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Re:	
Abstract	
Purpose	Adoption of proposed changes into P802.16e ~~Crossed-out indicates deleted text,~~ underlined blue indicates new text change to the Standard
Notice	
Release	
Patent Policy and Procedures	

Compact Codebooks for Transmit Beamforming in Closed-loop MIMO

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1 Introduction

The channel feedback mechanism in 16e D5a is not efficient for MIMO Precoding. The channel feedback defined 8.4.5.4.10.6 requires a large feedback bandwidth, which can't be fitted into two CQICH channels with 6 bits payload each for even small MIMO systems such as 2x2, 3x3, and 4x4. Therefore, this scheme can not be used for high mobility feedback using CQICH. A compact feedback format is proposed, which can be fit into either 3, or 6, or 9 bit CQICH payloads. Simulations demonstrate that 6 bit feedback per AMC band provides more than 3 dB gain over STC with the same rate for 4x1 and 4x2. More than 1 dB gain over STC is achieved for 2x2 with 1 stream using 3 bit feedback per AMC band.

The proposed feedback employs a codebook for the beamforming matrixes for each combination of number of BS antennas and number of data streams. The whole set of codebooks require less than 300 byte memory. Codebooks for various numbers of BS antenna and various numbers of data streams can be dynamically generated with low complexity.

2 Compact Codebooks

2.1 Usage mode

The codebook is employed in the feedback from SS to BS. The SS learns the channel state information from downlink and selects a transmit beamforming matrix for the codebook. The index of the matrix in the codebook is then fed back to the BS. Each codebook corresponds to a combination of N_t, N_s, and N_i, where N_t, N_s, and N_i are the numbers of BS transmit antennas, available data streams, and bits for the feedback index respectively. Once N_t, N_s, and N_i are determined in the SS, the SS will feed back the codebook indexes each of N_i bits. After receiving a N_i bit index, the BS will look up the corresponding codebook and select the matrix (or vector) according to the index. The selected matrix will be used as the beamforming matrix in MIMO precoding as in 8.4.8.3.6.

In order to make use of the existing CQICH feedback mechanism, the SS may feed back one index per AMC band. The CQICH payload sizes for codebook index is specified in contribution 552, which are 3, 6, and other multiple of 3.

2.2 Codebook construction

Since there are many combinations of N_t, N_s, and N_i and each of them requires a corresponding codebook, the storage of all codebooks are burdensome. A set of codebooks is proposed, most of which can be dynamically generated with low complexity. It is shown in [2] and the references therein that random codebook has better performance than that of structured codebook. Unfortunately, random codebook needs to be stored completely while structured codebook can be generated dynamically using parameters. The proposed set of codebooks is combination of both.

For small size codebooks, i.e. 2x1, 3x1, and 4x1 with 3 bit index, three optimized, random codebooks are stored. For 3x1 and 4x1 with 6 bit index, two structured codebooks are proposed, which can be dynamically generated using an improved Hochwald method. For all the other matrix codebooks such as 3x2 and 4x2, structured codebooks are proposed, which can also be dynamically generated with low complexity.

3 Simulation results

The set of codebooks are evaluated by simulations. The channel model is ITU downlink, pedestrian A and B with 3 km/h. Transmit antenna correlation is 0.2 and receive antenna correlation is 0. The feedback delay is 2 frames, i.e. 10 ms. System bandwidth is 10 MHz with 5 ms per frame. Packet size is 64 byte. One index is fed back per AMC band. Both codebook SVD and STC are simulated. The scheme using the proposed codebooks outperforms STC significantly as shown in the following figures.

