Comparison of effectiveness of different precoder approaches

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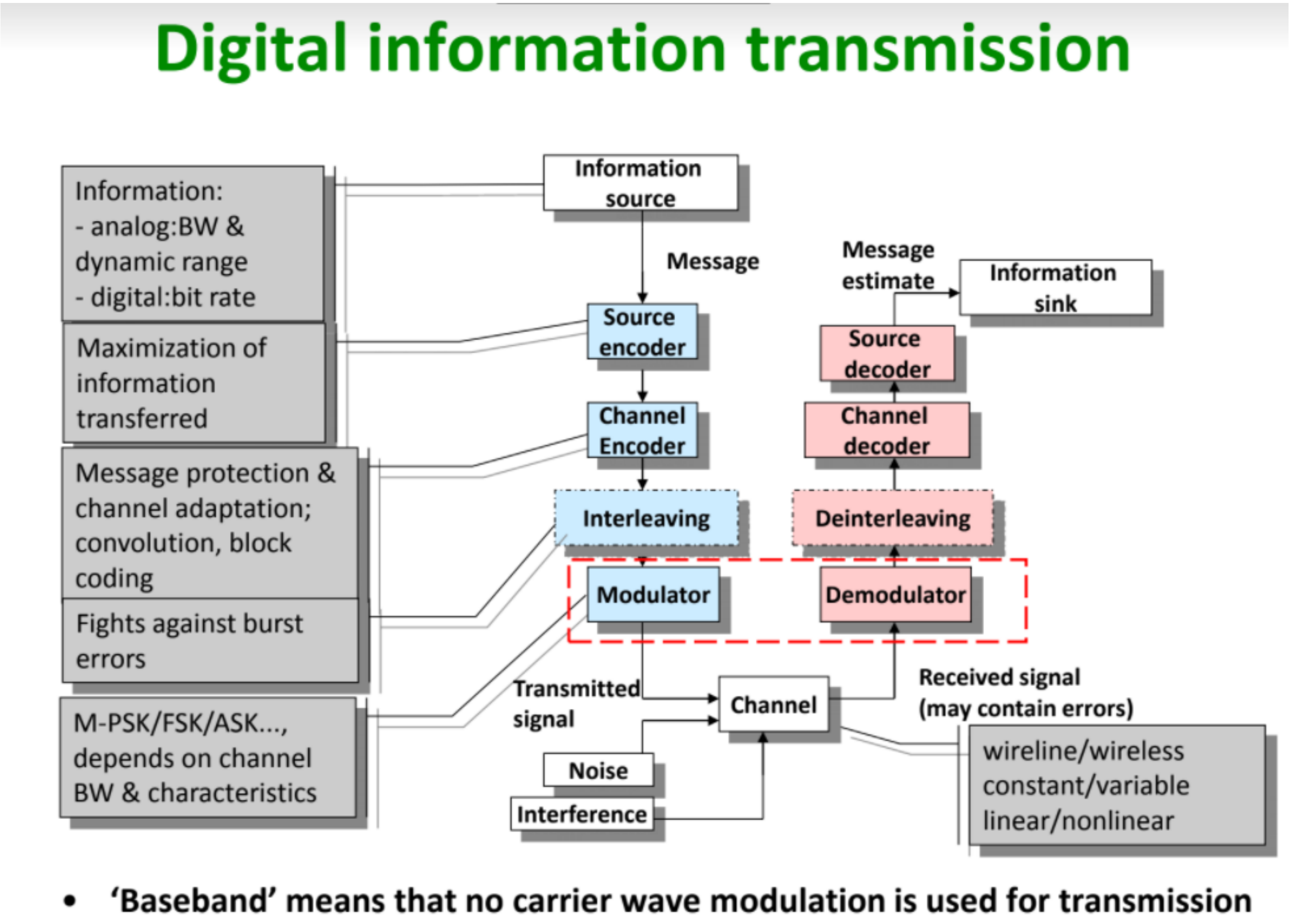
What & Why

Channel structure



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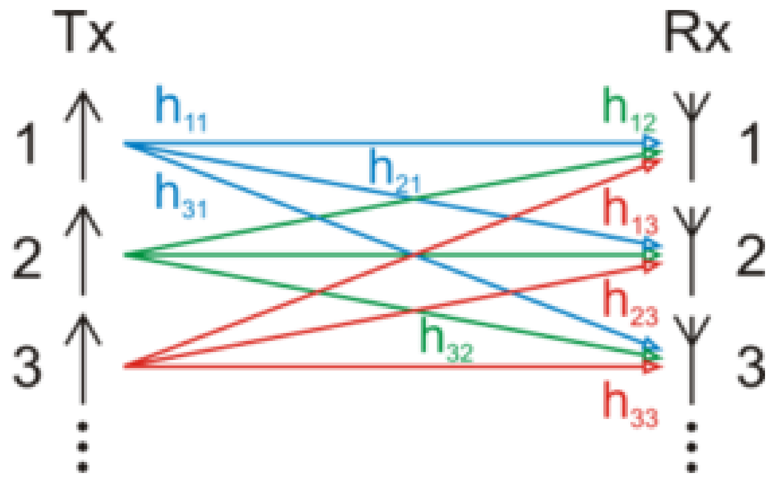
Main Idea from paper

The MIMO channel knowledge can be mathematically described by a subcarrier specific channel matrix **H,** and general received signal is:

$$y = H\,s + n$$



H can be decomposed applying SVD techniques.

$$H = UDV^*$$

Precoding technique can by applied using matrix V:

$$c = Vs$$

Received signal given by:

$$r = H\,Vs + n$$

Equalized signal:

$$y = U^*r = U^*H\,Vs + U^*n = U^*UDV^*\,Vs + U^*n = Ds + U^*n \text{ and } y_i = d_i s_i + \tilde{n}$$

Main Idea from paper

SVD-based methods:

Zero-forcing equalization

$$y = (HV)^{\dagger} r = (HV)^{\dagger} HVs + (HV)^{\dagger} n = s + (UD)^{-1} n, \textit{ where } M^{\dagger} = (M^{*}M)^{-1} M^{*}$$

MMSE equalization

$$y = (HV)^{\dagger} r, \textit{ where } M^{\dagger} = (\sigma^{2} I + M^{*}M)^{-1} M^{*} \textit{ and } \sigma^{2} \textit{ is noise variance}$$

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What & Why

In case of an ideal radio channel knowledge the SVD based precoding procedure, which is applied at the transmitter site, is going to consider all possible Eigenmodes which results in a perfect separation of all signals at the receive antenna output and into a minimum bit-error-rate(BER)

In case of non-ideal channel knowledge and a limited accuracy in the channel matrix H estimation a reduced number of Eigenmodes in the precoding process will be come an optimum and will lead into an increased BER performance.

