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SU-MIMO SVD DigCom System

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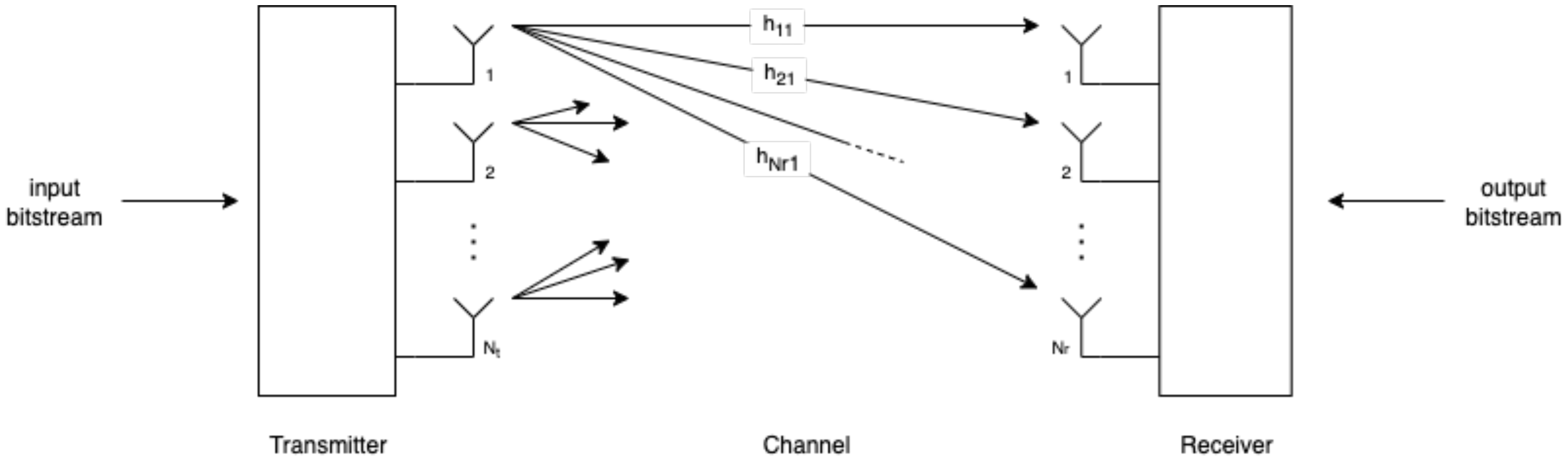
SU-MIMO SVD DigCom System



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SU-MIMO SVD DigCom System

A decomposition into R_H parallel eigenchannels when CSI is available.

The received symbol vector **r** is can be expressed as

$$\mathbf{r} = \mathrm{H} \cdot \mathbf{s} + \mathbf{w}$$

SVD of the channel matrix: $\mathrm{H} = \mathrm{U} \cdot \Sigma \cdot \mathrm{V}^{\mathrm{H}}$

$$\mathbf{r} = (\mathrm{U} \cdot \Sigma \cdot \mathrm{V}^{\mathrm{H}}) \cdot \mathbf{s} + \mathbf{w}$$

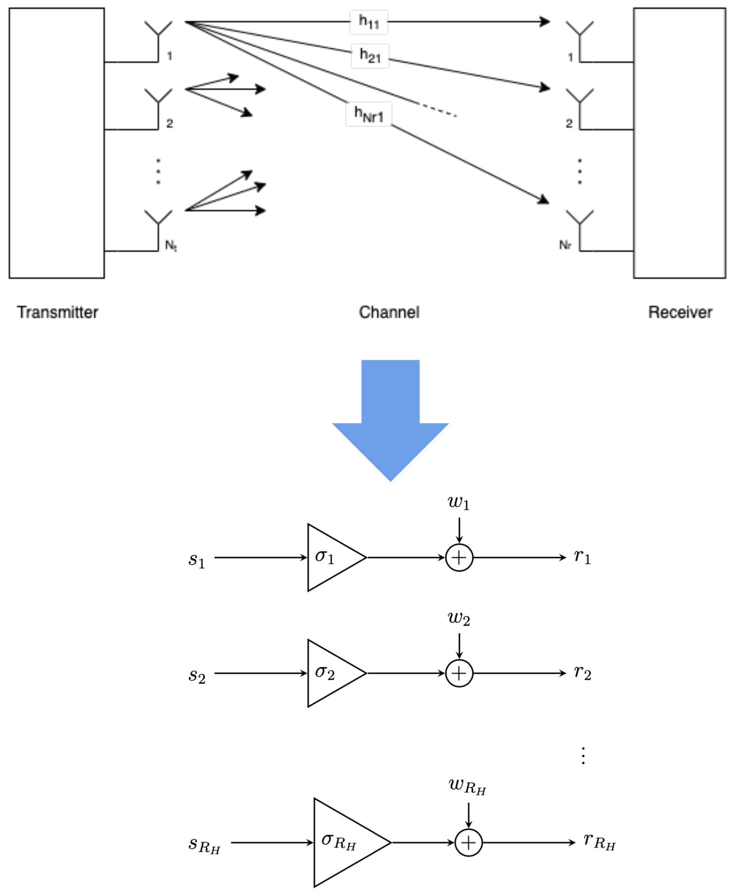
Precoding at transmitter: $\mathbf{s} = \mathrm{V} \cdot \mathbf{s}'$

Postcoding at receiver: $\mathbf{r} = \mathrm{U}^{\mathrm{H}} \cdot \mathbf{r}'$

$$\mathbf{r}' = \mathrm{U}^{\mathrm{H}} \cdot (\mathrm{U} \cdot \Sigma \cdot \mathrm{V}^{\mathrm{H}}) \cdot \mathrm{V}\, \mathbf{s}' + \mathrm{U}^{\mathrm{H}} \cdot \mathbf{w}$$

$$\mathbf{r}' = \Sigma \cdot \mathbf{s}' + \mathrm{U}^{\mathrm{H}} \cdot \mathbf{w}$$

$$\mathbf{r}' = \Sigma \cdot \mathbf{s}' + \mathbf{w}'$$



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SU-MIMO SVD DigCom System

Extension: power & constellation allocation

The capacity of the system can be expressed as:

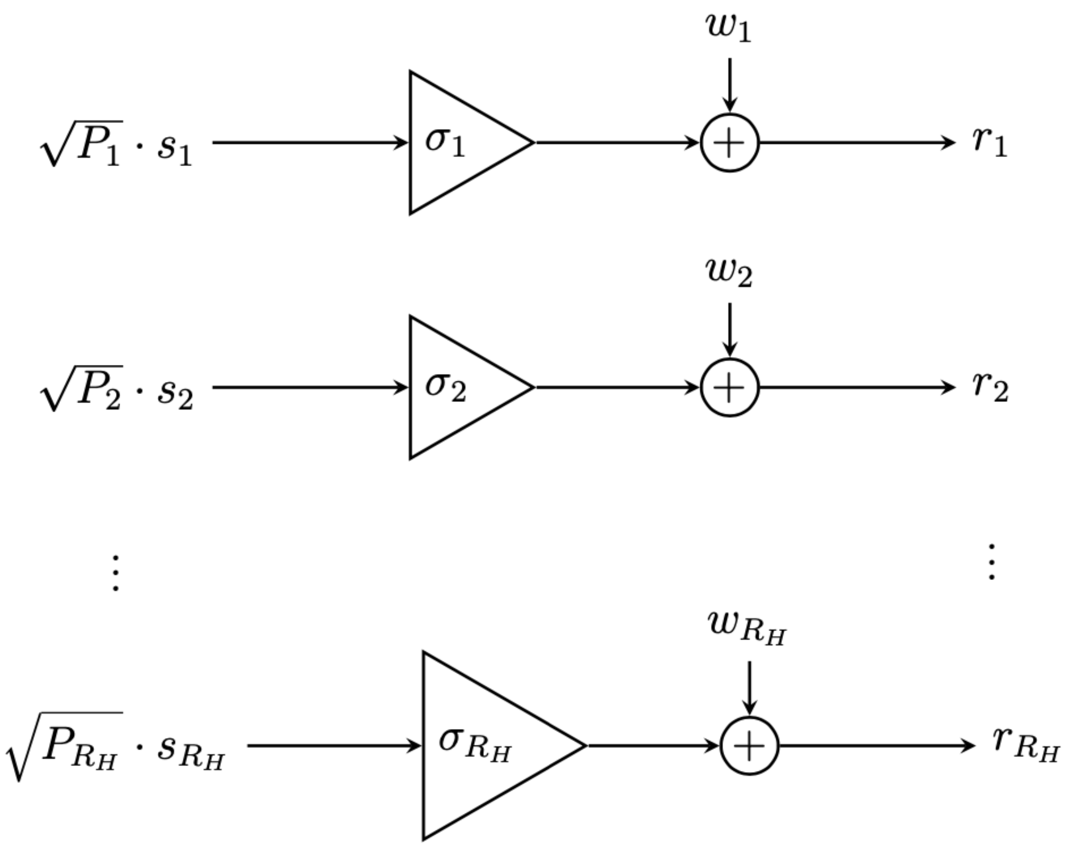
$$C = 2B \cdot \sum_{i=1}^{R_H} \log_2 \left(1 + \frac{P_i \sigma_i^2}{2BN_0}\right)$$

Maximize the capacity by allocating the available transmit **power** across the transmit antennas in an optimal way.

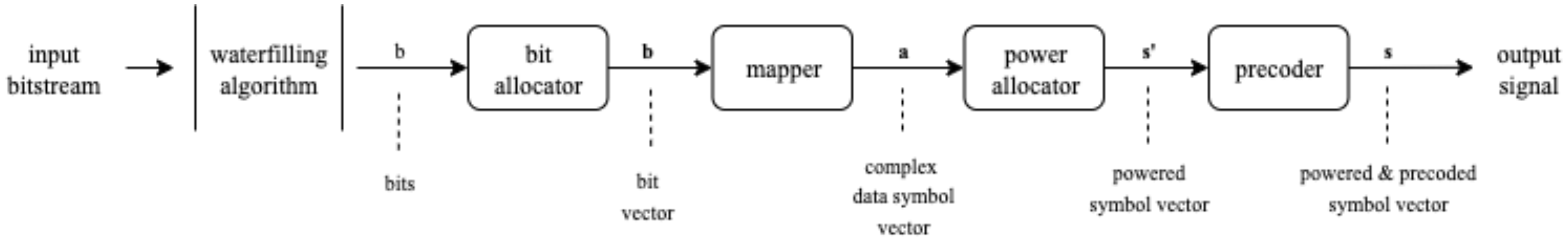
Send data at full capacity rate in each eigenchannel by varying the **constellation size** for each transmit antenna.

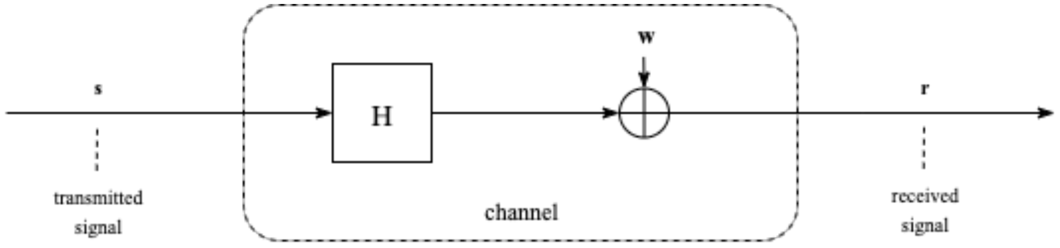
The optimal power allocation and constellation sizes are calculated using the **waterfilling algorithm**.

