Karlsruher Institut für Technologie

Development of a Single-Carrier SM-MIMO Transceiver

Channel Estimation & Synchronization
Complete System Analysis

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Classic Channel Estimation scheme

- For each transmission antenna: send training sequence.
- Using Gold Sequences: no multi-path effects for different antennas.
  - A frame can contain multiple antenna sequences.
- Correlate with the corresponsing sequence at the receiver.
  - Channel Impulse Response for each transmit antenna.
- Reconstruct channel matrix with impulse responses.

- Performance trade-offs:
  - Longer sequences → lower threshold for reconstruction & more overhead.
  - More N_t → more index information & more overhead.
  - More N_r → lower channel estimation SNR needed.

Simulation Results: Classic Approach (1)

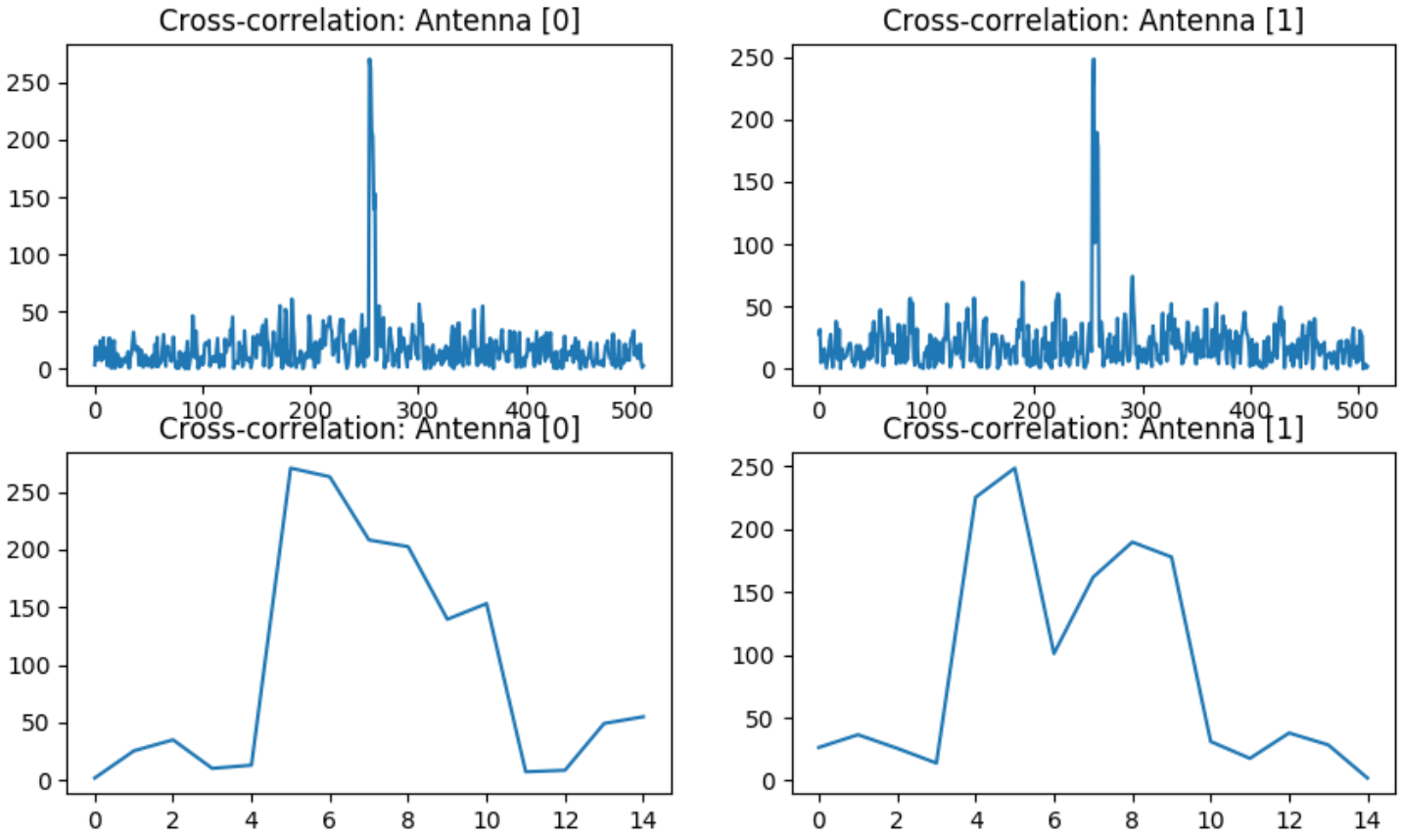

Figure 1: Results of correlation: Channel Impulse Response for different sending antennas [N_r =2; N_r = 2; hard coded].