Main Idea from paper

In real channel we have $\widetilde{H} = \widetilde{U}\widetilde{D}\widetilde{V^*}$ and sent signal precoded as $\tilde{c} = \tilde{V}s$

Since that, unitary property doesn't work: $V^*\tilde{V} \neq I$ we will get more errors

The idea of reducing BER in this case is as follows:
Before the number of exploited Eigenmodes for precoding were always related to the number of transmit antennas Nt , the columns of matrix $\tilde{V} \in \mathbb{C}^{N_t \times N_t}$. The new approach of precoding with Eigenmode selection considers a number of exploited Eigenvectors K, which are usually chosen to be less than the number of transmit antennas $(K < N_t)$ with matrix $\tilde{V} \in \mathbb{C}^{N_t \times N_t}$. . The remaining N_t − K columns of $\tilde{V}$, and therefore the Eigenmodes, are manually discarded and not scheduled for information precoding. The new transmit signal is described by:

$$\begin{pmatrix} c_1 \\ \vdots \\ c_{N_t} \end{pmatrix} = \begin{pmatrix} \tilde{V}_{1,1} & \cdots & \tilde{V}_{1,K} & \times \\ \vdots & \ddots & \vdots & \times \\ \tilde{V}_{N_t,1} & \cdots & \tilde{V}_{N_t,K} & \times \end{pmatrix} \cdot \begin{pmatrix} s_1 \\ \vdots \\ s_K \\ \times \end{pmatrix}$$

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Methods in real case

- SVD $y = DV^*\tilde{V}s + U^*n$
- Zero-Forcing $y = (HV)^\dagger H\tilde{V}s + (HV)^\dagger n = V^*\tilde{V}s + (UD)^{-1}n$
- MMSE $y = (HV)^\dagger r$, where $M^\dagger = (\sigma^2 I + M^*M)^{-1}M^*$

Approximations:
To obtain first results we have significantly simplified transmission process
We have used 16-QAM for obtaining symbols for vector $\boldsymbol{s}$
We decided to not calculate BER for pure SVD approach, because it is not clear how it was calculated.

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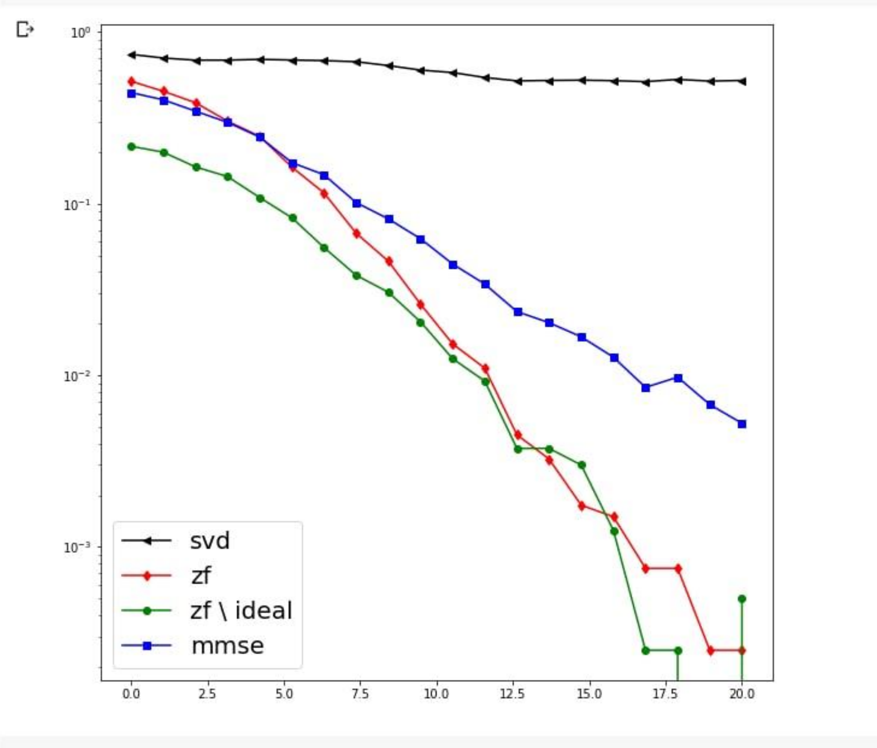
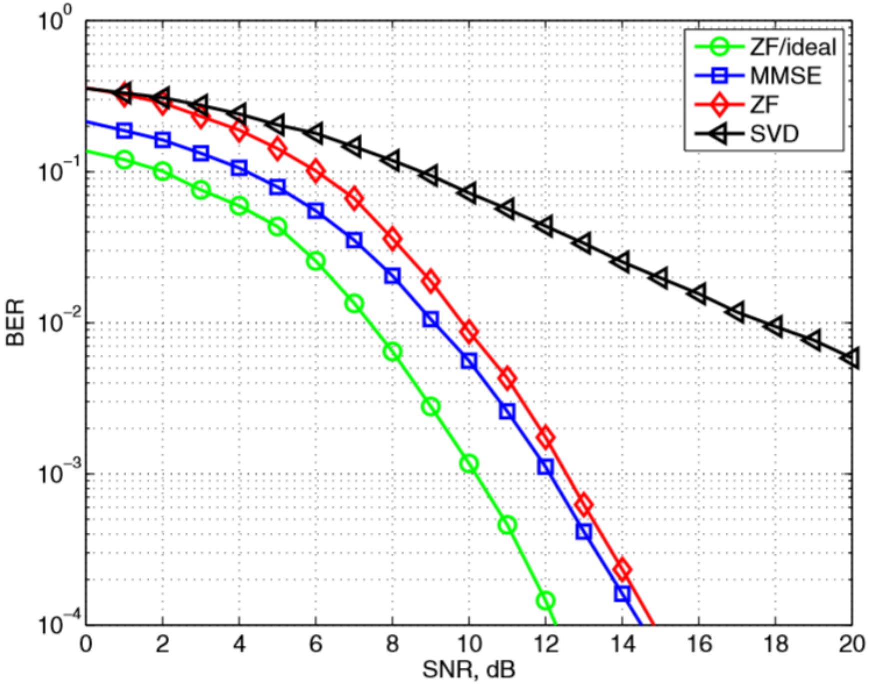
Work Process step 1