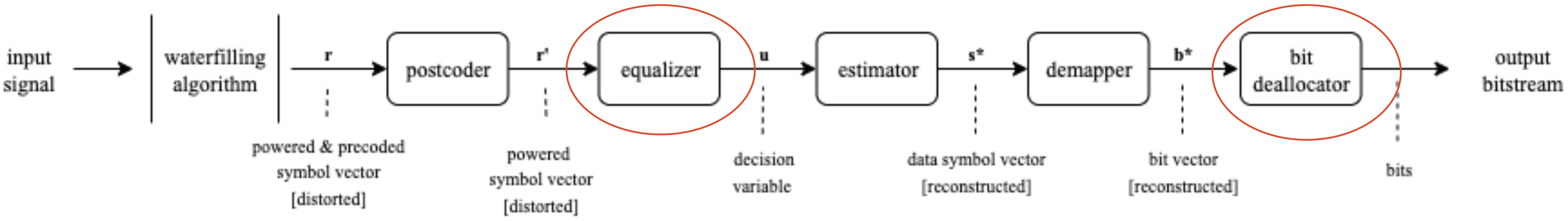
SU-MIMO SVD DigCom System



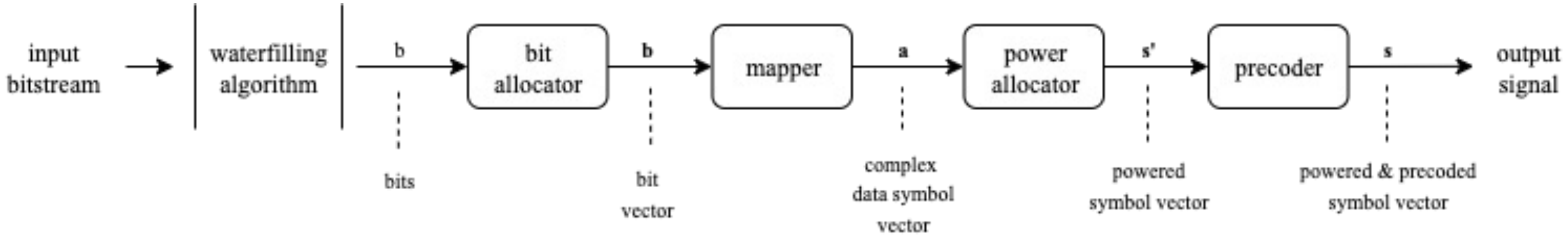
System Design

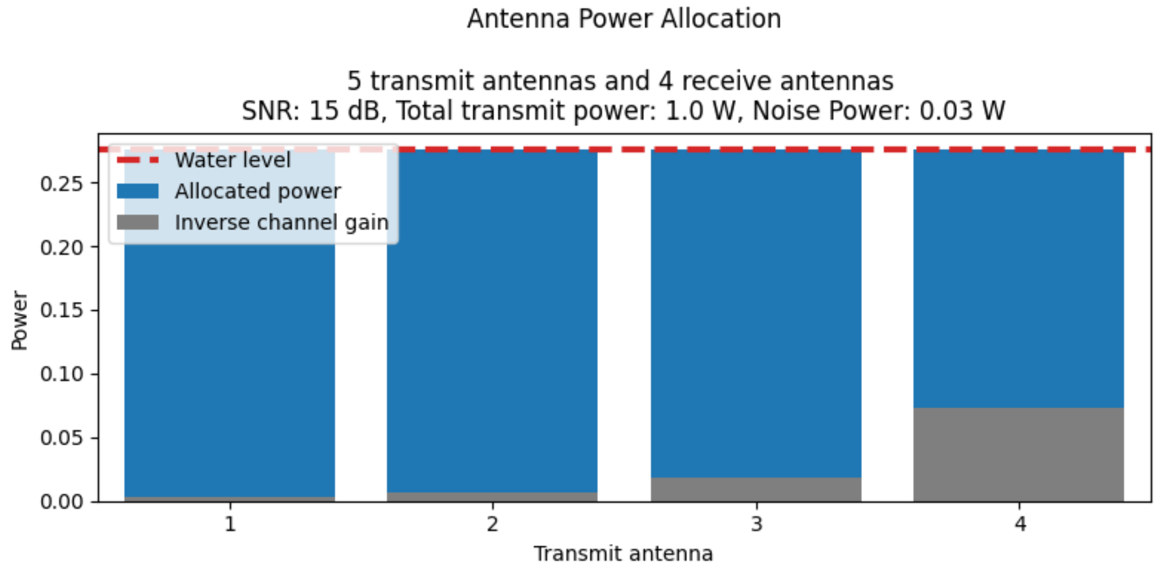


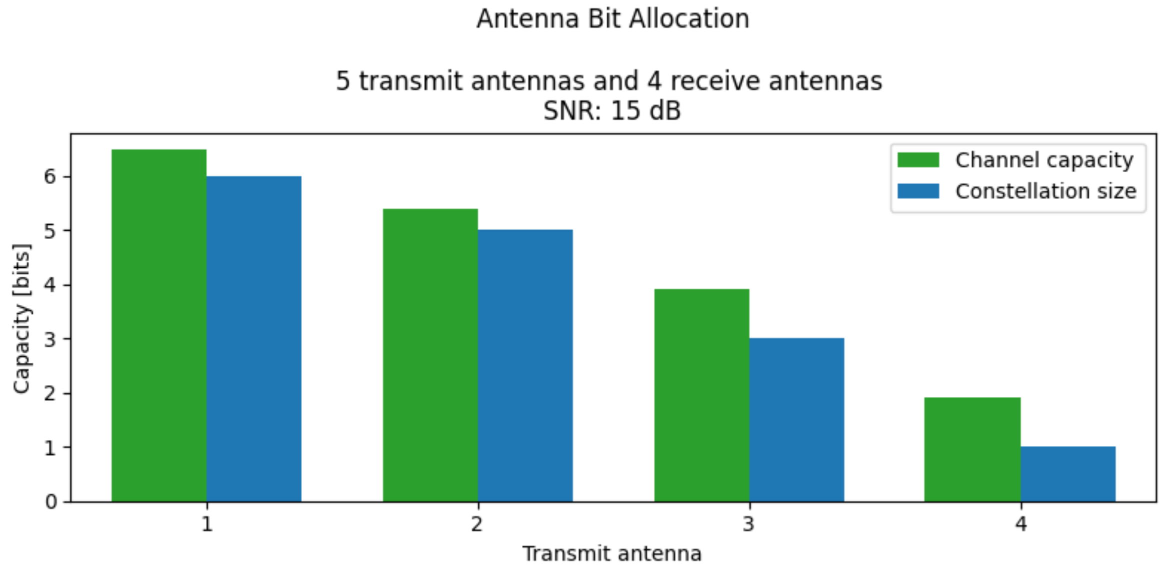




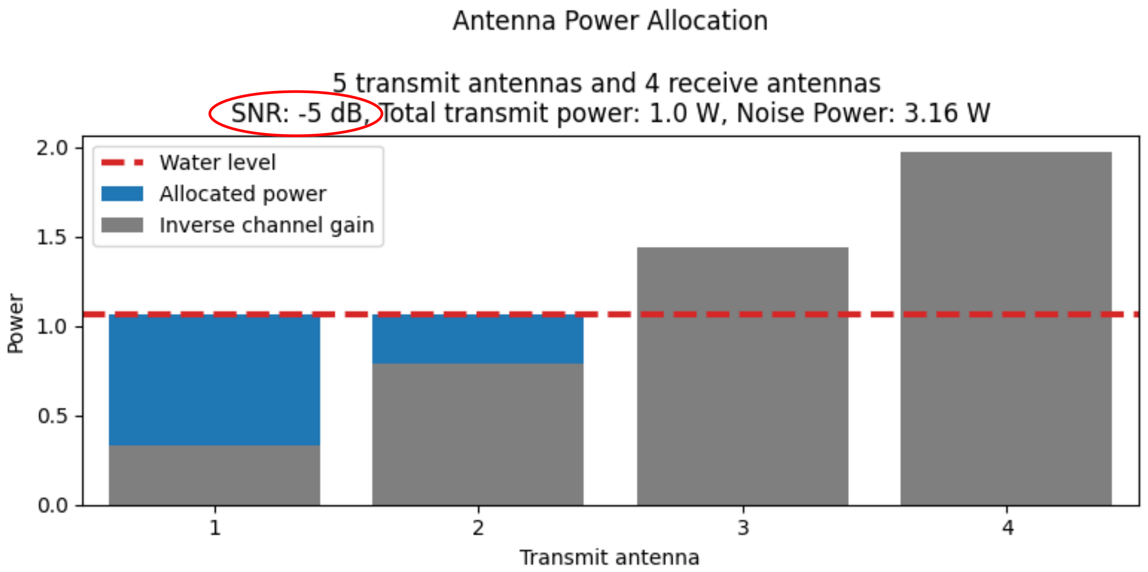
System Design - The Transmitter

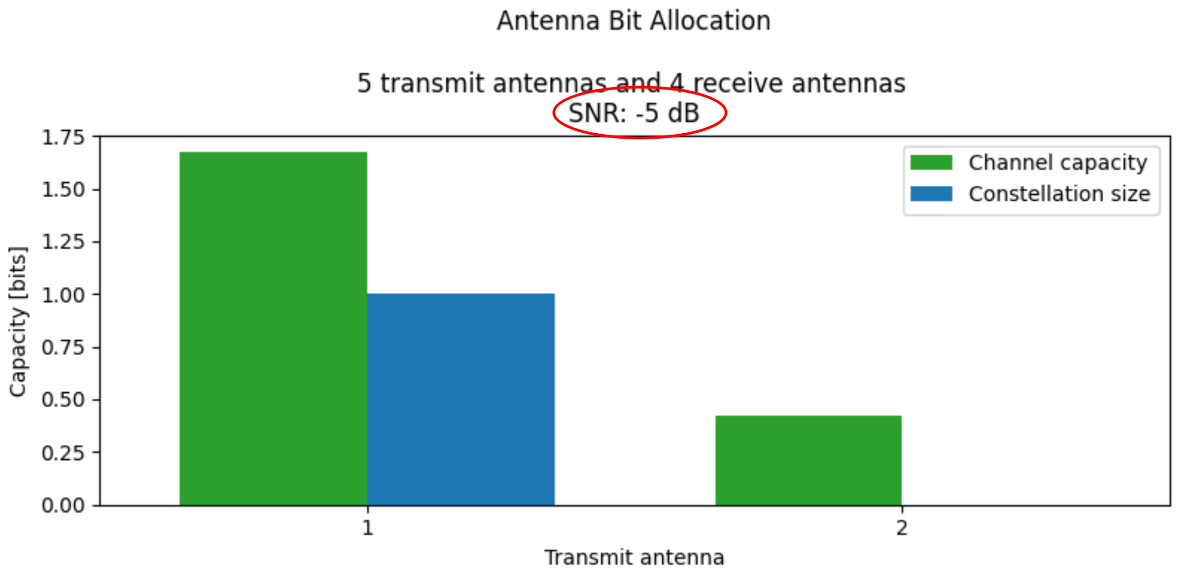


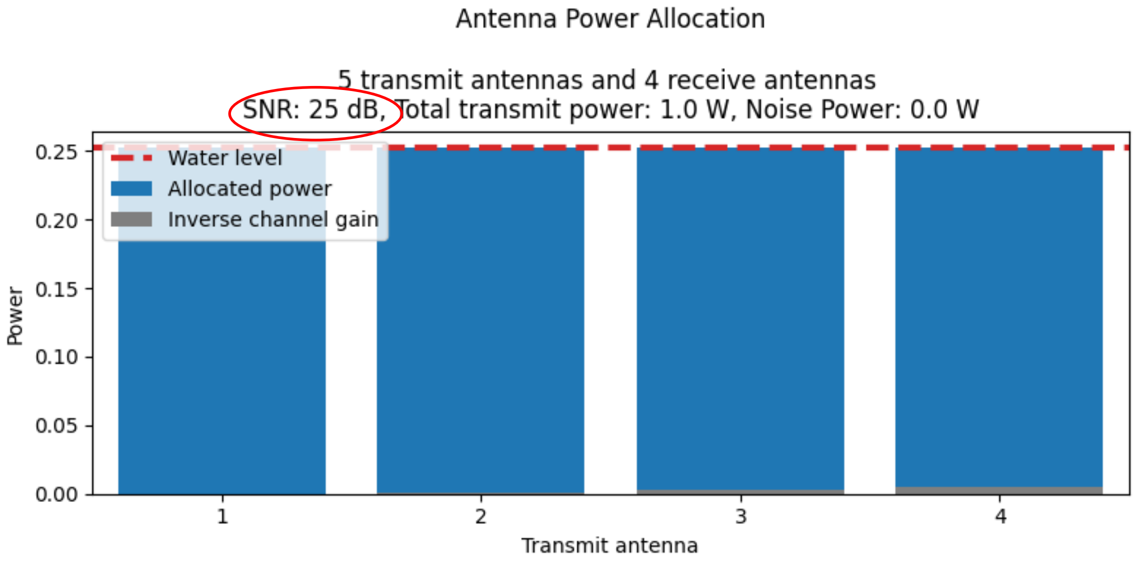


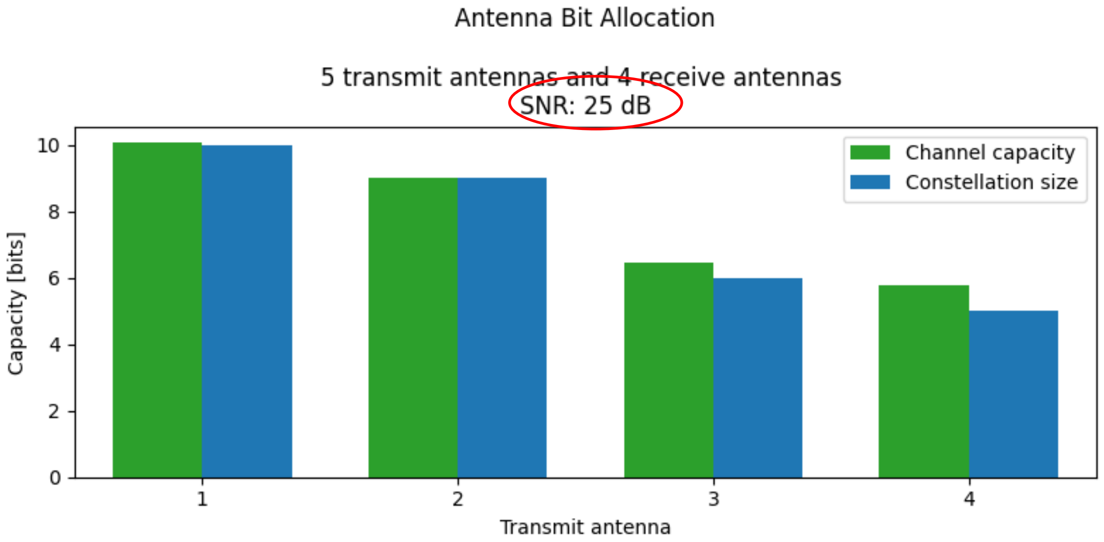


