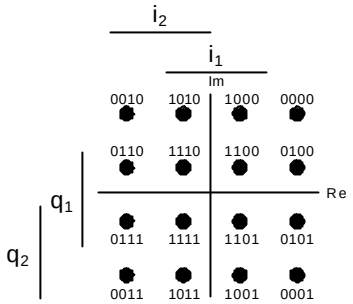

Figure 2.1.3

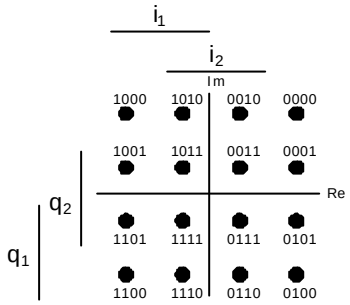

Figure 2.1.4

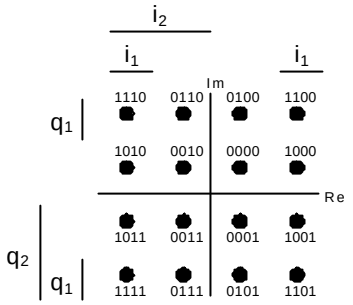

Figure 2.1.1~2.1.4 Constellation rearrangement for 16 QAM (bars indicating rows/columns for which the respective bit equals 1)

2.2 Constellation rearrangement for 64 QAM

For Gray labeling in 64QAM, there are there different reliabilities levels as shown in Figure 2.2.1. The reliability levels from high to low are i_1, i_2, and i_3 respectively.

Similar to the approach for 16 QAM, we swap bits with different bit reliability levels to obtain better performance.

Transmission No.	Bit mapping order	Figure No.
1	$i_1 q_1 i_2 q_2 i_3 q_3$	Figure 2.2.1
2	$i_2 q_2 i_3 q_3 i_1 q_1$	Figure 2.2.2
3	$i_3 q_3 i_1 q_1 i_2 q_2$	Figure 2.2.3
4	$i_1 q_1 \overline{i_2 q_2 i_3 q_3}$	Figure 2.2.4
5	$i_2 q_2 \overline{i_3 q_3 i_1 q_1}$	Figure 2.2.5
6	$i_3 q_3 \overline{i_1 q_1 i_2 q_2}$	Figure 2.2.6
Further transmissions	Repeatedly using constellations from transmissions 1-4	Figure 2.2.1~2.2.6