Basic approach with small amount of iterations





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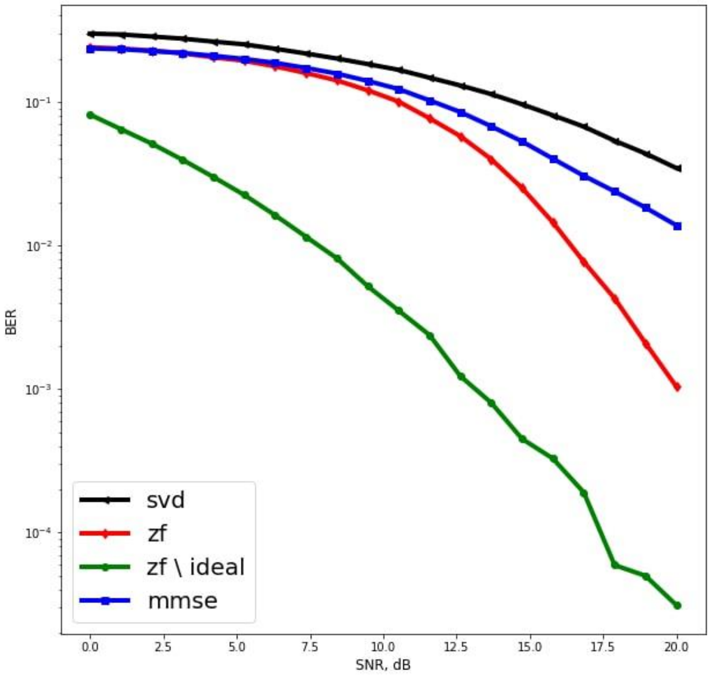
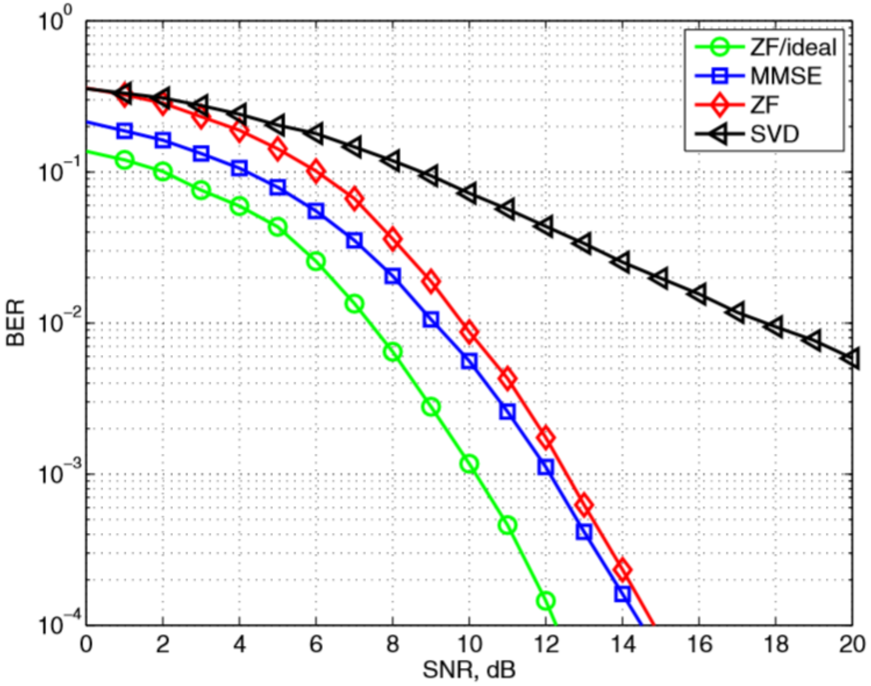
Work Process step 2

Fixed errors and increase number of iterations





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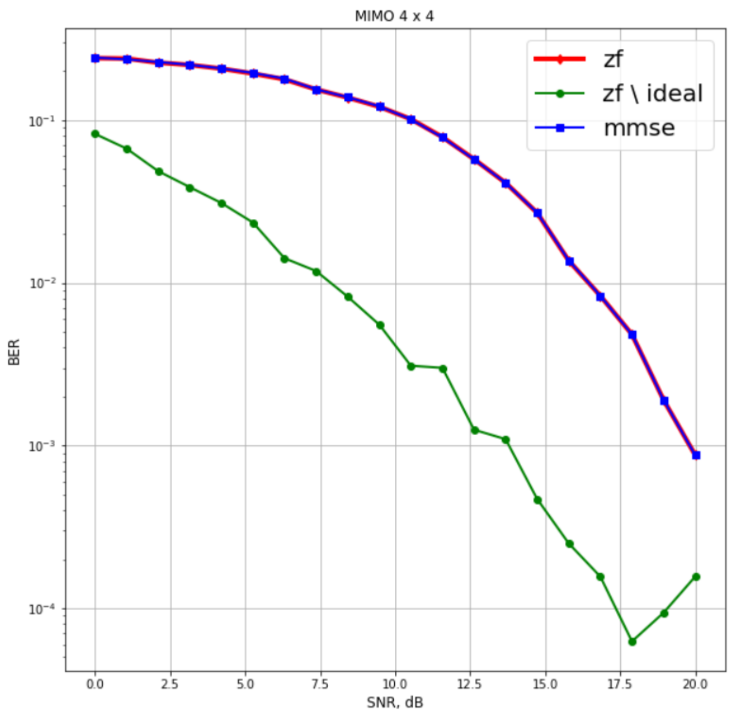
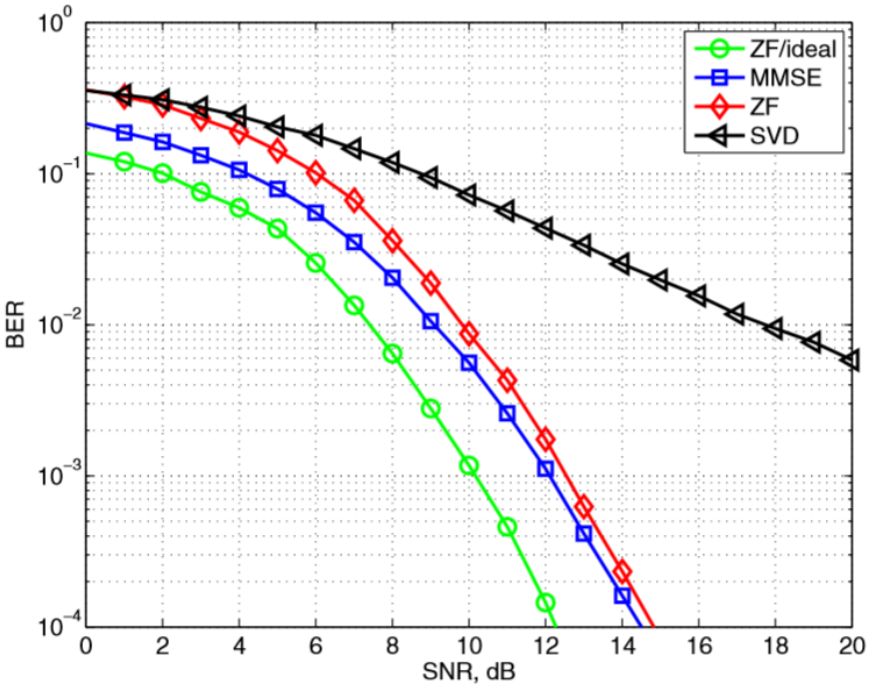
Work Process step 3