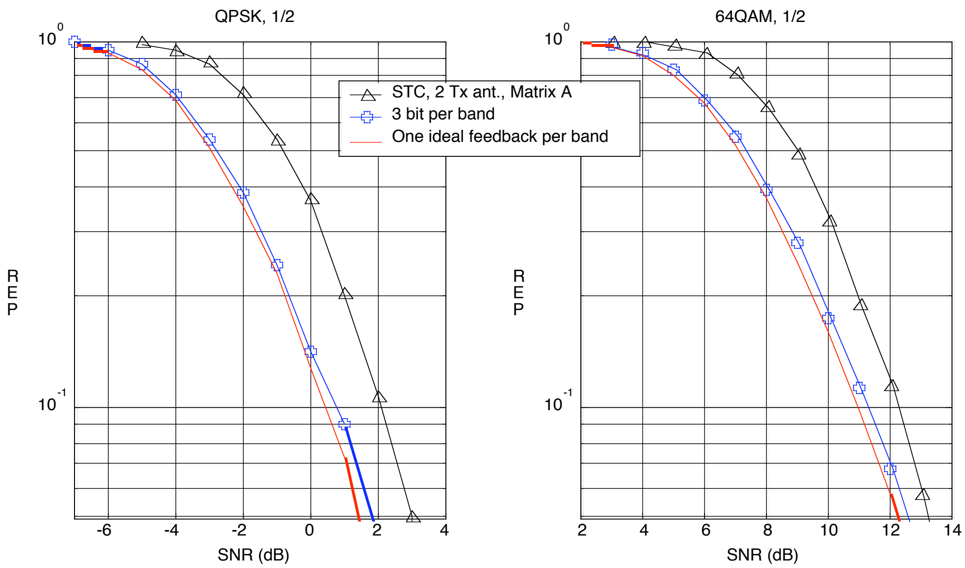

Figure 1 PER performance, 2x2 with 1 data stream, ITU pedestrian B.

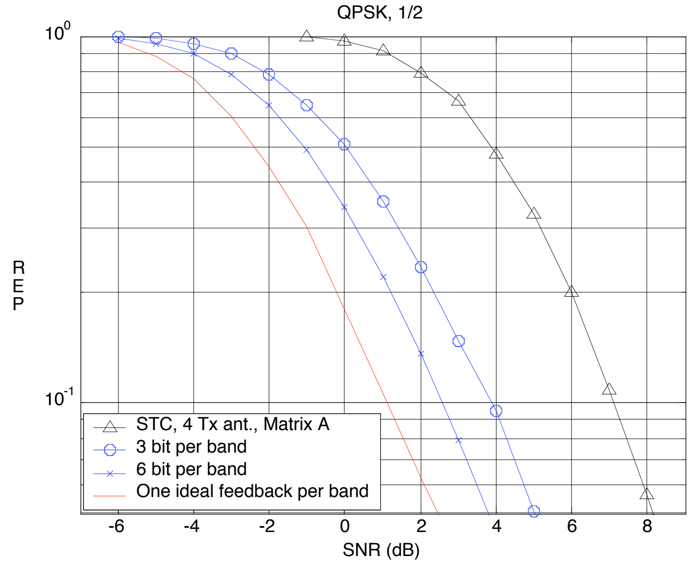

Figure 2 PER performance, 4x1 with 1 data stream, ITU pedestrian B.

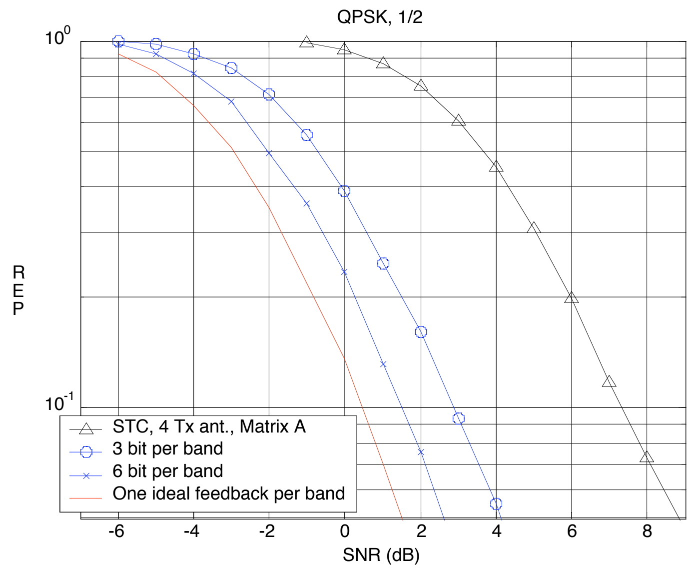

Figure 3 PER performance, 4x1 with 1 data stream, ITU pedestrian A.