System Design - The Transmitter

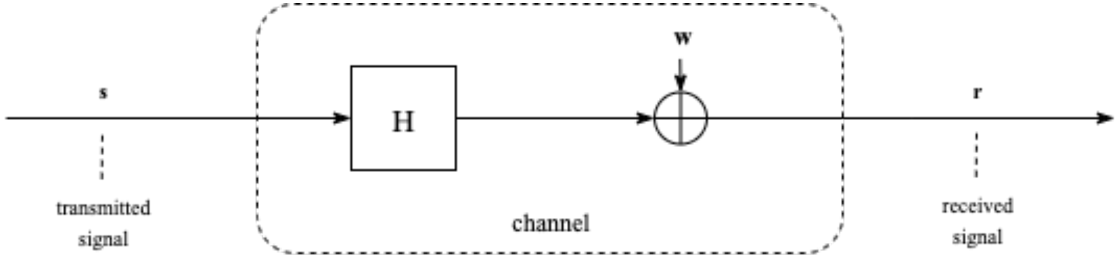


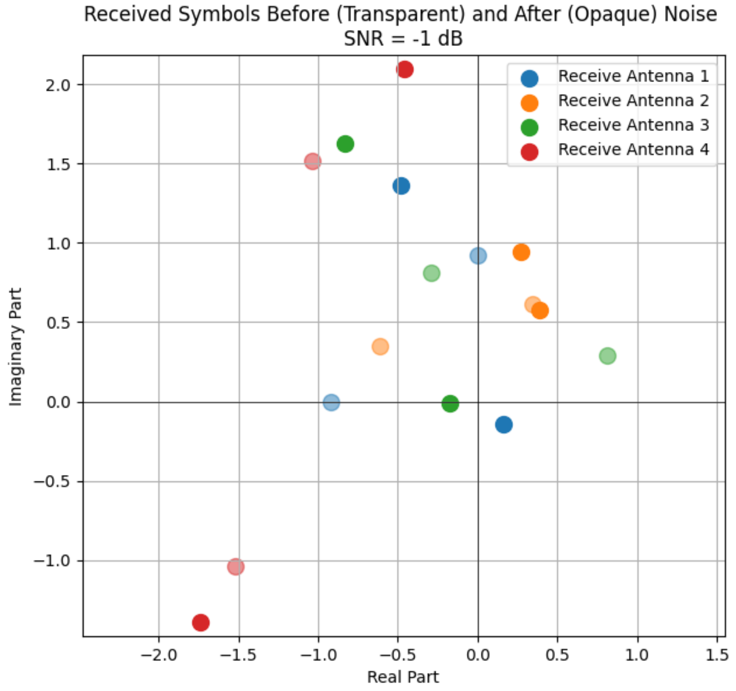


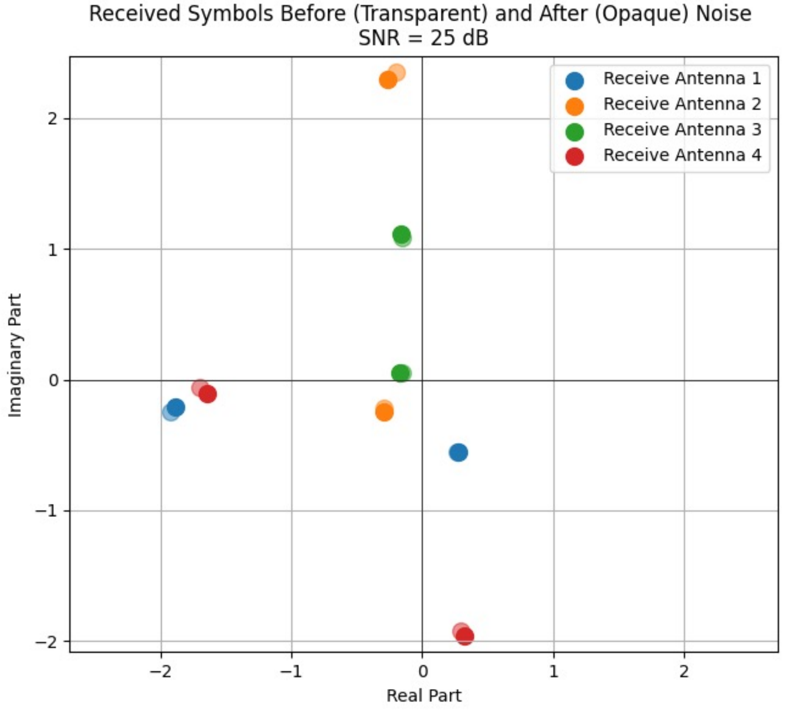




System Design - The Channel







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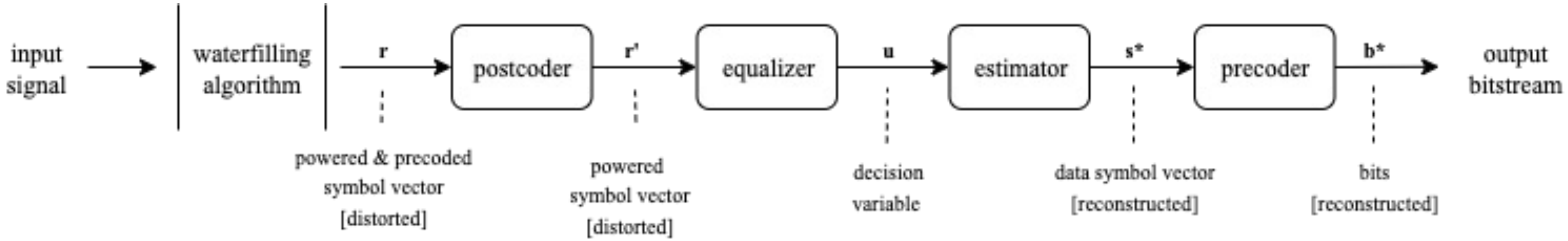
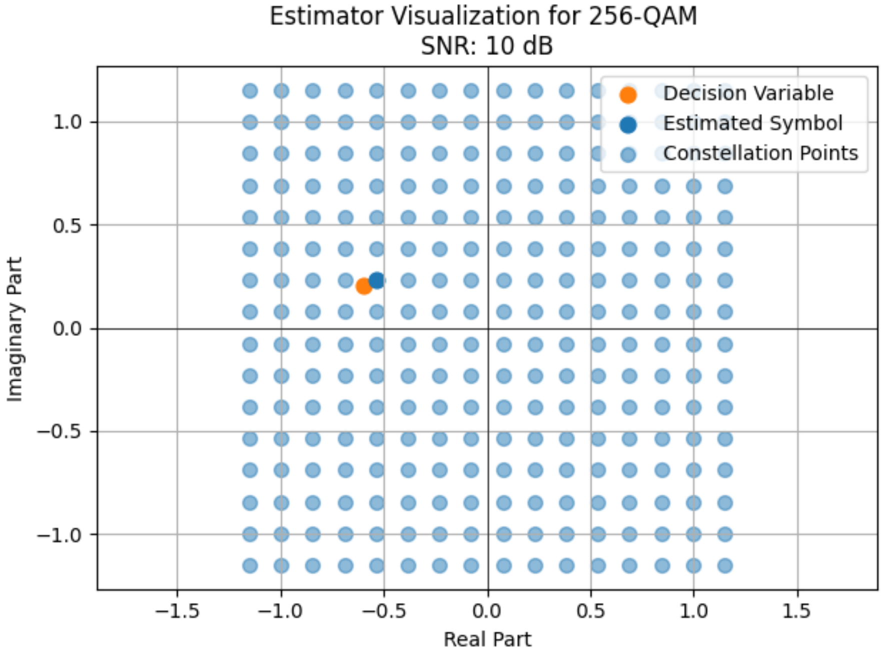
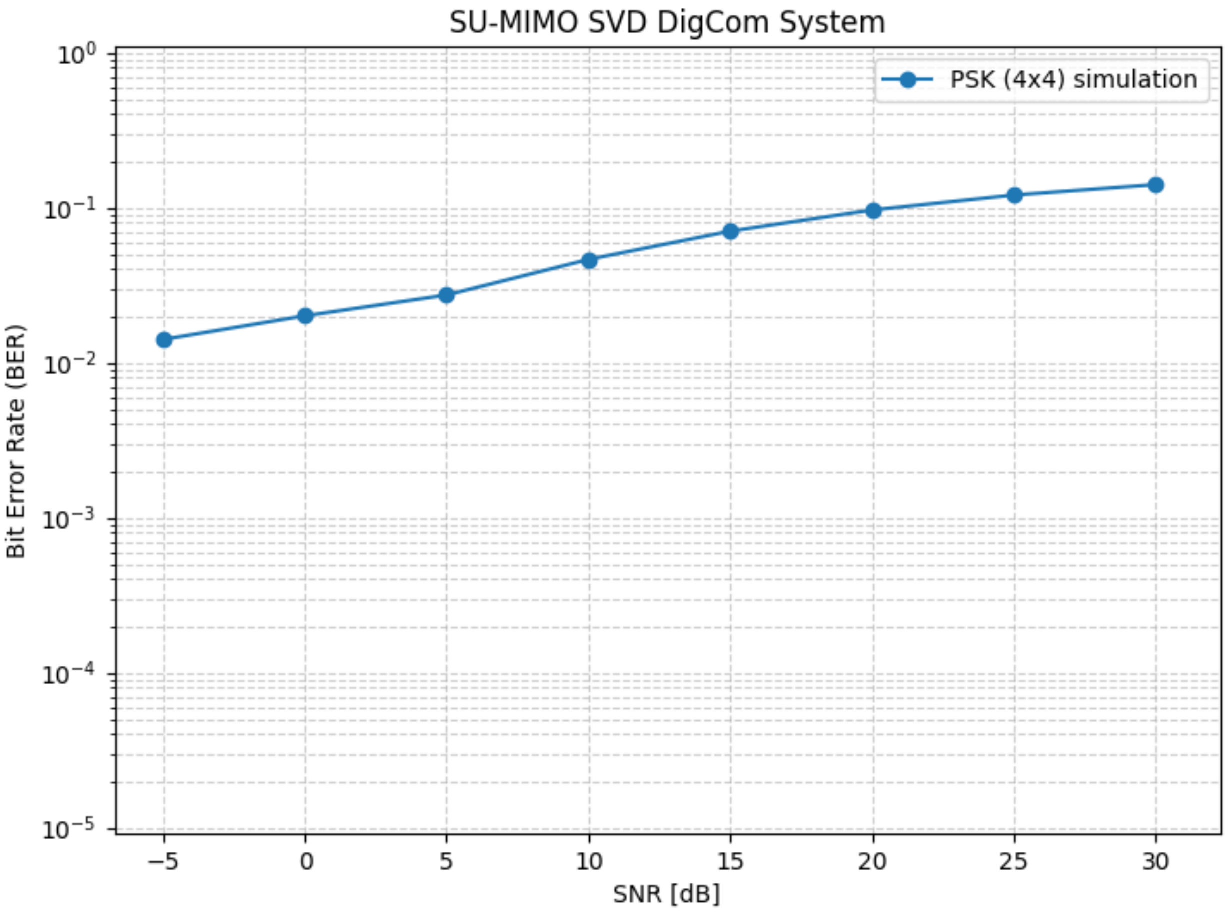
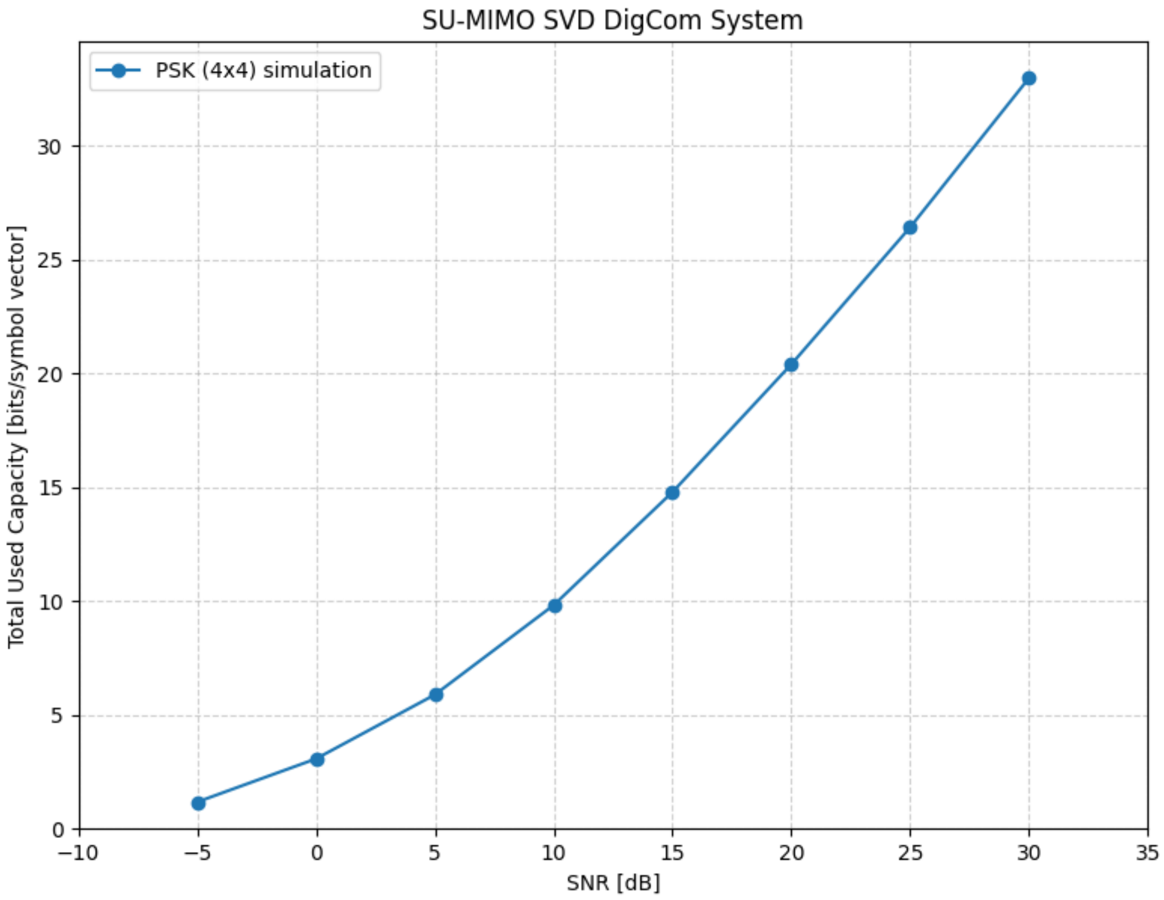
System Design - The Receiver