Tuned noise parameter for MMSE and removed pure SVD from calculations





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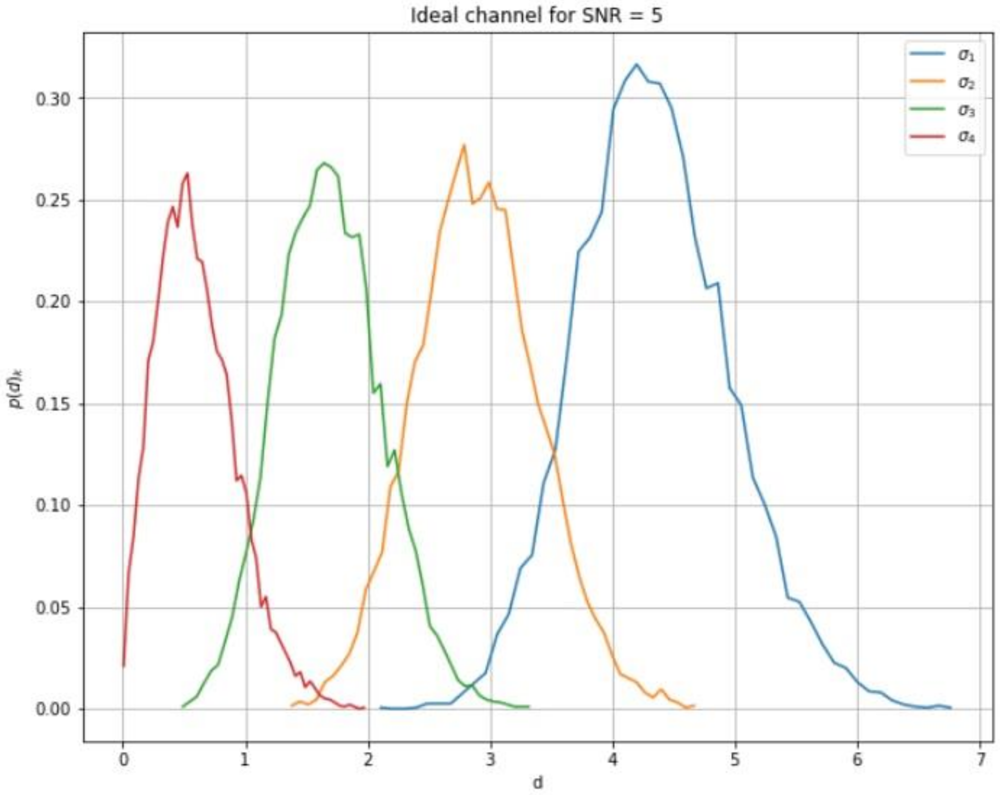
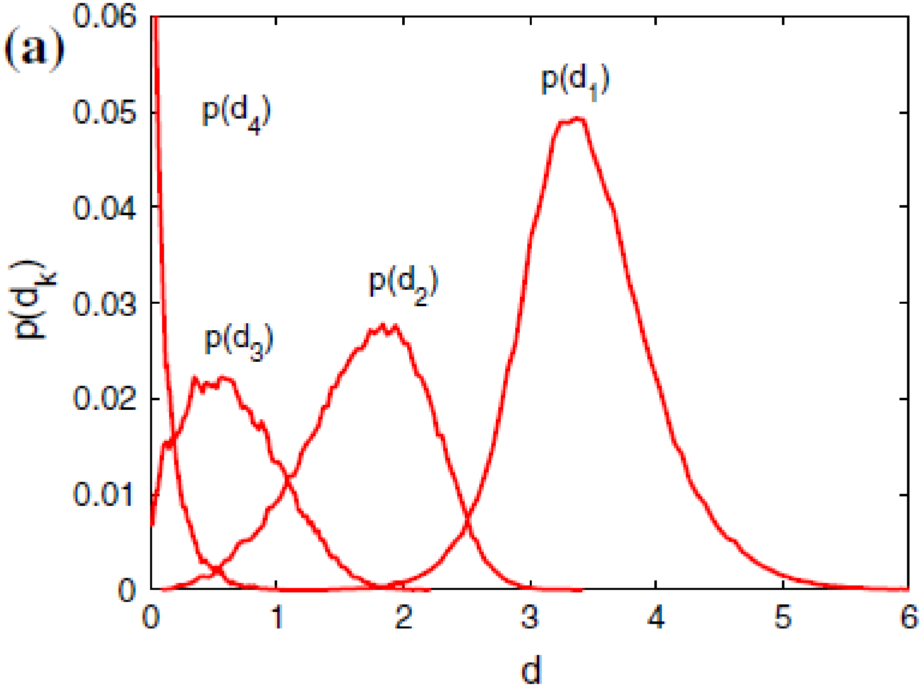
Channels singular values distributions