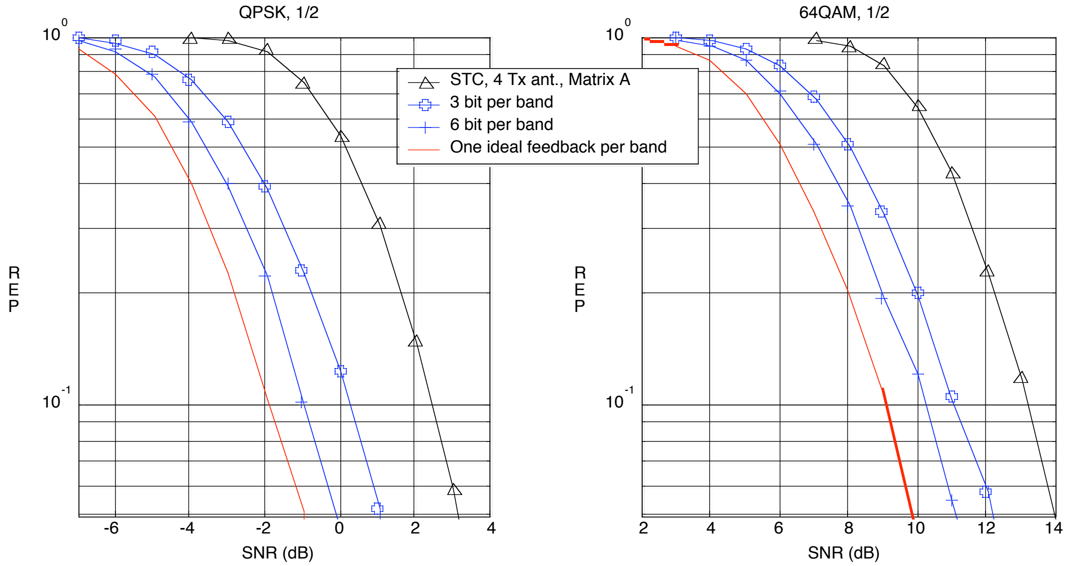

Figure 4 PER performance, 4x2 with 1 data stream, ITU pedestrian B.

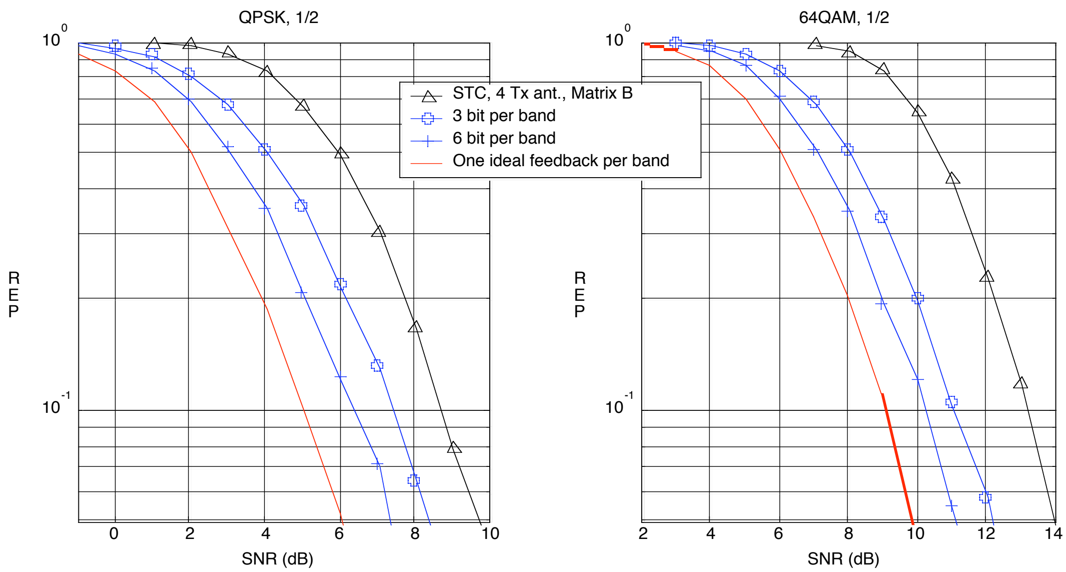

Figure 5 PER performance, 4x2 with 2 data streams, ITU pedestrian B.

4 Specific Text Changes

Added at the end (i.e., line 49) in section 8.4.5.4.10.12on page 270 of [1] as follows

References:

[1] IEEE P802.16e/D5a Air Interface for Fixed and Mobile Broadband Wireless Access Systems – Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands, 2004.

[2] Q. Li, *et al.*, IEEE C80216e-04/527r4, 2004.