Figure 2.2.1

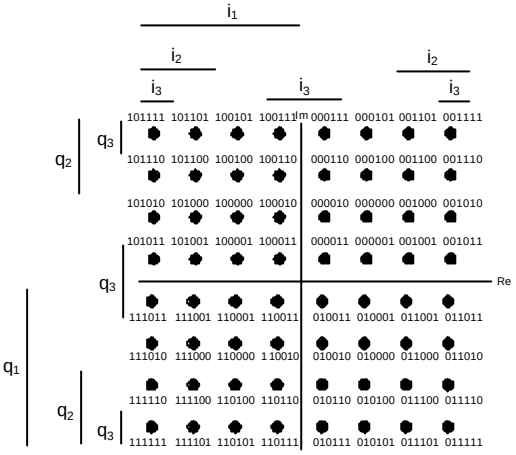

Figure 2.2.2

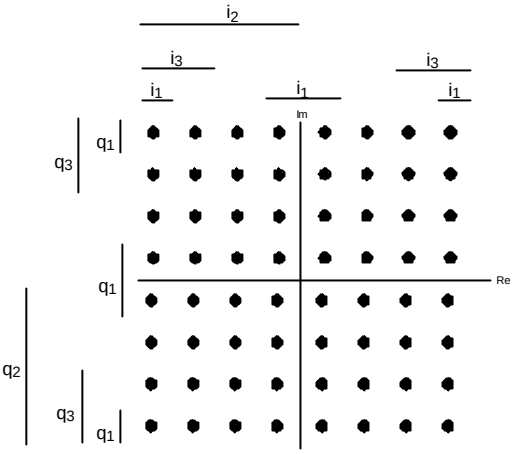

Figure 2.2.3

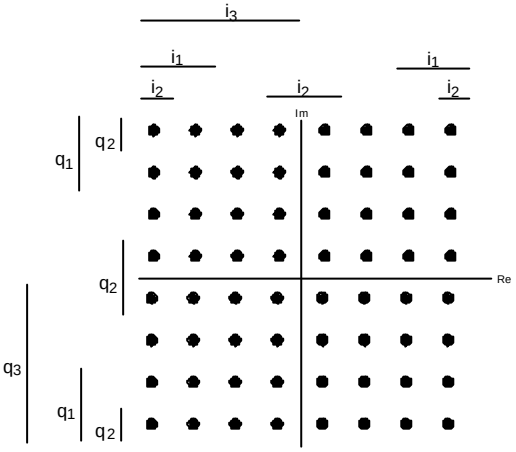

Figure 2.2.4

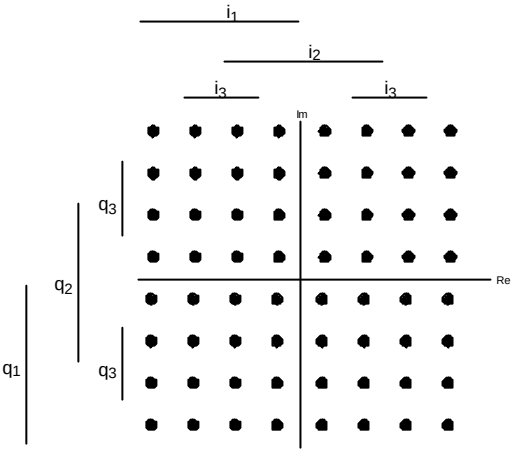

Figure 2.2.5

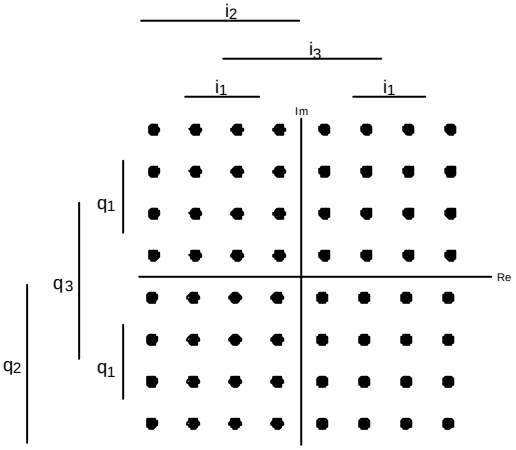

Figure 2.2.6

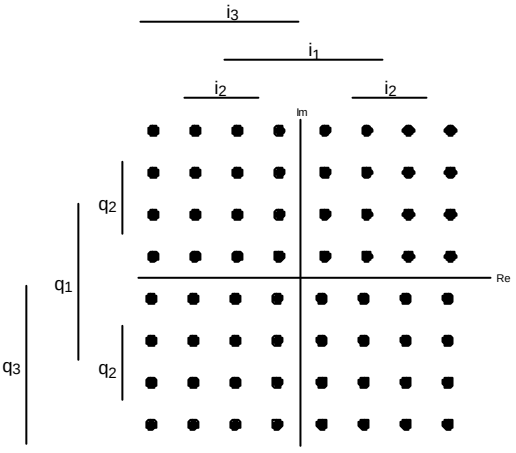

Figure 2.2.1~2.2.6 Constellation rearrangement for 64 QAM (bars indicating rows/columns for which the respective bit equals 1)

3. Simulation Results

This section evaluates the error rate performance for both retransmission methods—the proposed HARQ method with constellation rearrangement vs. the Chase Combining. The simulation environment is AWGN channel. Log-MAP algorithm with 8iterations is performed in our simulation. The following table shows the simulation parameters including packet size, modulation and code rate.

Modulation	Information bits per packet	Turbo code rate	Number of transmission	Figure No.
16-QAM	96	1/2	1~4	Figure 3.1
64-QAM	144	1/2	1~4	Figure 3.2

Figure 3.1 shows that the proposed strategy has a gain over Chase Combining of about 1.3dB, 2dB and 2.6dB for the first, second and third retransmission, respectively. The 2nd retransmission of the proposed method performs significantly better than the 3rd retransmission utilizing Chase Combining. I.e. instead of 3 retransmissions using Chase Combining two retransmissions with the proposed method would be sufficient.