Calculated for ideal channel





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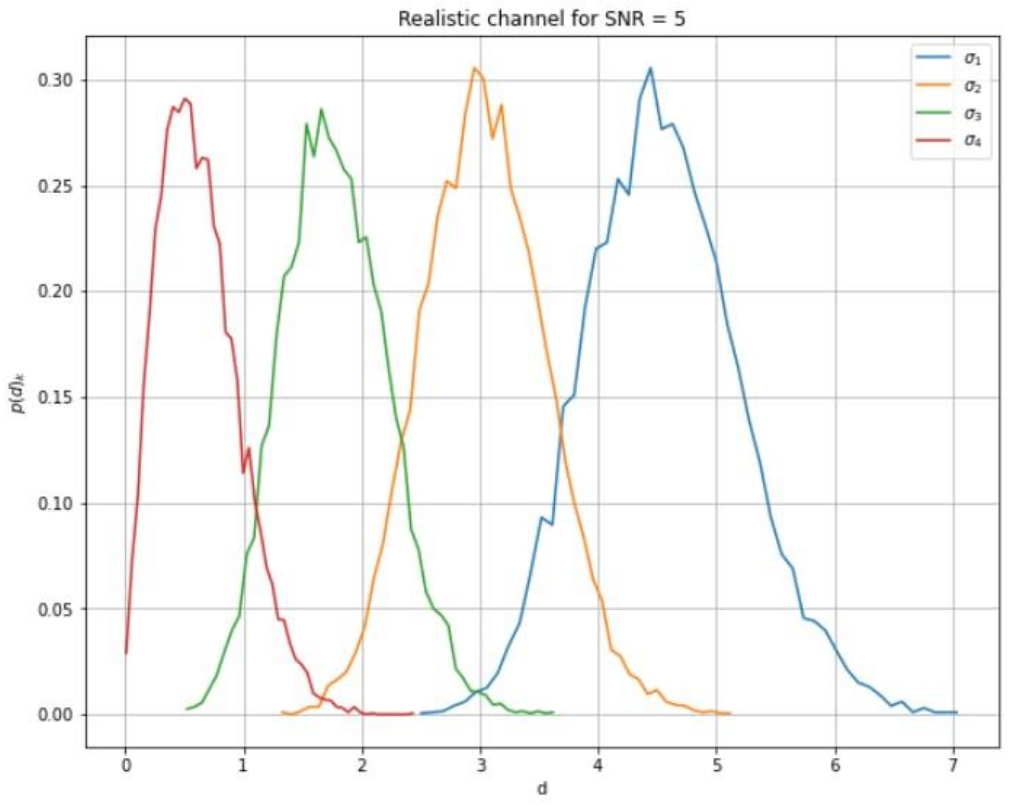
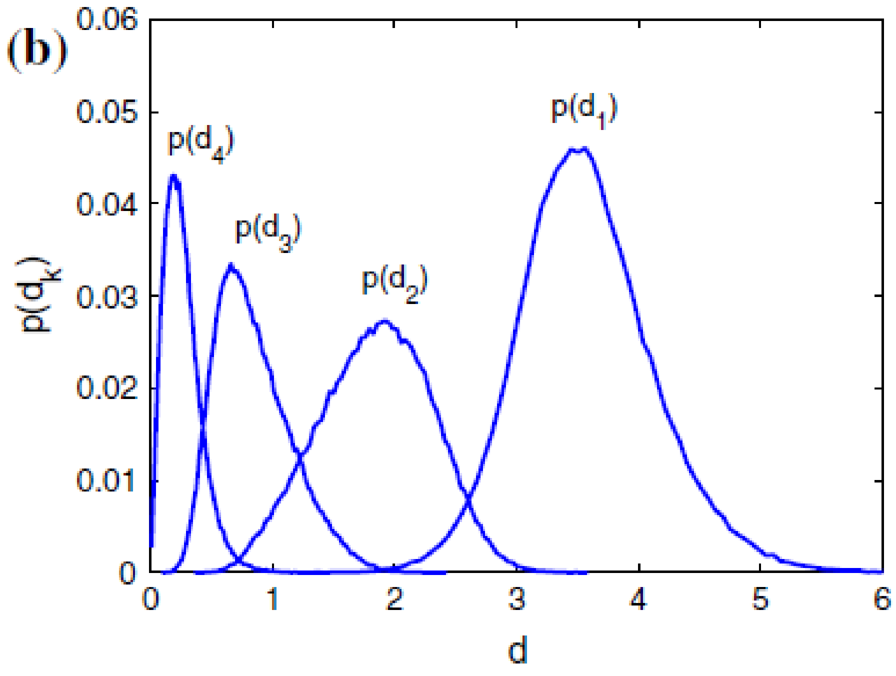
Channels singular values distributions

