Power Loading for MIMO Downlink Transmission

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Purpose:

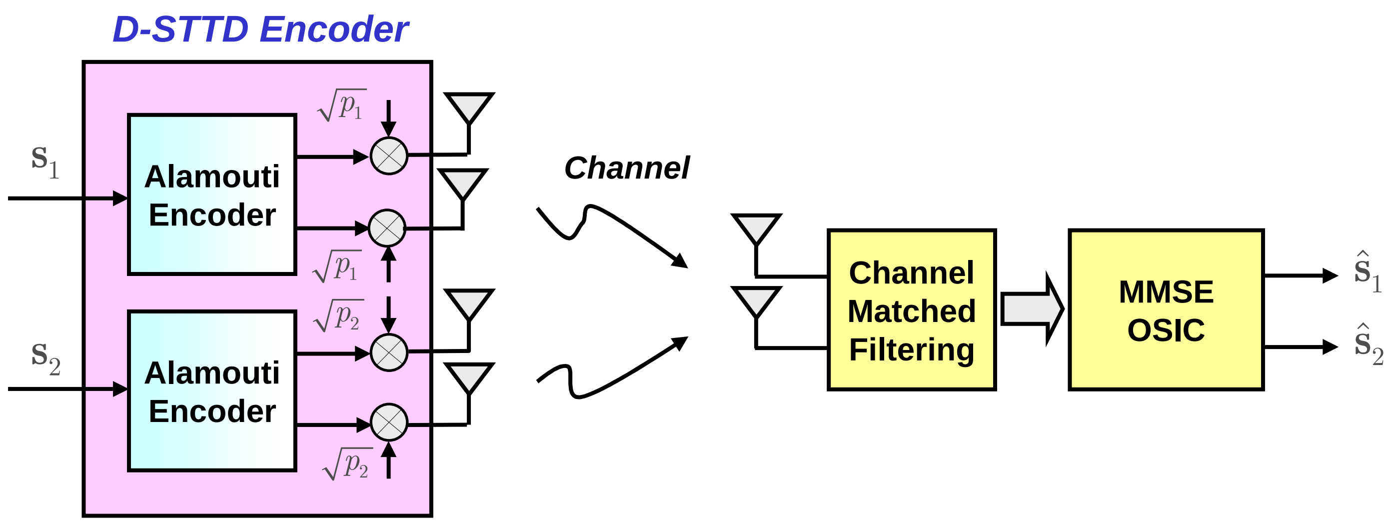
Propose to be discussed and adopted by TGm for the use in Project 802.16m SDD

Power Loading

- Suggest to include power loading to enhance performance of two-data-stream MIMO systems
- How to get optimal power loading factors at BS?
  - For two-data-stream case, it is easy to derive optimal loading factors
  - Only power ratio of the two data streams should be feedbacked
    - Thus feedback information is quite limited
  - Performance gain is large as will be shown in following design example

Design Example

- Double space-time transmit diversity (D-STTD) system
  - MMSE ordered successive interference cancellation (MMSE-OSIC) receiver is adopted to decouple data
  - Goal: adjust p_1 and p_2 to achieve optimal BER under a total power constraint $p_1 + p_2 = P$



- Analysis: when is average BER minimized?
  - It can be proven that when respective BERs of two data streams are equal, system average BER is minimized [1]

$$Q(SINR_{stream1}) = Q(SINR_{stream2}) \Rightarrow \frac{1}{2}\left(Q(SINR_{stream1}) + Q(SINR_{stream2})\right)$$

is minimized

- Find p_1 and p_2 to let $SINR_{stream1} = SINR_{stream2}$

[1] D. P. Palomar, J. M. Cioffi, and M. A. Lagunas, "Joint Tx-Rx beamforming design for multicarrier MIMO channels: A unified framework for convex optimization," IEEE Trans. Signal Processing, vol. 51, no. 9, pp. 2381-2401, Sept. 2003

- By some manipulations, we have following power ratio

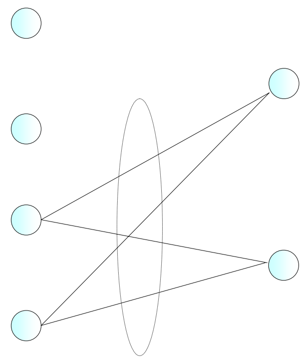
If $\alpha < \beta$

$$p_1 : p_2 = 1 : \frac{\alpha^2}{(\alpha\beta - \gamma)}$$

< 1

elseif $\alpha > \beta$

$$p_1 : p_2 = \frac{\beta^2}{(\alpha\beta - \gamma)} : 1$$



for calculating β

- $\alpha = |h_{11}|^2 + |h_{12}|^2 + |h_{21}|^2 + |h_{22}|^2$
- $\beta = |h_{13}|^2 + |h_{23}|^2 + |h_{14}|^2 + |h_{24}|^2$
- $\gamma = |h_{11}^* h_{13} + h_{12}^* h_{14} + h_{21}^* h_{23} + h_{22}^* h_{24}|^2 + |h_{12}^* h_{13} - h_{11}^* h_{14} + h_{22}^* h_{23} - h_{21}^* h_{24}|^2$