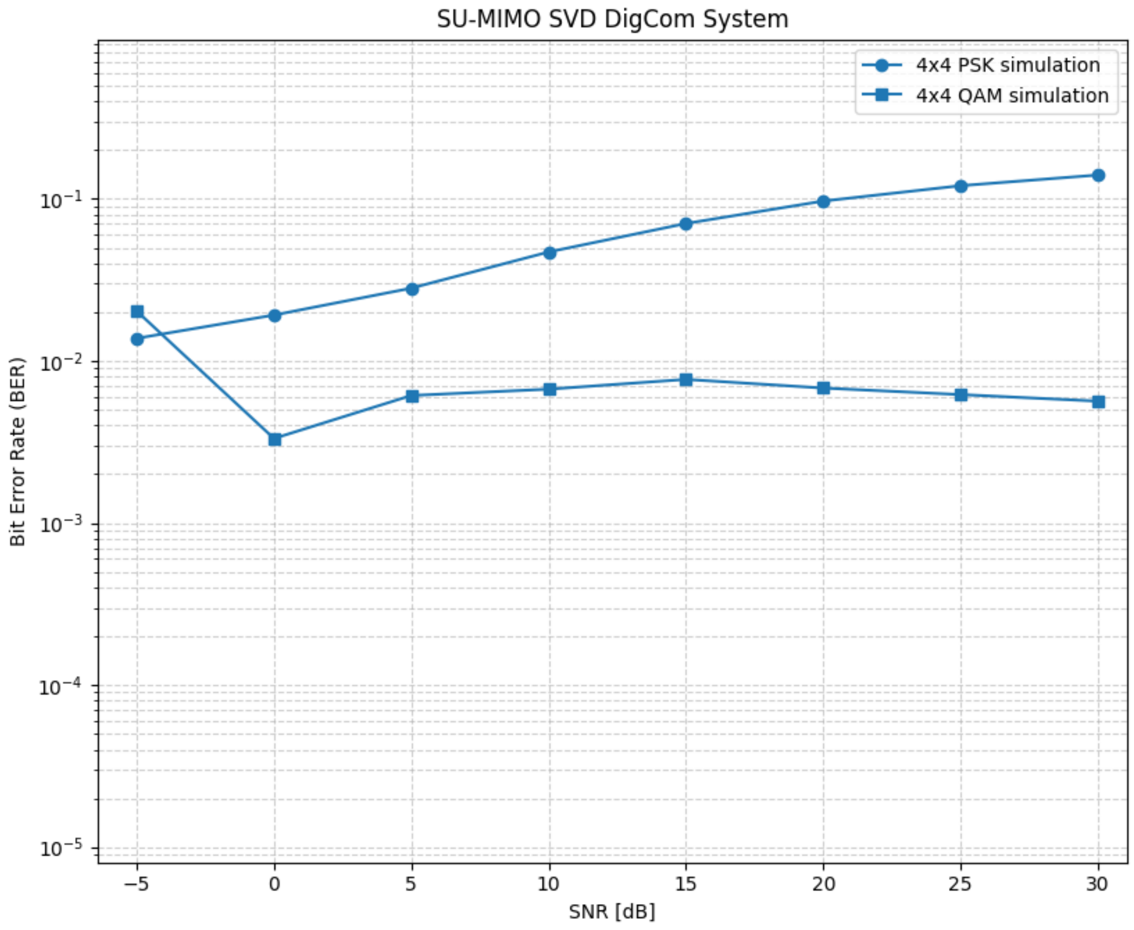
System Performance - Simulatons

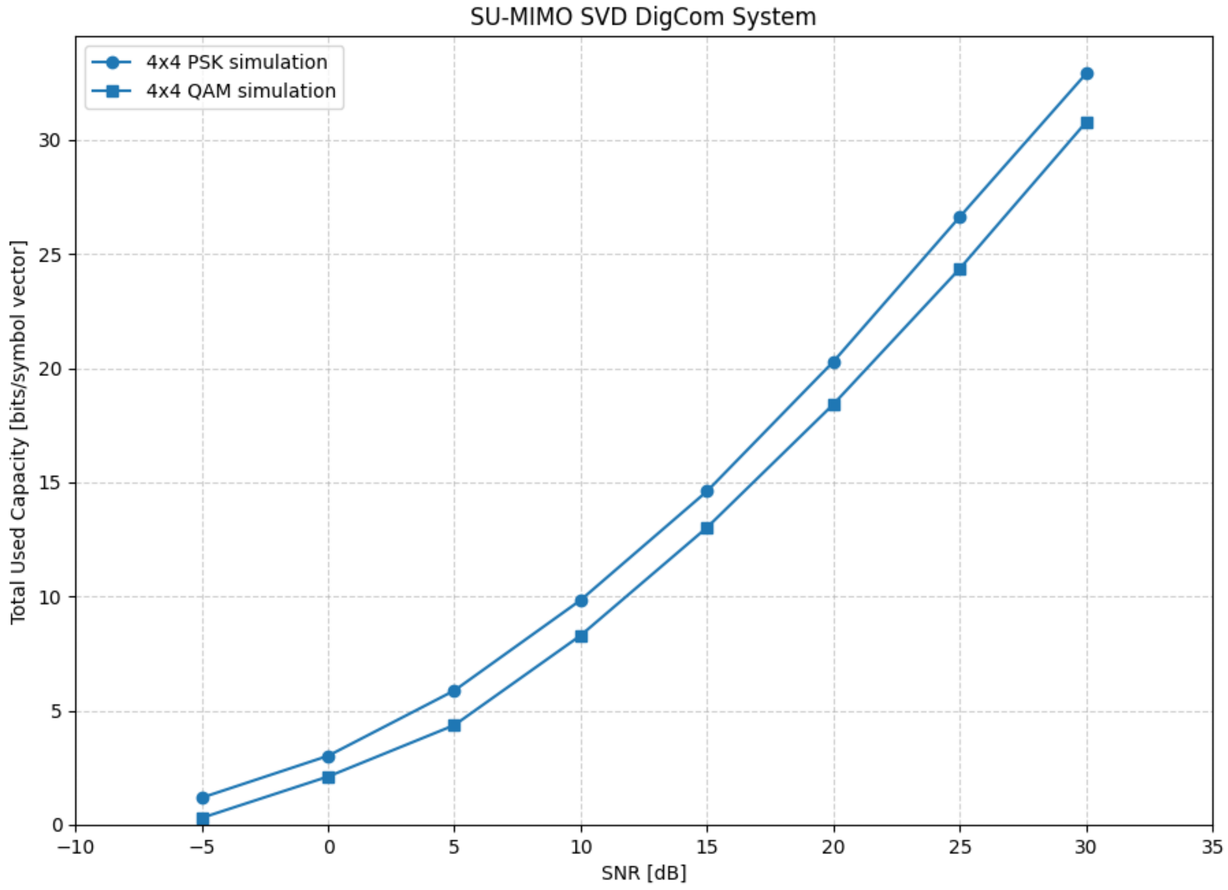




System Performance - Simulatons

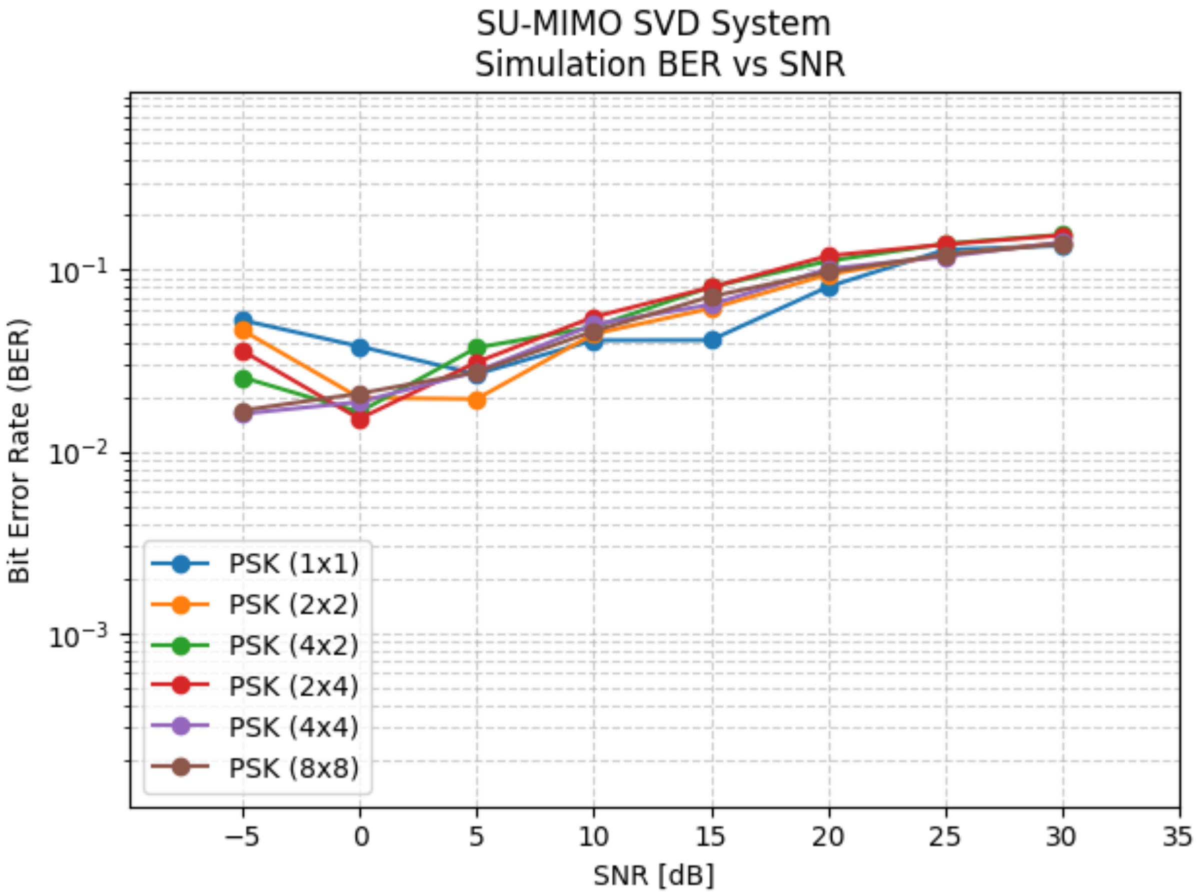
Different Systems

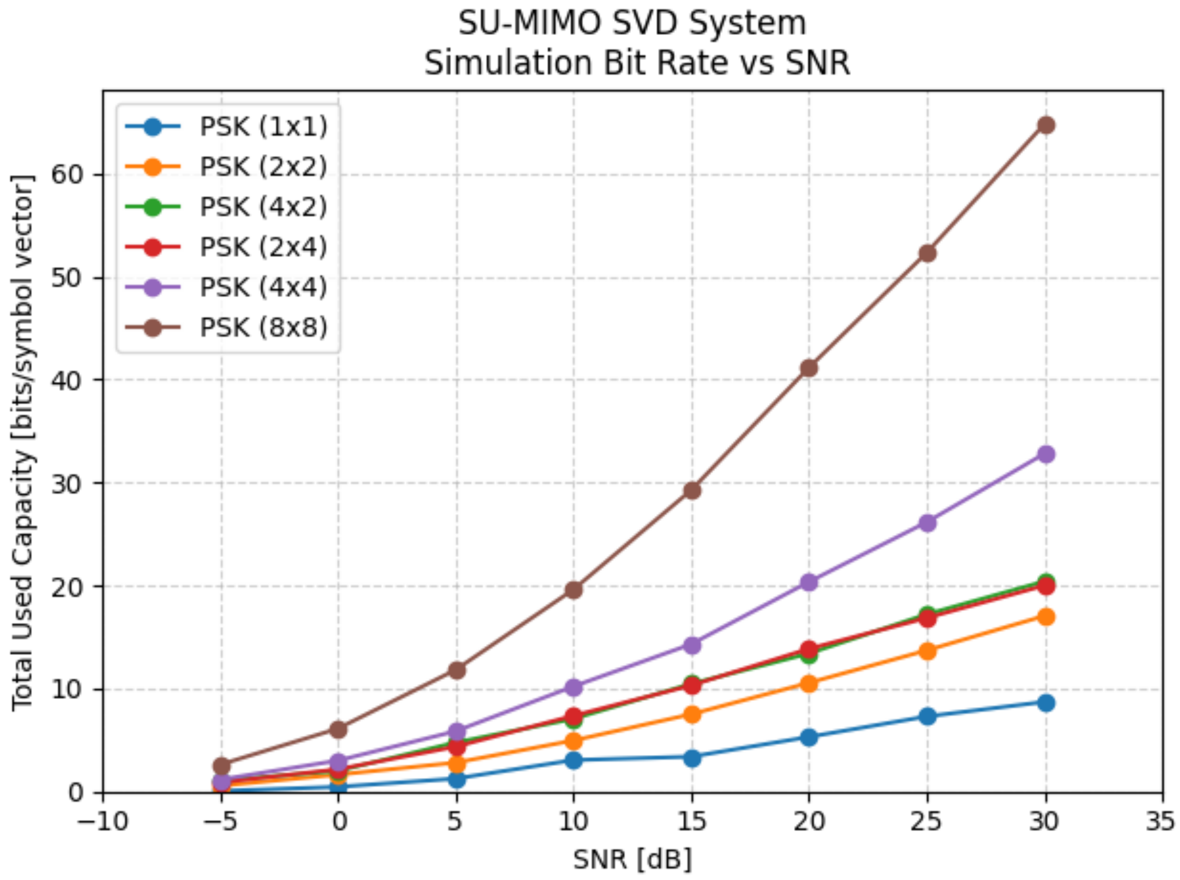




System Performance - Simulatons

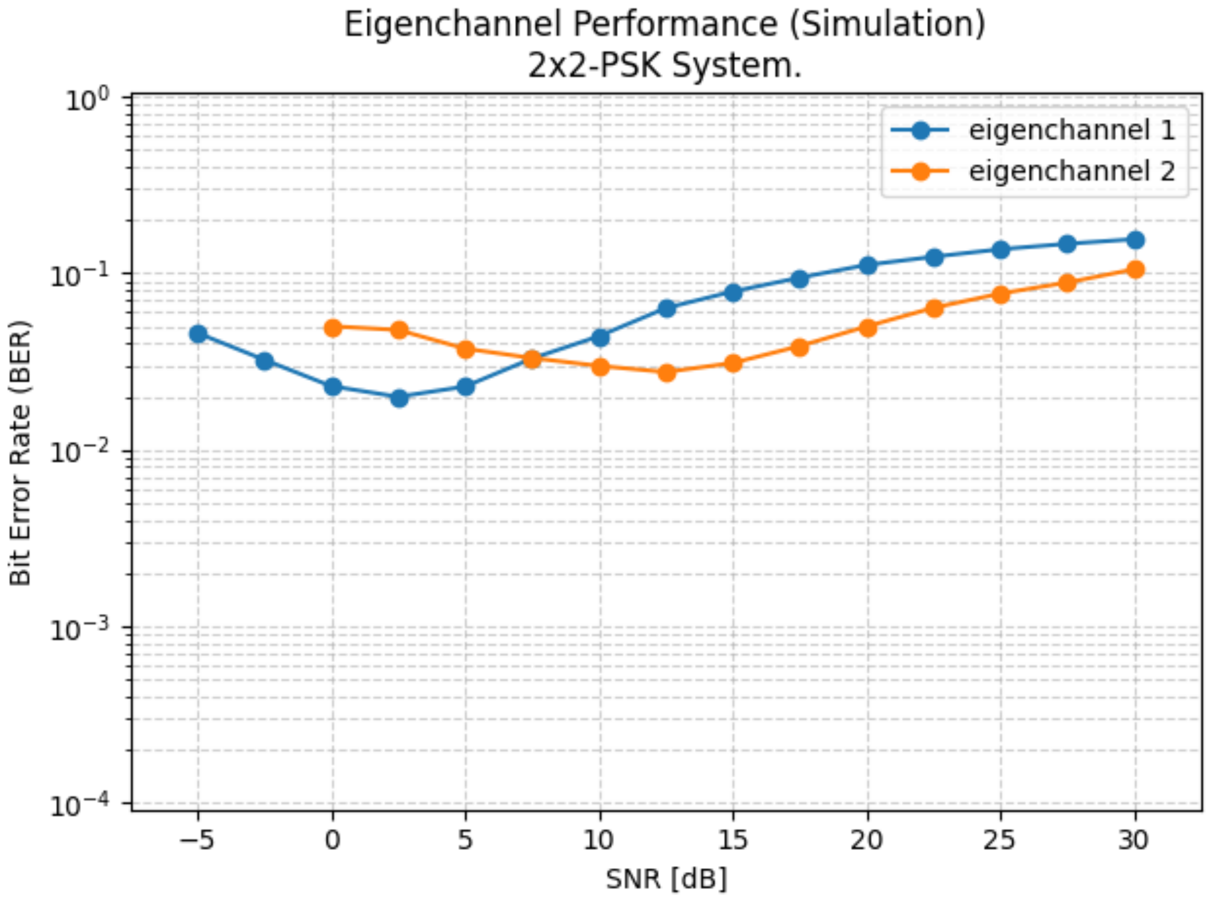
Different Systems