Calculated for real channel





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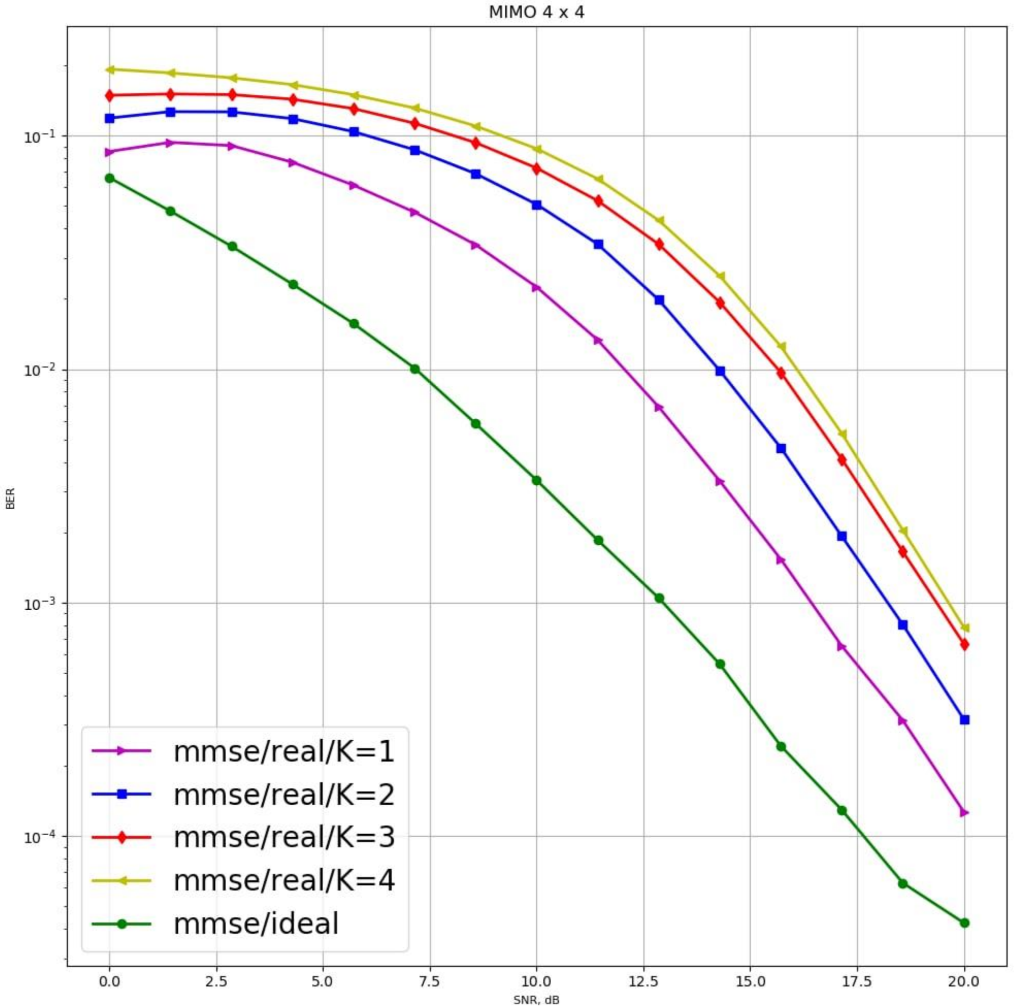
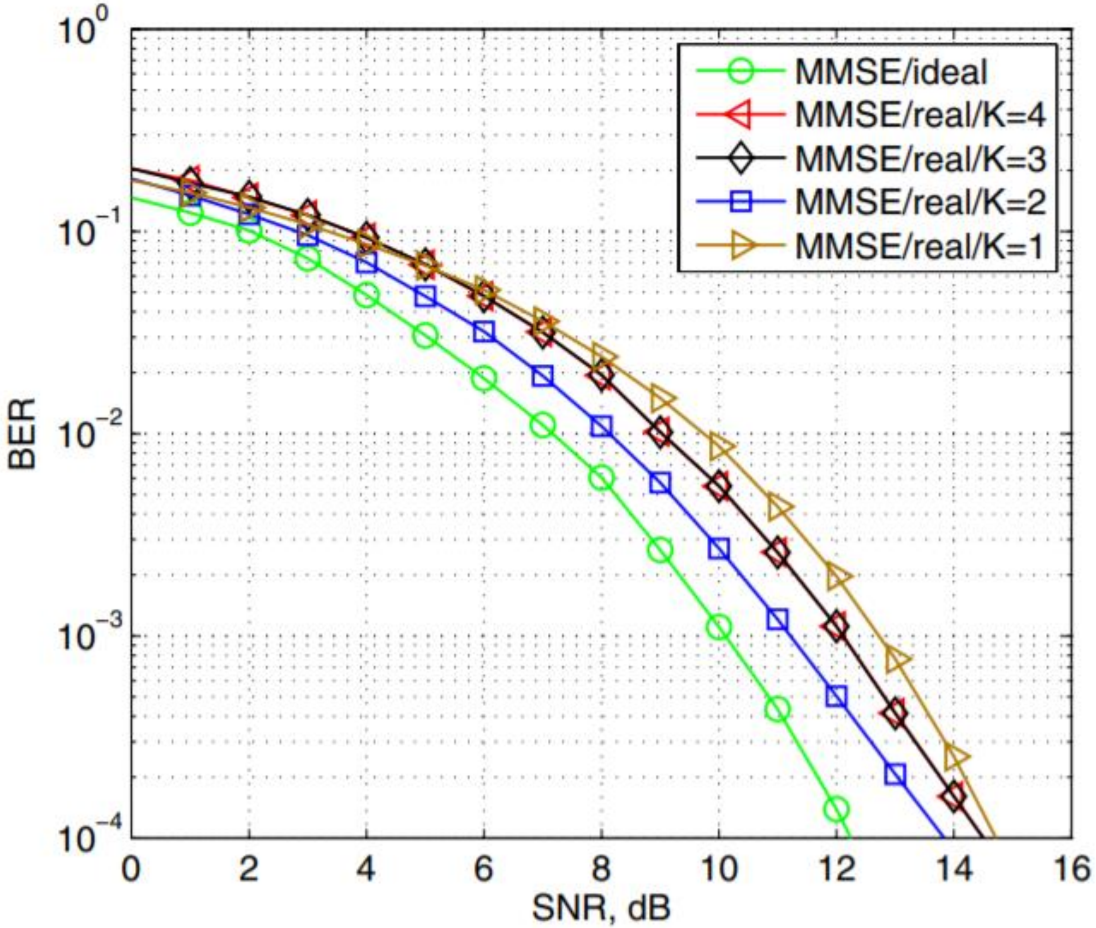
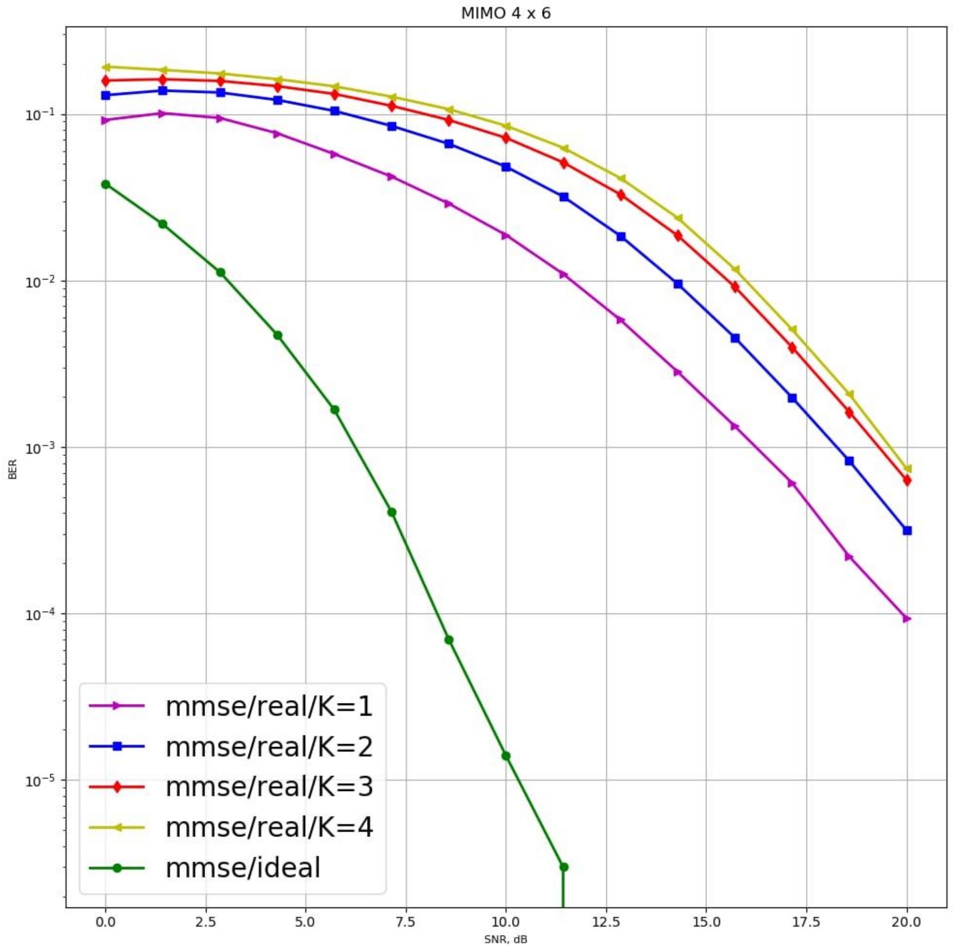
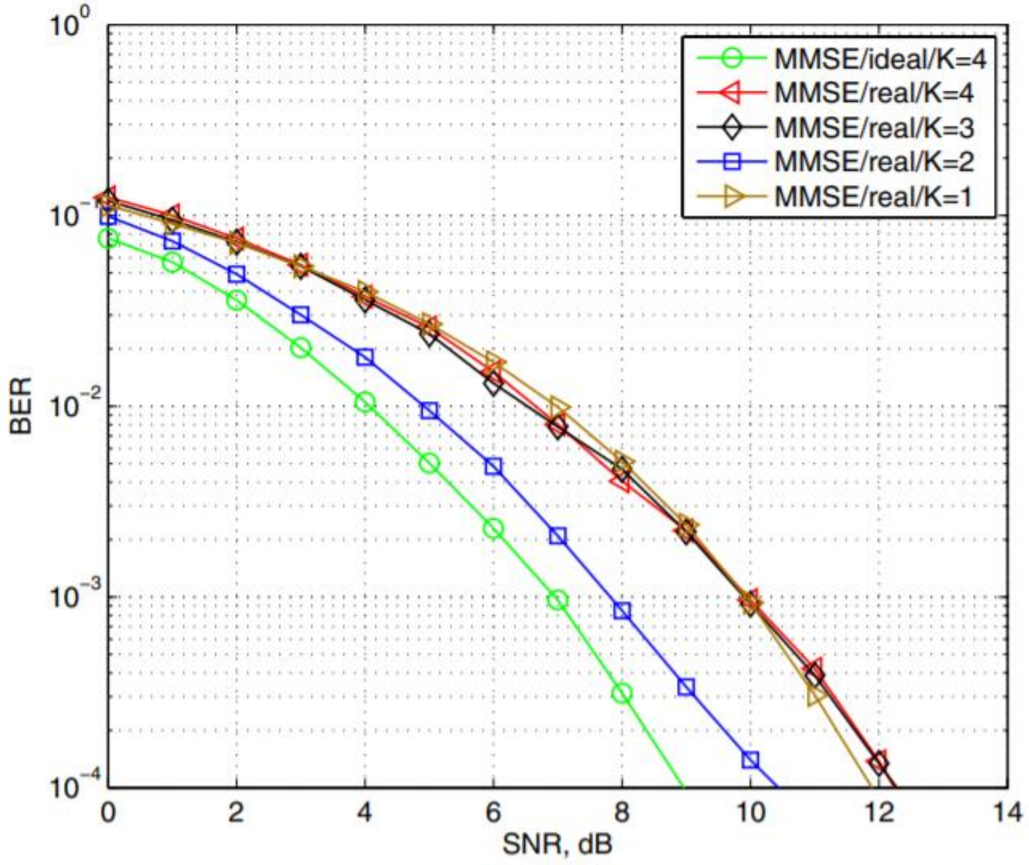
MIMO 4x4 with eigenmode selection