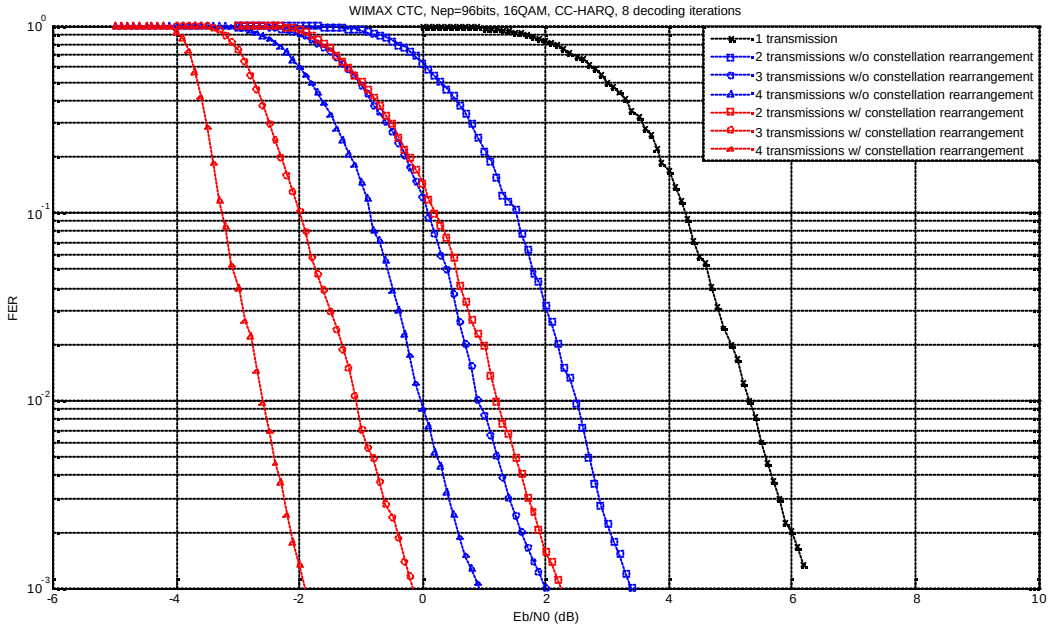

Figure 3.1 Performance comparison with Nep=96bits and 16QAM modulation.

Figure 3.2 shows that the proposed strategy has a gain over Chase Combining of about 2.2dB, 4dB and 5dB for the first, second and third retransmission, respectively. In this case, we only requires one retransmission

with the proposed strategy to outperform Chase Combining method.

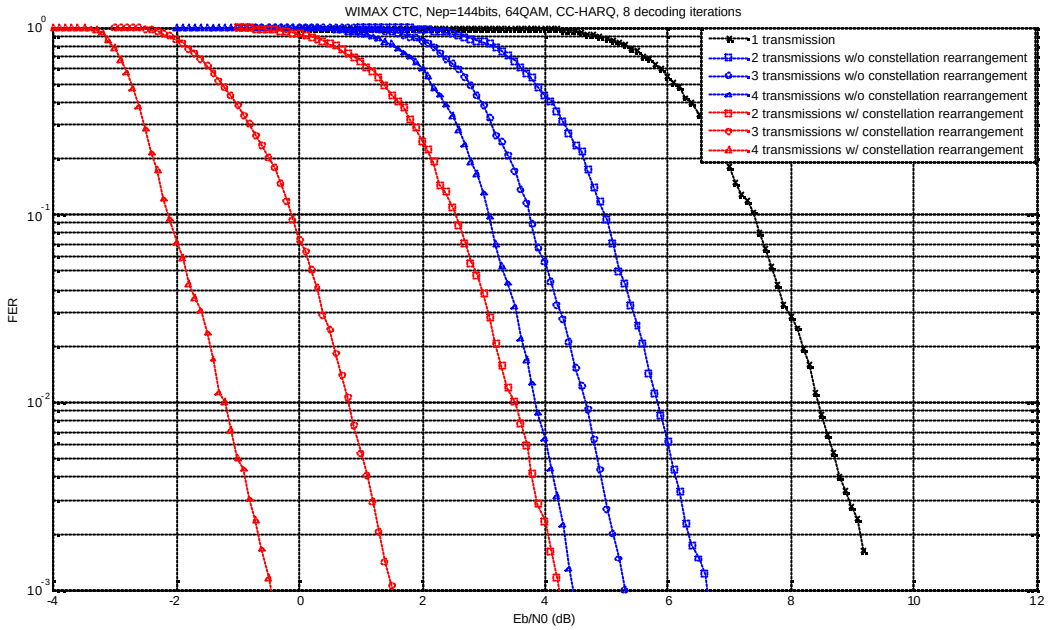

Figure 4 Performance comparison with Nep=144bits and 64QAM modulation.

4. Conclusions

In this contribution a new HARQ method using signal constellation rearrangement is presented. When transmitting repeated bits is required, this new method uses different mappings for retransmission and performing MRC (maximal ratio combining) to combine all the received symbols. The proposed method has shown significant gain over the conventional schemes.

References

[1] R1-01-0237, Panasonic, "enhanced HARQ method with signal constellation rearrangement" Las Vegas, USA February 27-March 2, 2001