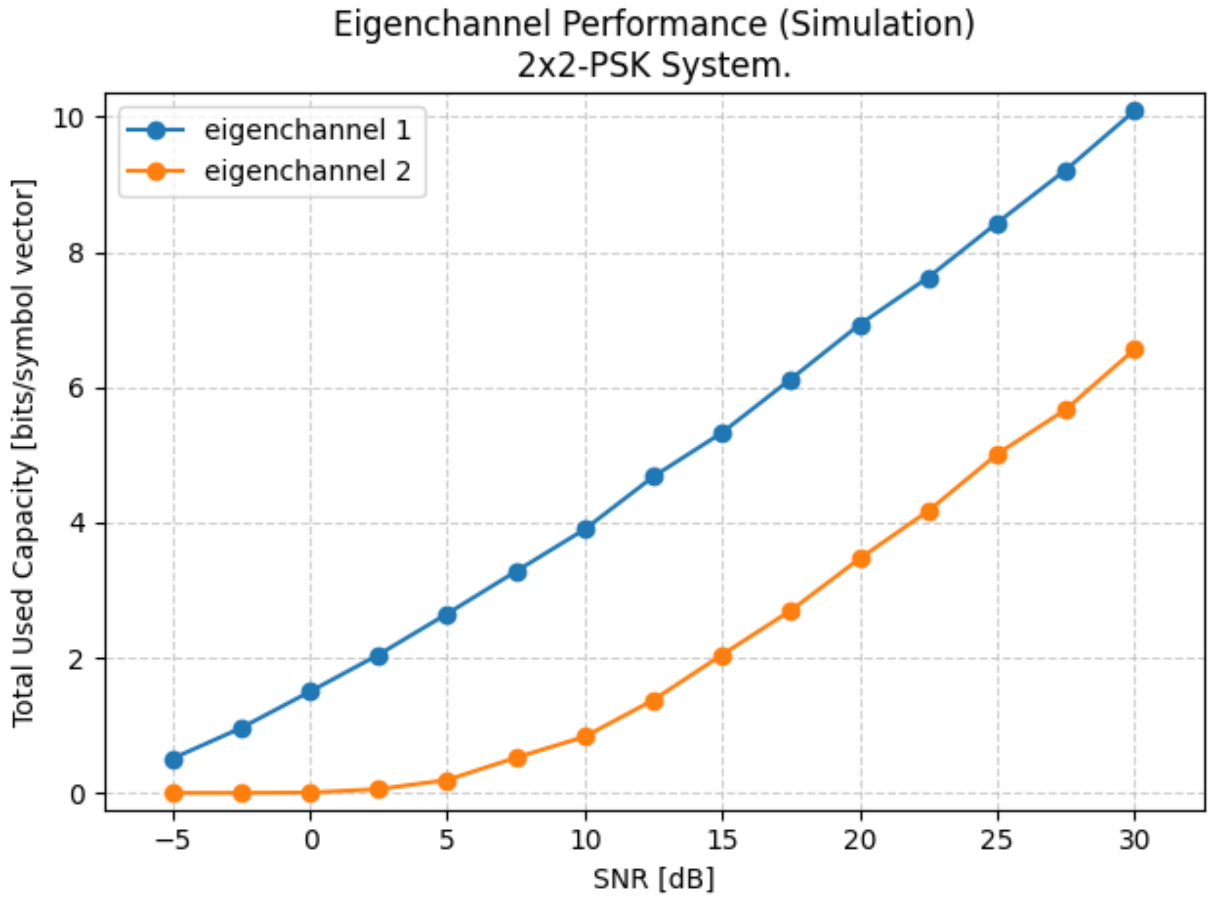




System Performance - Simulatons

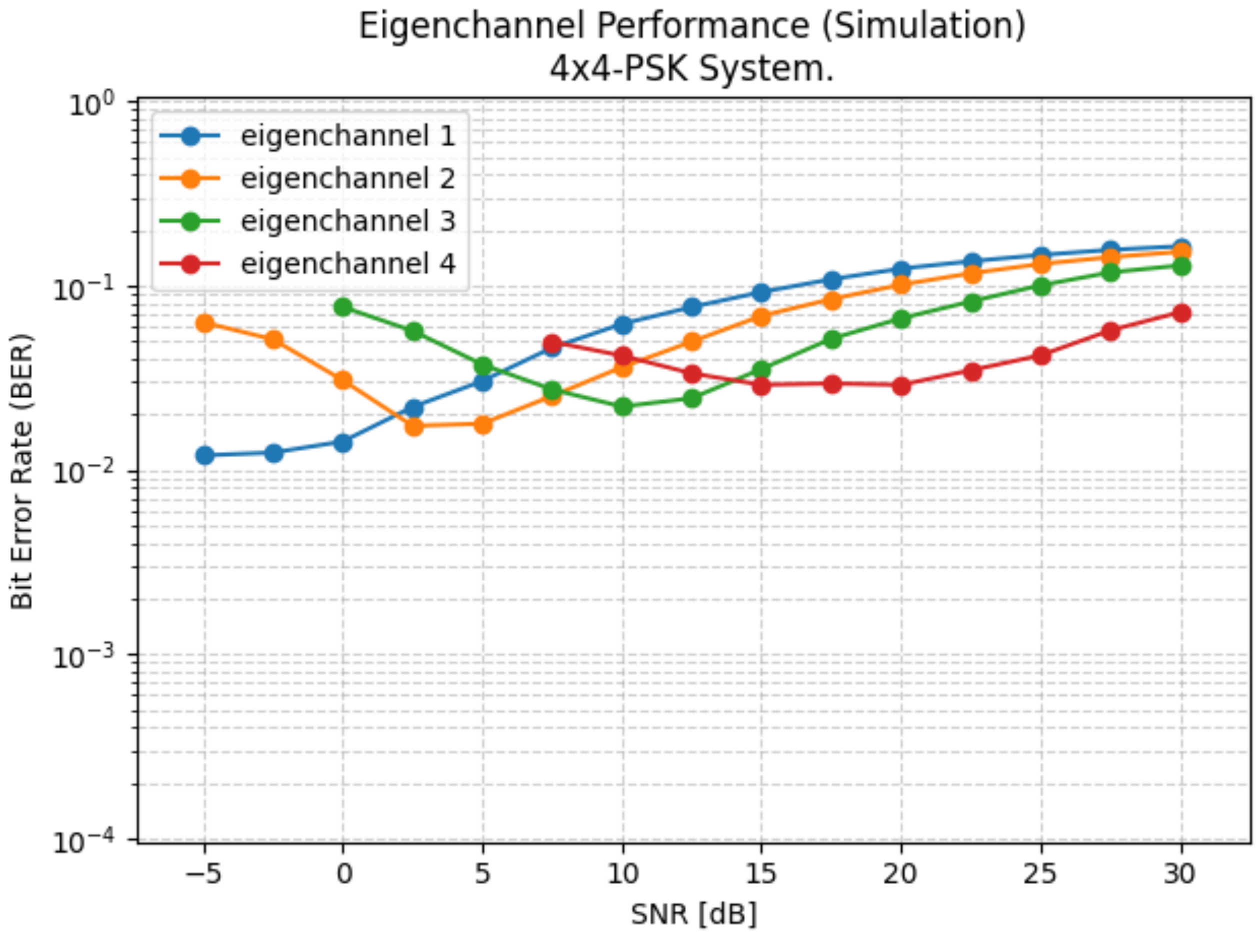
Different Eigenchannels

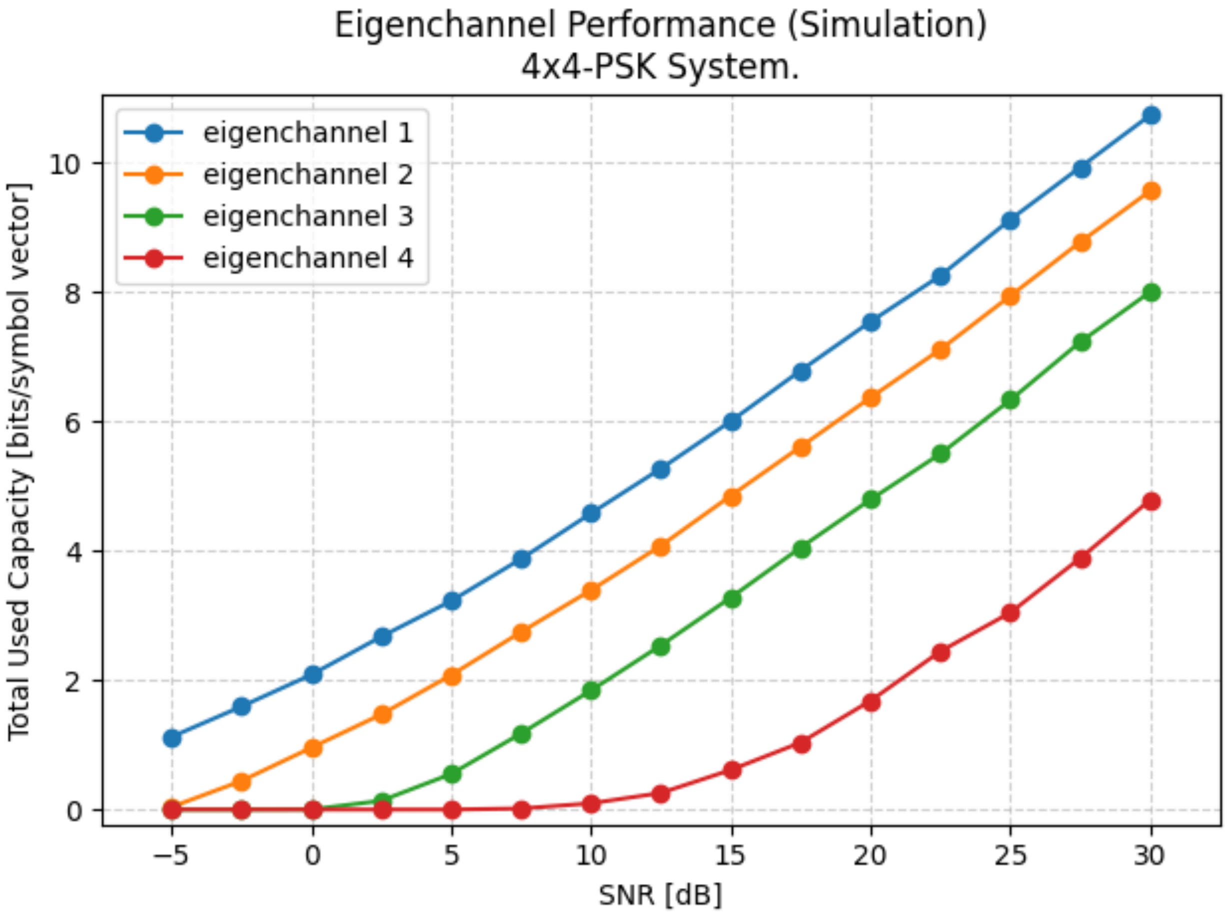




System Performance - Simulatons

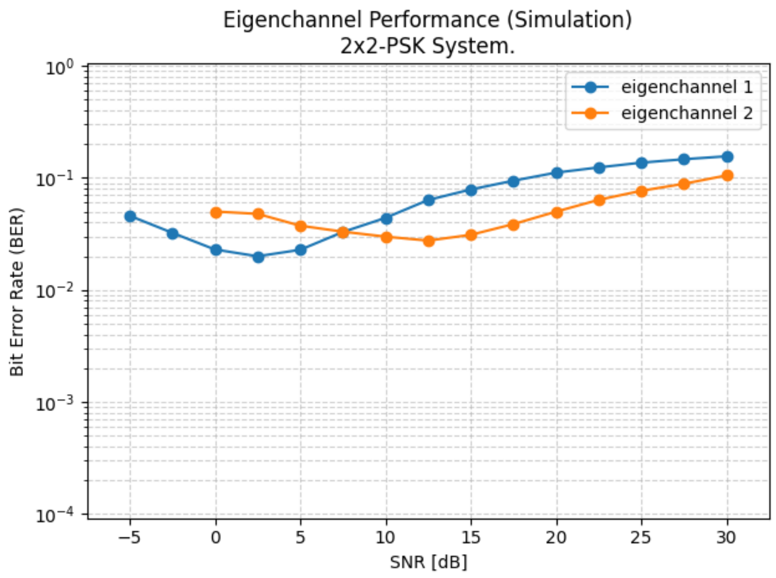
Different Eigenchannels

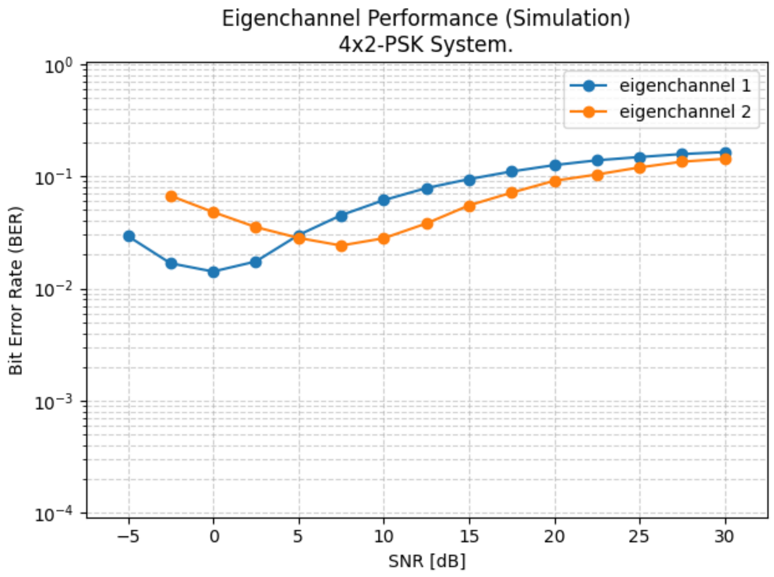


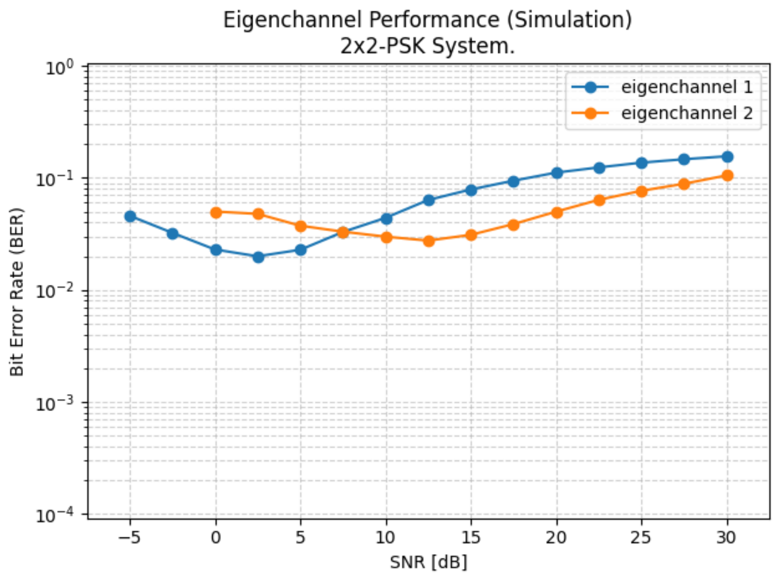