MIMO 4x6 with eigenmode selection





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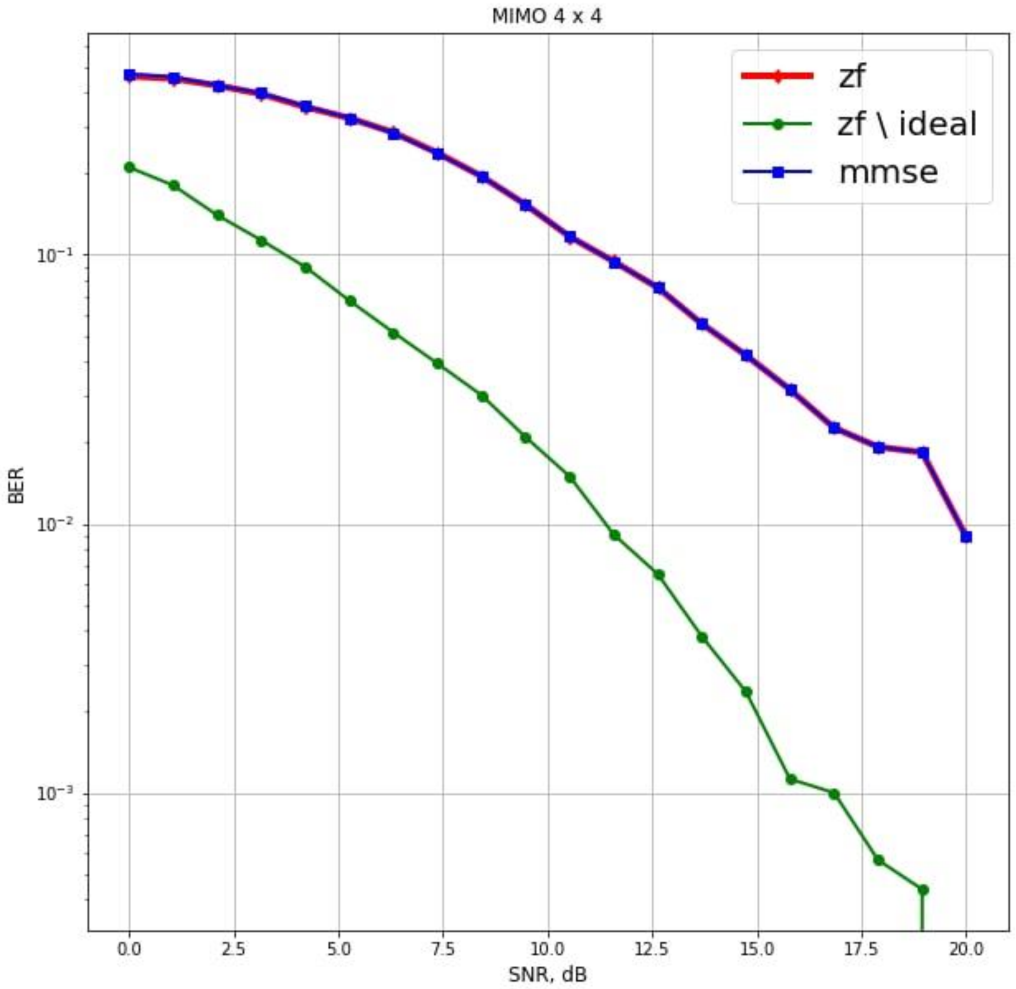
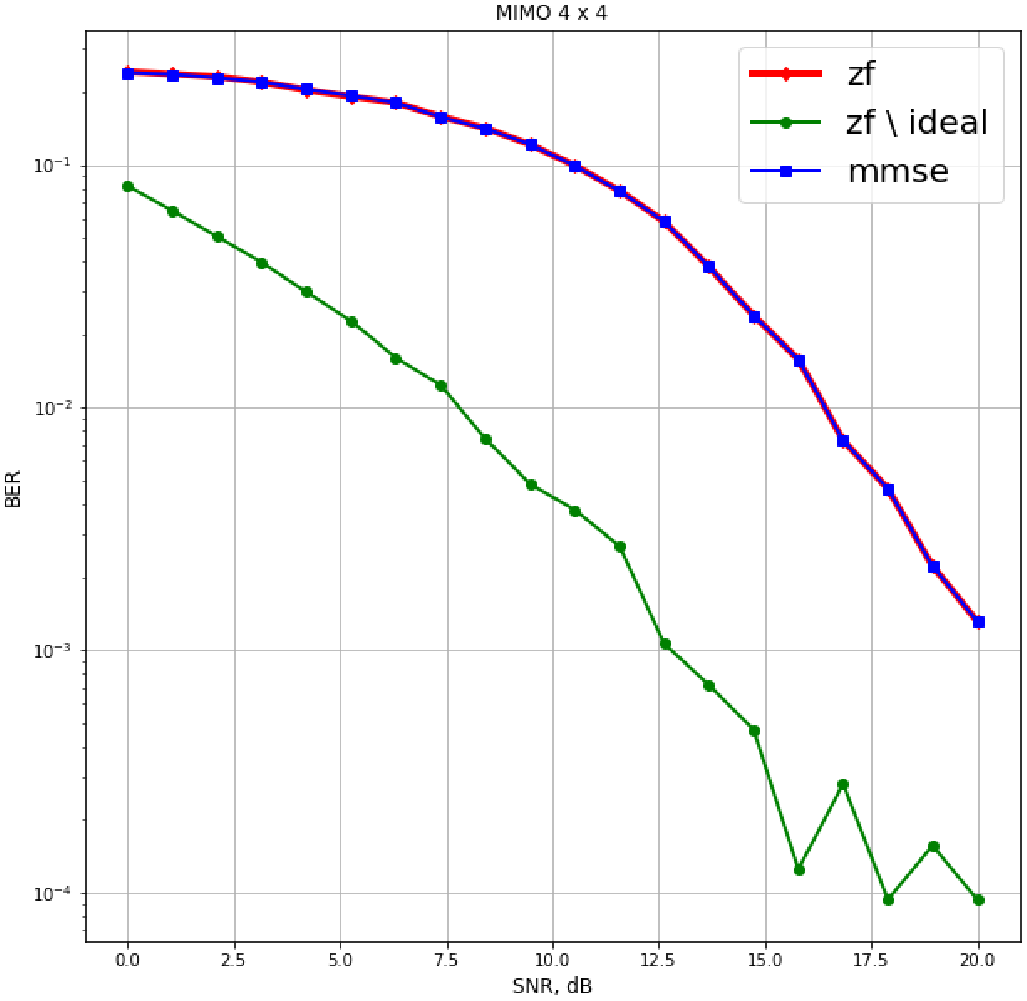
QAM random signal test





