

Development of a Single-Carrier SM-MIMO Transceiver

Detector Design MIMO Implementation

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System Model SC-SM



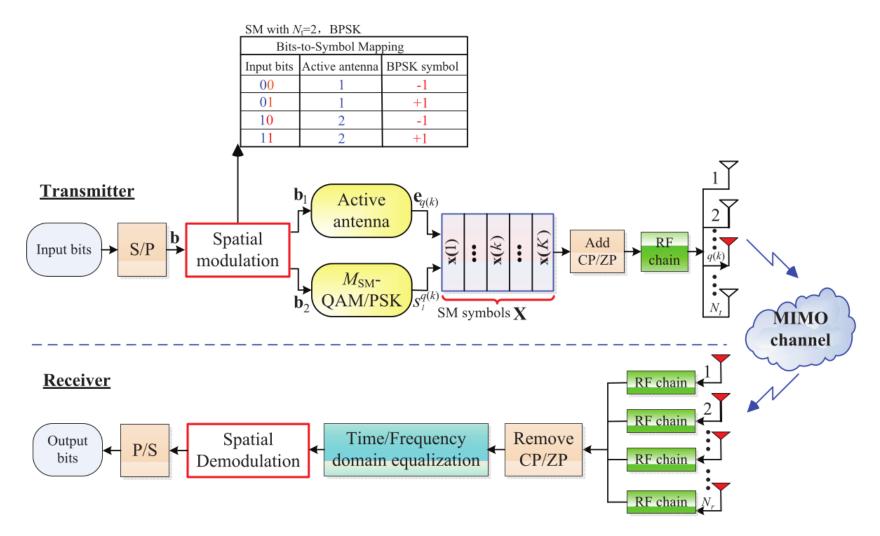


Figure 1: General transceiver structure of SC-SM systems [1]



Low-Complexity Detection Scheme for GSM-SC



- Based on M-algorithm
- Single stream ML detection
- Avoids QR-decomposition
- Balanced trade-off: performance & complexity
- Scheme approaches ML detector with increasing M
- Efficient operation even in rank-deficient channel scenarios

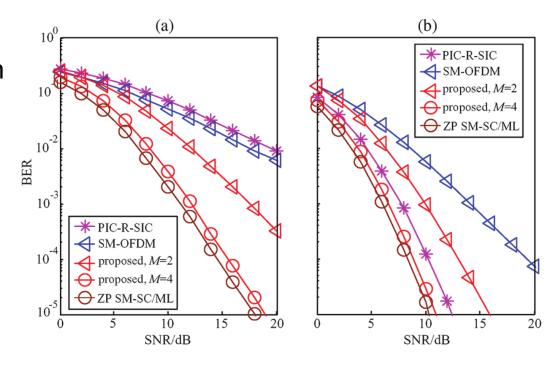


Figure 4: BER of ZP-aided SM-SC and SM-OFDM with different receiver antennas: (a) $N_r = 1$; (b) $N_r = 2$ [1]



Current Detector Design



Transmission system fully implemented:

$$\underbrace{\begin{bmatrix} \mathbf{Y}_{1} \\ \mathbf{Y}_{2} \\ \vdots \\ \mathbf{Y}_{K+P-1} \end{bmatrix}}_{\mathbf{Y} \text{ of } \text{size}(K+P-1)N_{r} \times 1} = \underbrace{\begin{bmatrix} \mathbf{H}_{0} & \mathbf{O} & \dots & \mathbf{O} & \mathbf{O} \\ \mathbf{H}_{1} & \mathbf{H}_{0} & \dots & \mathbf{O} & \mathbf{O} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \mathbf{H}_{P-1} & \mathbf{H}_{P-2} & \dots & \mathbf{H}_{0} & \mathbf{O} \\ \mathbf{O} & \mathbf{H}_{P-1} & \dots & \mathbf{H}_{1} & \mathbf{H}_{0} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \mathbf{O} & \mathbf{O} & \dots & \mathbf{H}_{P-1} & \mathbf{H}_{P-2} \\ \mathbf{O} & \mathbf{O} & \dots & \mathbf{O} & \mathbf{H}_{P-1} \end{bmatrix}}_{\mathbf{X} \text{ of } \text{size } KN_{t} \times 1} + \underbrace{\begin{bmatrix} \mathbf{n}_{1} \\ \mathbf{n}_{2} \\ \vdots \\ \mathbf{n}_{K+P-1} \end{bmatrix}}_{\mathbf{n} \text{ of } \text{ size } (K+P-1)N_{r} \times KN_{t}}$$

Channel Matrix scales according to N_t, N_r:

```
-0.50745165-0.87831815i
                         0.000000000+0.i
                                                   0.00000000+0.i
                                                                            0.00000000+0.i
                                                                                                     0.000000000+0.i
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                                                                                                                                                        0.00000000+0.j
                                                                                                                                                                                -0.24550281-0.42326164j]
```



Current Detector Design



- Working MIMO implementation (N $t \times N r$):
 - 1 x 2

$$\mathbf{e}_{2}^{m} = \begin{vmatrix} \hat{\mathbf{Y}}_{2} - \begin{pmatrix} \mathbf{H}_{0} & 0 \\ \mathbf{H}_{1} & \mathbf{H}_{0} \end{pmatrix} \begin{pmatrix} \mathbf{x}_{1}^{m} \\ \mathbf{x}_{2} \end{pmatrix} \Big|_{F}^{2}$$

$$= \tilde{\mathbf{e}}_{1}^{m} + \left\| \mathbf{Y}_{2} - (\mathbf{H}_{1} & \mathbf{H}_{0}) \begin{pmatrix} \mathbf{x}_{1}^{m} \\ \mathbf{x}_{2} \end{pmatrix} \right\|_{F}^{2}, \mathbf{x}_{2} \in C_{GSM}$$

- M smallest metrics are chosen by M-algorithm:
 - M = 1
 - No final detection yet: $|\hat{\mathbf{x}}_{proposed} = |\arg\min| ||\mathbf{Y} \mathbf{H}\mathbf{D}_K^m||_F^2$ $m \in (1, 2, ..., \hat{M})$
- Script to test the detector:
 - If every sent symbol is correctly detected: True
 - \sim 45% of the time this is the case (SNR = 10 dB)

Prospects



- Adjust sent symbols
- Generalize for number of multi-path links (P)
- Generalize for M (starting with M = 2)
- Compare BER performance with results in paper
- MIMO schemes to implement:
 - 2 x 1
 - NtxNr
- Fuse scripts: class based SISO transmission and MIMO detector scheme
- Addition of spatial modulation / spatial modulation symbols
- Proof of concept with GNU Radio



Any questions?



- Sources
 - [1] L. Xiao, D. Lilin, Y. Zhang, Y. Xiao, P. Yang and S. Li, "A lowcomplexity detection scheme for generalized spatial modulation aided single carrier systems," IEEE Commun. Lett., vol. 19, no. 6, pp. 1069-1072, Jun. 2015

Manuel Roth - Single-Carrier SM-MIMO

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