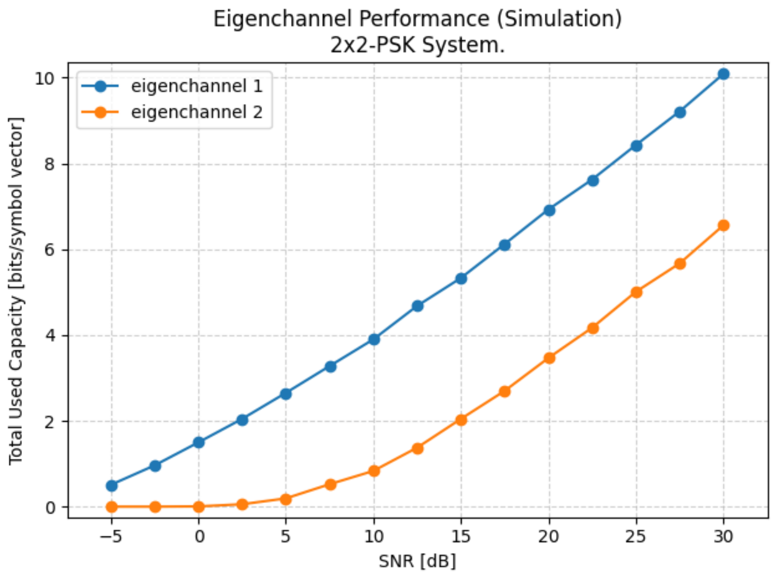
System Performance - Simulatons

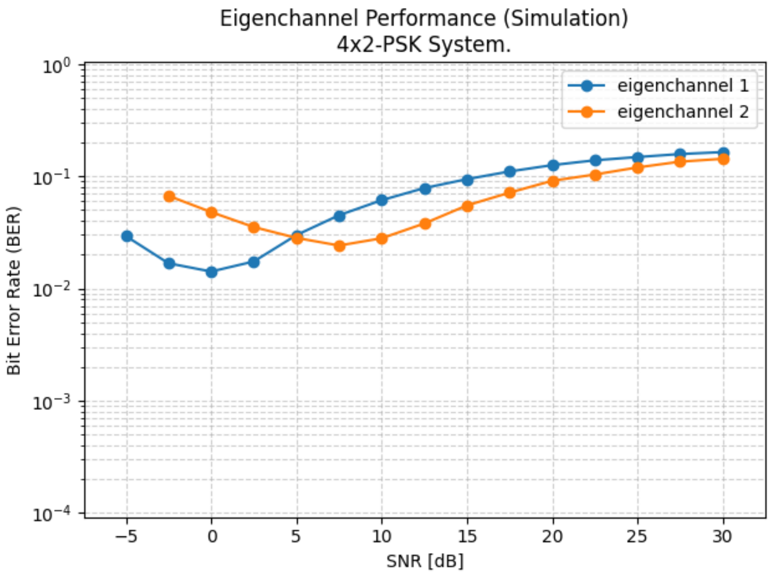
Different Eigenchannels: difference between 2x2 and 4x2 systems

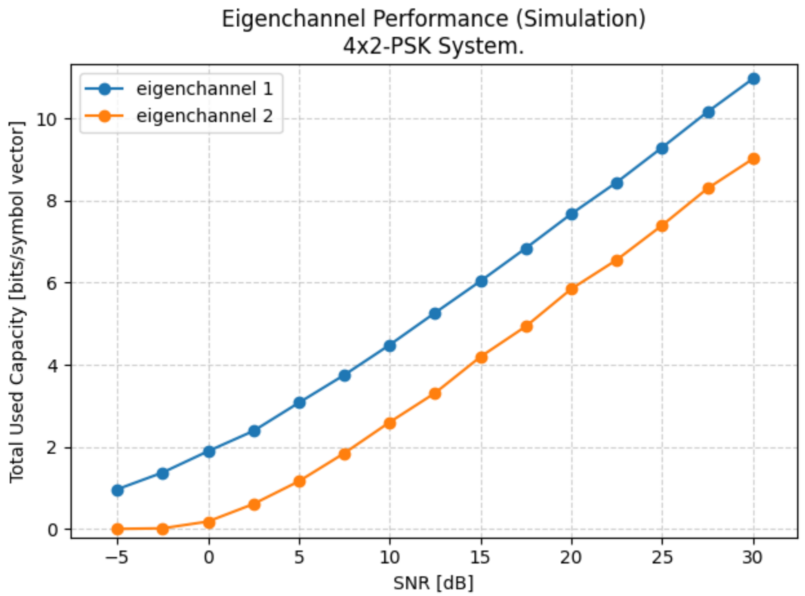

Eigenchannel Performance (Simulation)
2x2-PSK System.
eigenchannel 1
eigenchannel 2
Bit Error Rate (BER)
SNR [dB]