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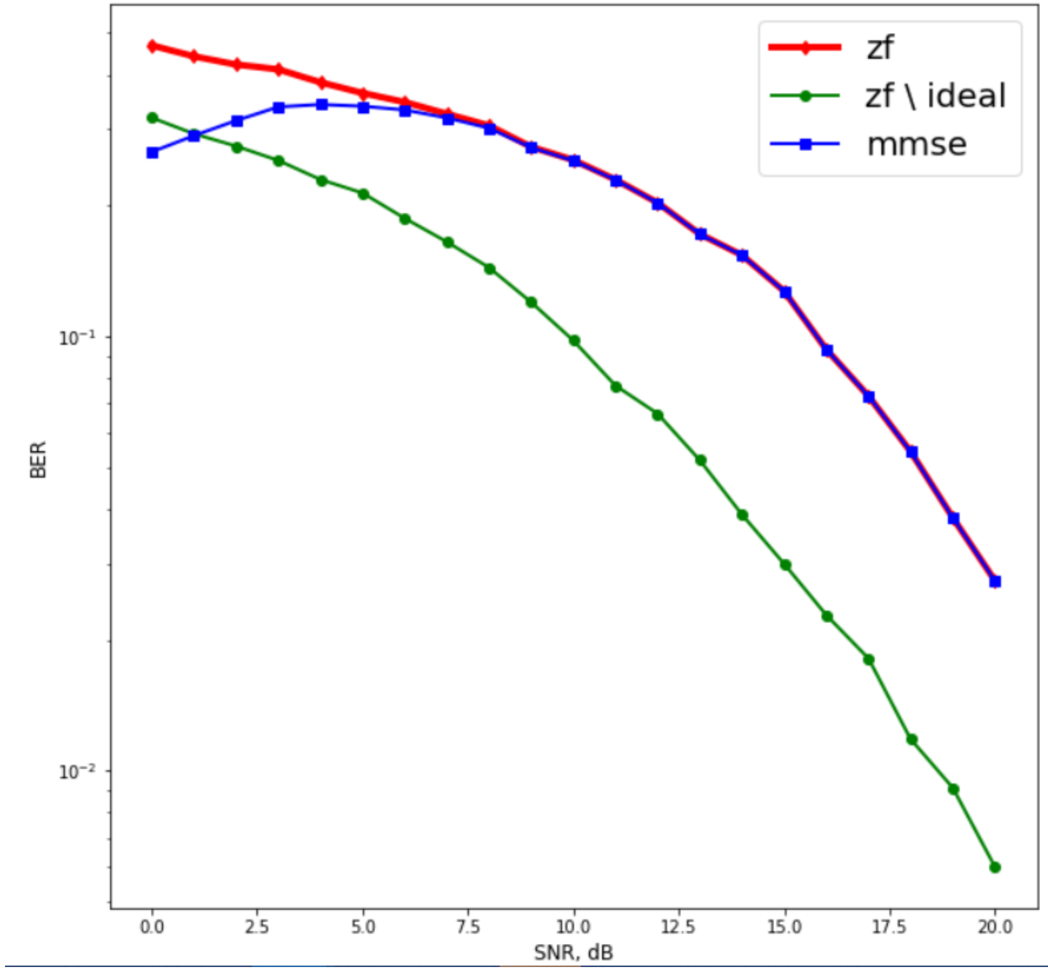
QAM DMRS test



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Summary

We have repeated (almost) most of the paper work. Some of the conclusions are not the same.
We couldn’t build spectral efficiency chart of eigenmodes due to lack of Information.
We can improve our project with massive mimo models such as 4x64 or with a lot of users interferance

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We are team ADA


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thx.

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