- For D-STTD, optimal power loading (in term of BER) only requires the following real value

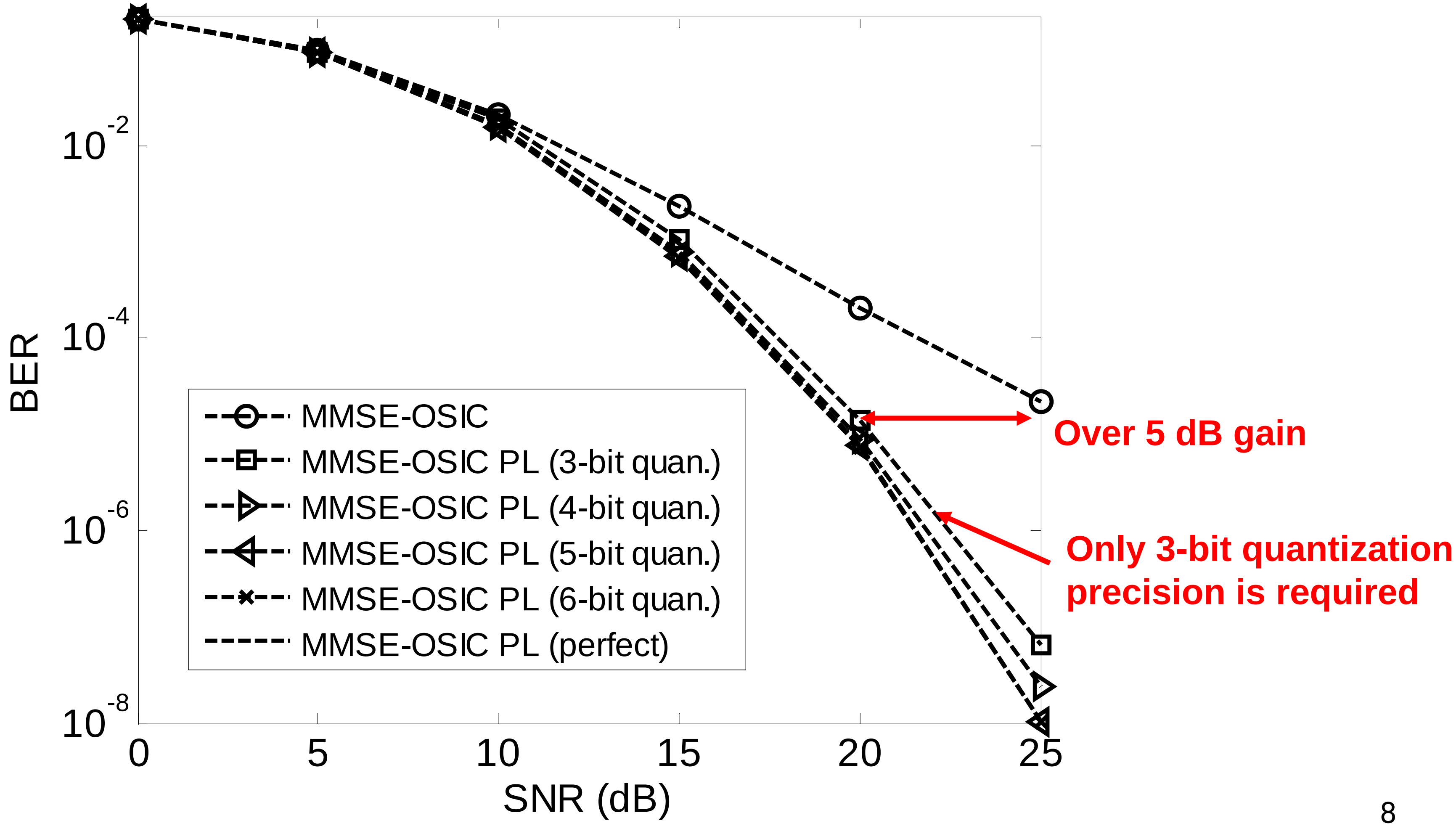
$$\frac{\alpha^2}{(\alpha\beta - \gamma)} \quad \text{or} \quad \frac{\beta^2}{(\alpha\beta - \gamma)}$$

  - MS only requires quantizing the value and sending it back without any codebook being stored

Simulation Results

- Simulation parameters
  - D-STTD (4-by-2) MIMO-OFDM system with MMSE-OSIC detector
  - 512 subcarriers
  - QPSK modulation
  - Channel impulse response follows ITU Pedestrian B model
  - Perfect synchronization and channel estimation are assumed
  - Comparative methods
    - MMSE-OSIC with power loading
    - MMSE-OSIC without power loading

- BER performance comparison



Conclusion

- Power loading is appealing to two-data-stream MIMO systems
  - Only a power ratio of the two data streams should be feedbacked
    - In design example, 3-bit quantization precision is sufficient to get over 5-dB SNR gain
  - It is beneficial to trade a small feedback overhead for such a large performance gain