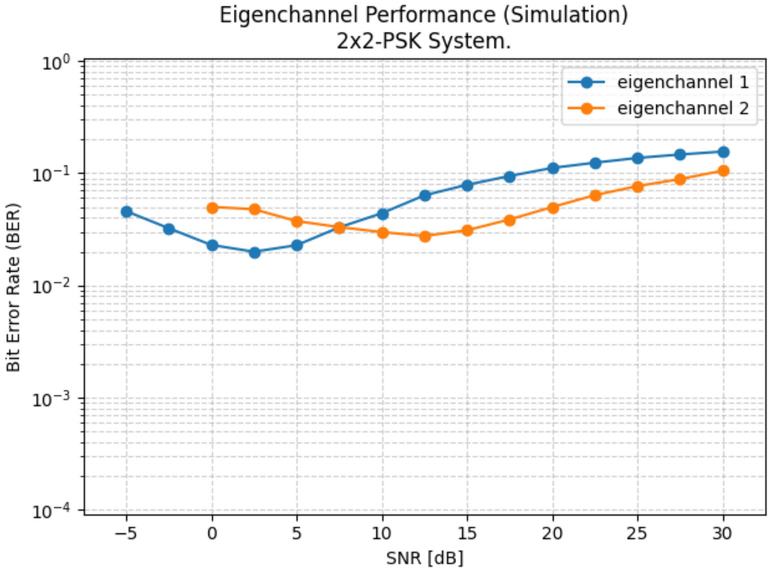

Eigenchannel Performance (Simulation)
4x2-PSK System.
eigenchannel 1
eigenchannel 2
Bit Error Rate (BER)
SNR [dB]

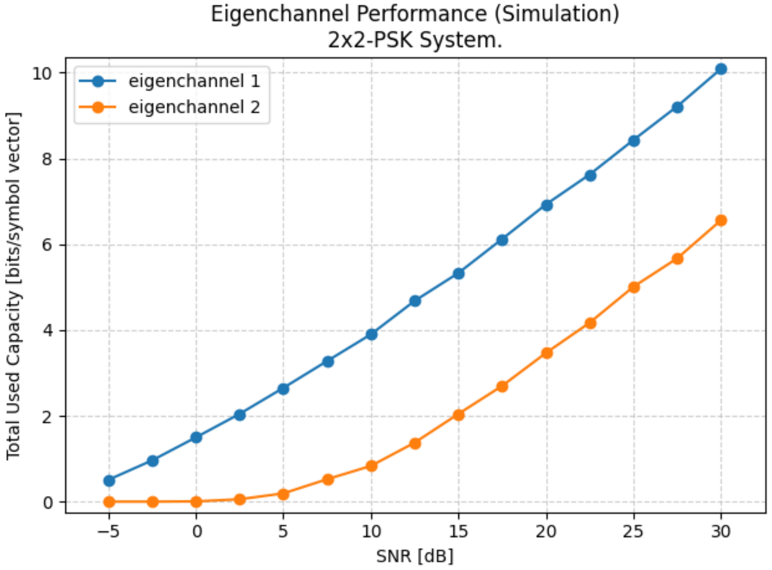

Eigenchannel Performance (Simulation)
2x2-PSK System.
Bit Error Rate (BER)
SNR [dB]
eigenchannel 1
eigenchannel 2

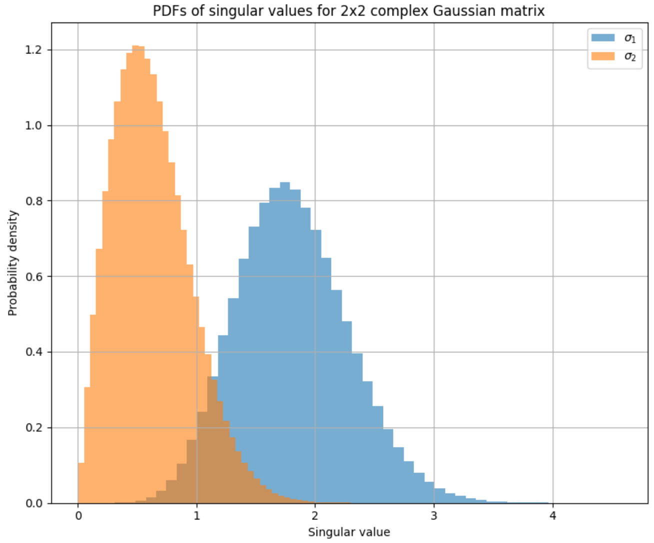

Eigenchannel Performance (Simulation)
2x2-PSK System.
Total Used Capacity [bits/symbol vector]
SNR [dB]
eigenchannel 1
eigenchannel 2

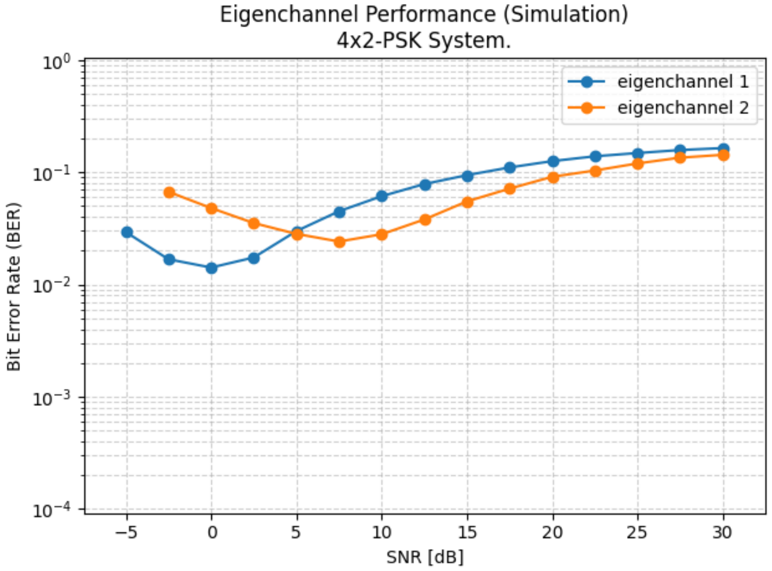

Eigenchannel Performance (Simulation)
4x2-PSK System.
Bit Error Rate (BER)
SNR [dB]
eigenchannel 1
eigenchannel 2

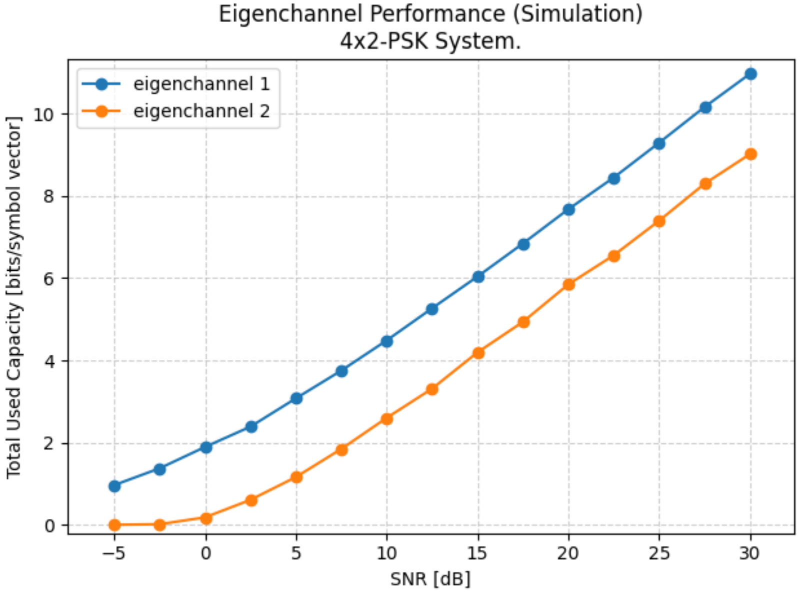

Eigenchannel Performance (Simulation)
4x2-PSK System.
Total Used Capacity [bits/symbol vector]
SNR [dB]
eigenchannel 1
eigenchannel 2

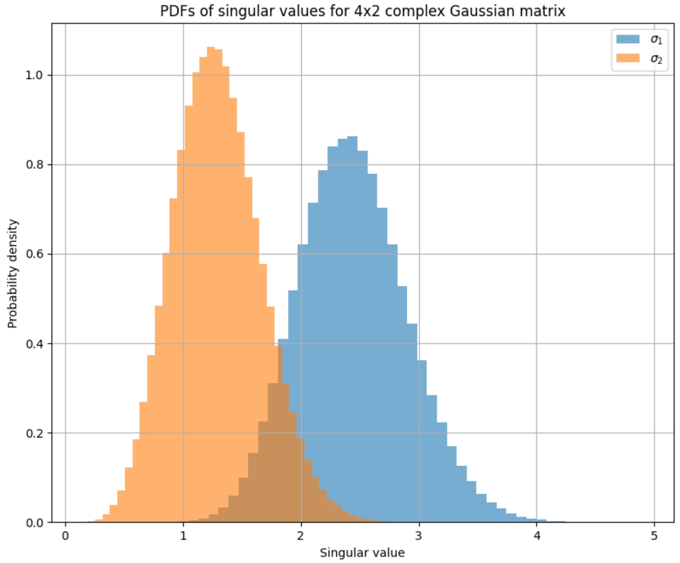

Eigenchannel Performance (Simulation)
2x2-PSK System.
Bit Error Rate (BER)
SNR [dB]
eigenchannel 1
eigenchannel 2


Eigenchannel Performance (Simulation)
2x2-PSK System.
Total Used Capacity [bits/symbol vector]
SNR [dB]
eigenchannel 1
eigenchannel 2


PDFs of singular values for 2x2 complex Gaussian matrix
Probability density
Singular value
σ_1
σ_2

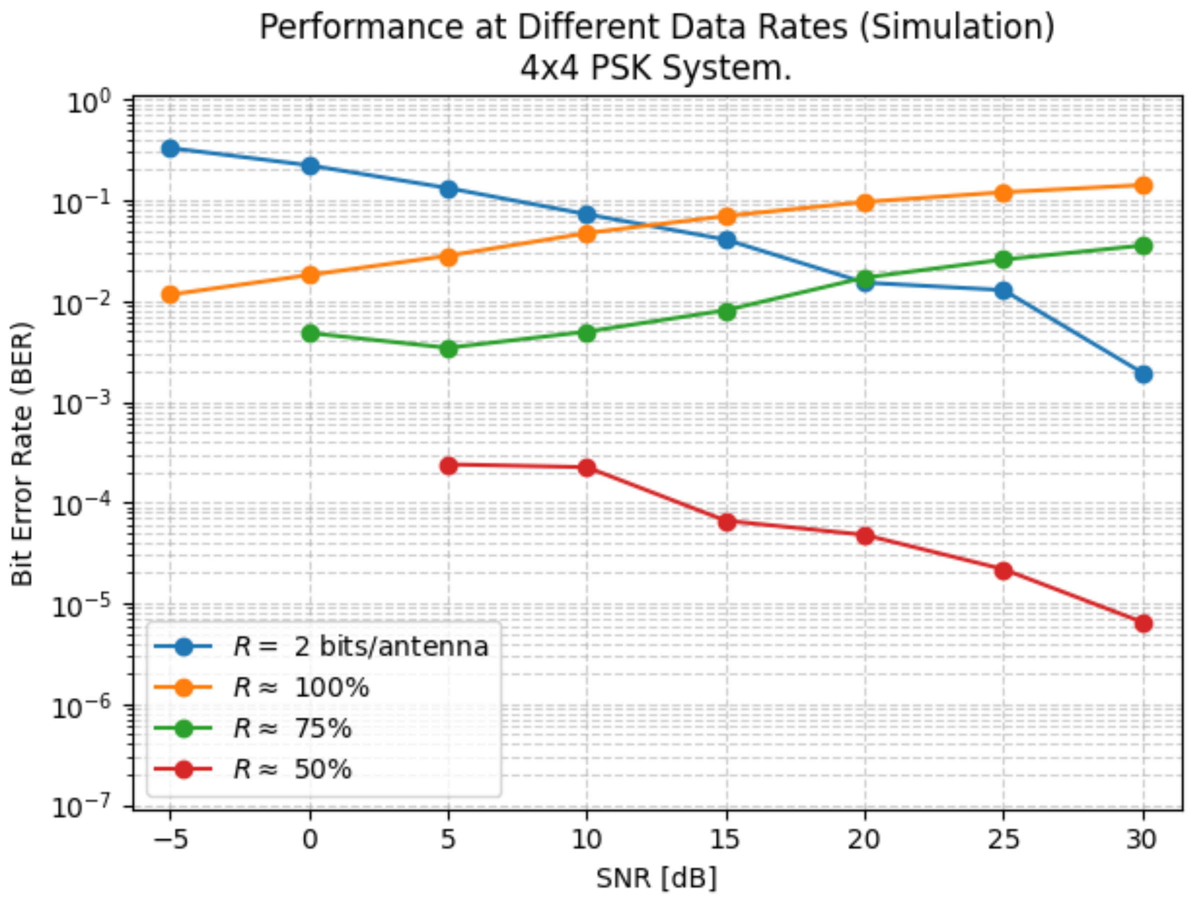

Eigenchannel Performance (Simulation)
4x2-PSK System.
Bit Error Rate (BER)
SNR [dB]
eigenchannel 1
eigenchannel 2

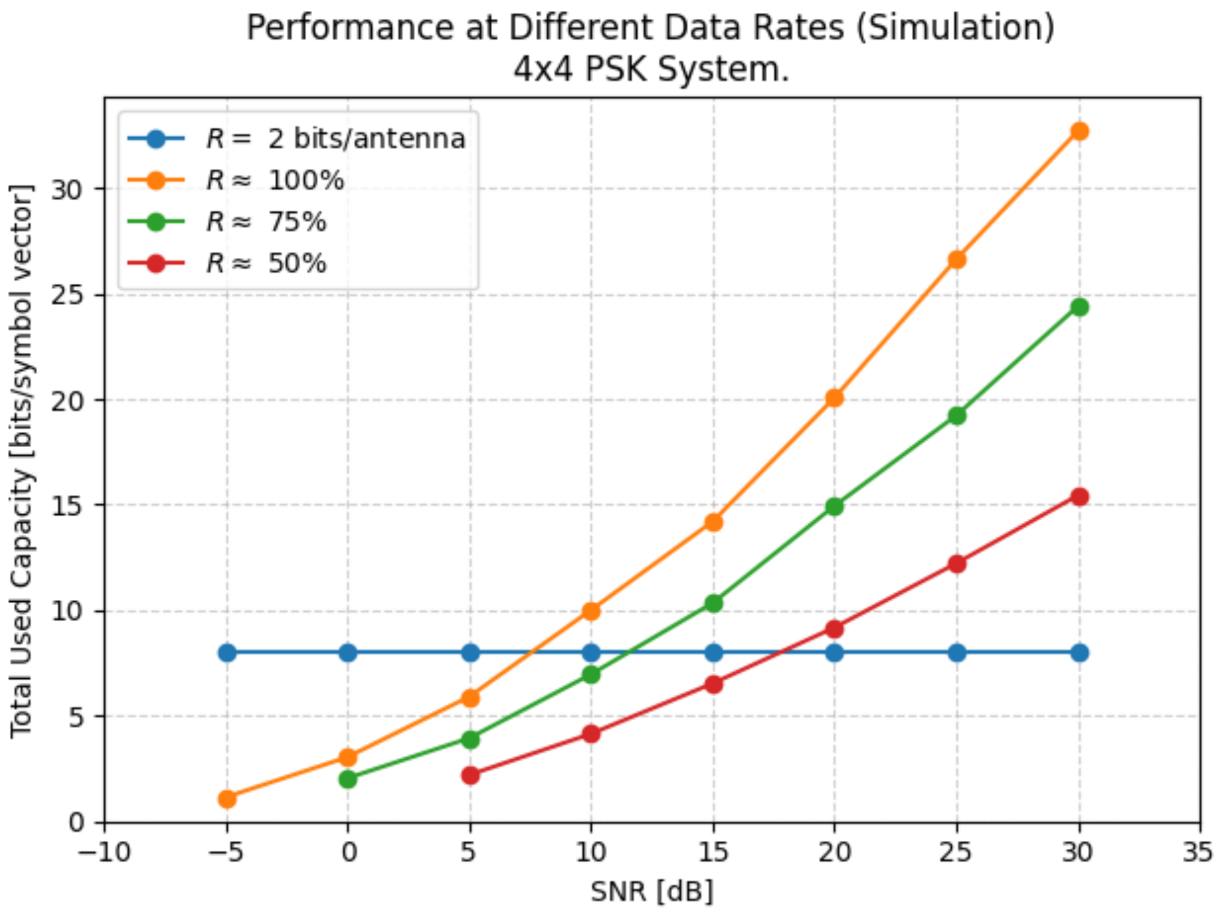

Eigenchannel Performance (Simulation)
4x2-PSK System.
Total Used Capacity [bits/symbol vector]
SNR [dB]
eigenchannel 1
eigenchannel 2


PDFs of singular values for 4x2 complex Gaussian matrix
Probability density
Singular value
σ_1
σ_2

System Performance - Simulatons

Different Data Rates





System Performance – Theoretical BER

$$\text{BER} = \frac{1}{C_{\text{total}}} \sum_{i=0}^{R_H} \lfloor C_i \rfloor \, \text{BER}_i$$

The capacity of the eigenchannels: $C_i = 2B \cdot \log_2(1 + \frac{P_i \sigma_i^2}{2BN_0})$

The BER of the eigenchannels [1]: $\text{BER}_i = \frac{1}{\log_2 M_i} \sum_{(\hat{\alpha},\alpha)\in\mathcal{C}_i^2} \text{N}(\hat{\alpha},\alpha) \cdot \text{P}[\hat{s}_i = \hat{\alpha} \wedge s_i = \alpha] \quad = \frac{1}{M_i \log_2 M_i} \sum_{(\hat{\alpha},\alpha)\in\mathcal{C}_i^2} \text{N}(\hat{\alpha},\alpha) \cdot \text{P}(\hat{\alpha},\alpha)$

- An Upper Bound: $\text{P}(\hat{\alpha},\alpha) \leq \text{P}\Big(|u_i - \hat{\alpha}| < |u_i - \alpha| \;\Big|\; s_i = \alpha\Big) \;= \text{Q}\Big(\frac{P_i \sigma_i^2}{N_0} \cdot |\hat{\alpha} - \alpha|\Big)$
- An Approximation: $\text{BER}_i \approx \frac{1}{M_i \log_2 M_i} \sum_{\alpha\in\mathcal{C}_i} \sum_{\hat{\alpha}\in\mathcal{S}(\alpha)} \text{N}(\hat{\alpha},\alpha) \cdot \text{Q}\Big(\frac{P_i \sigma_i^2}{N_0} d_{\min}\Big) \quad = \quad \frac{K}{\log_2 M_i} \text{Q}\Big(\frac{P_i \sigma_i^2}{N_0} d_{\min}\Big)$

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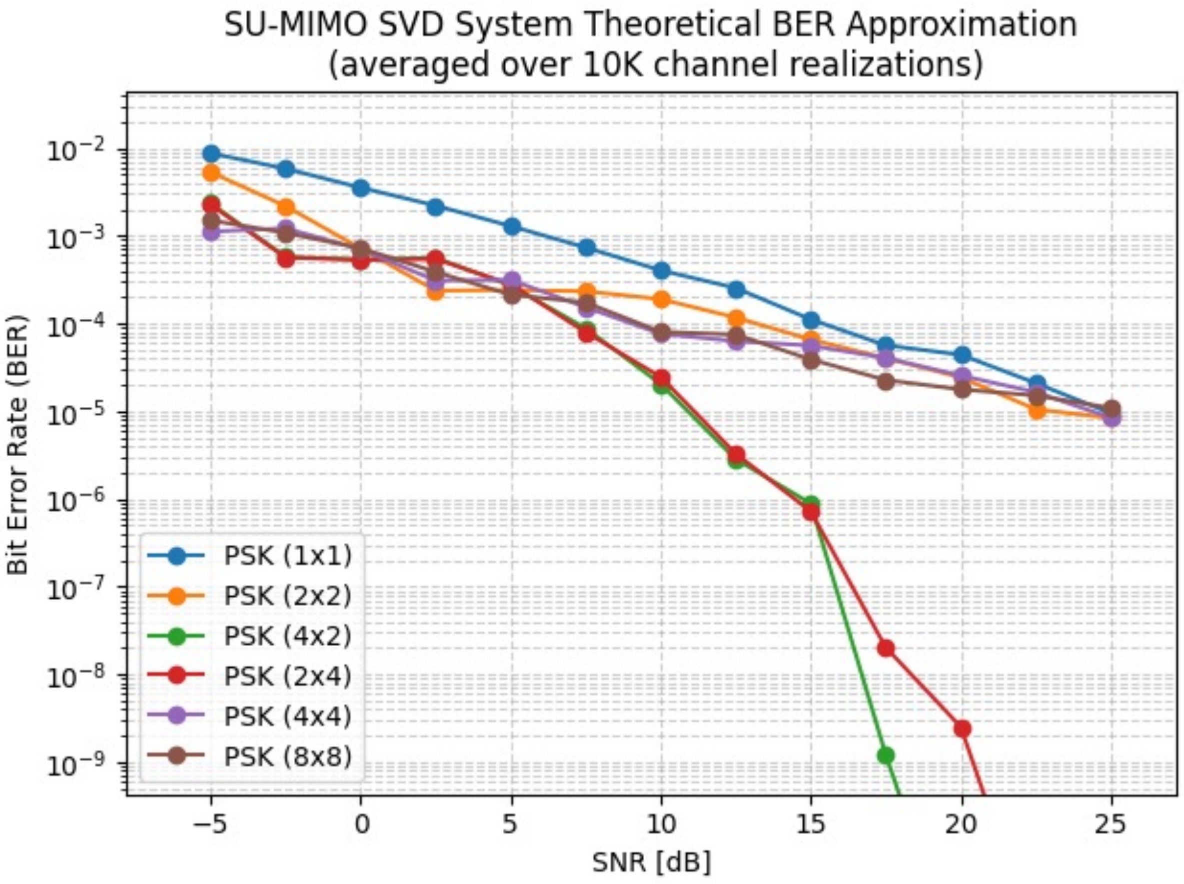
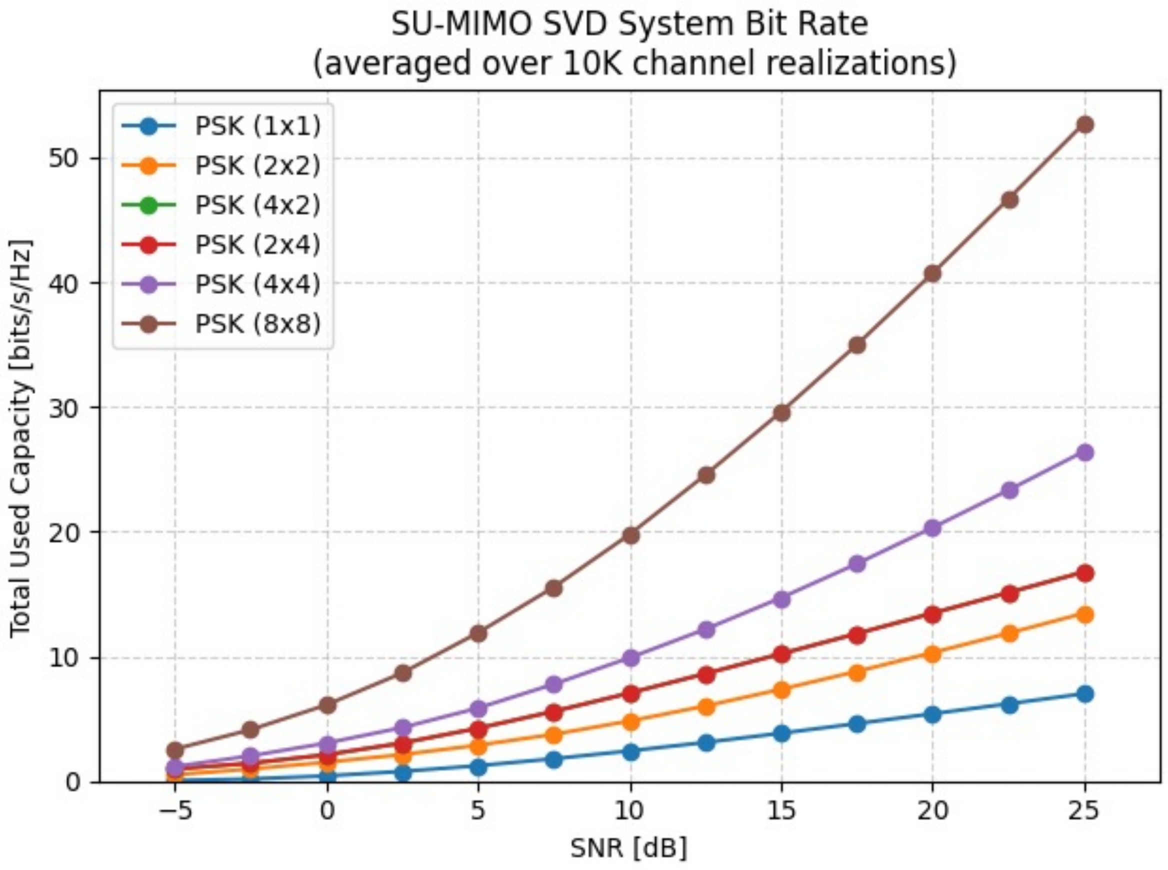
[1] P. M. M. Prof. Nele Noels, *Communicatietheorie*. Ghent, Belgium: Ghent University,

System Performance

Theoretical BER Approximation Curves





System Performance – Analytical VS Simulation