Simulation Results: Classic Approach (2)

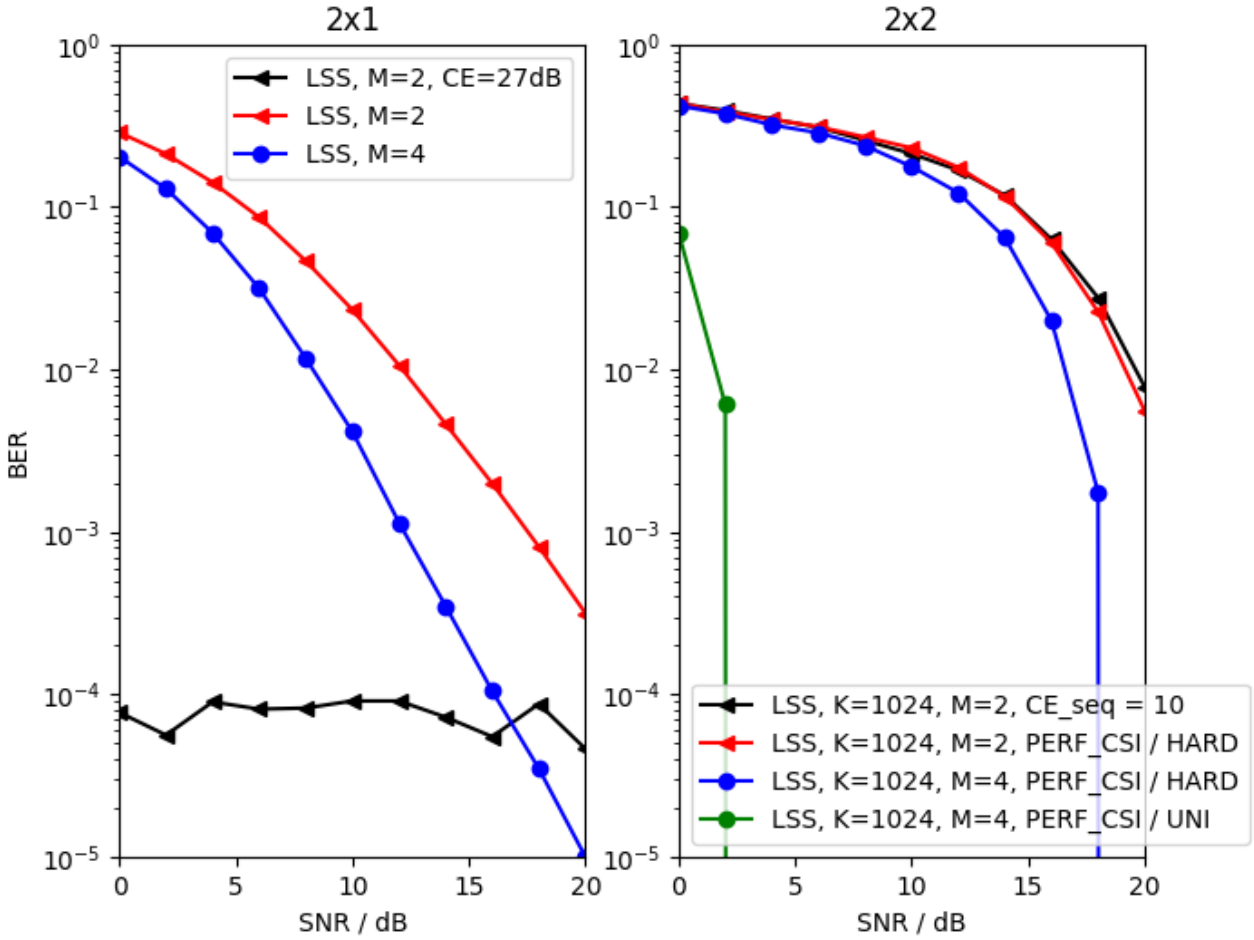

Figure 2: Classic SC-SM Channel Estimation scheme.

Simultaneous Frame Synchronization and Channel Estimation scheme

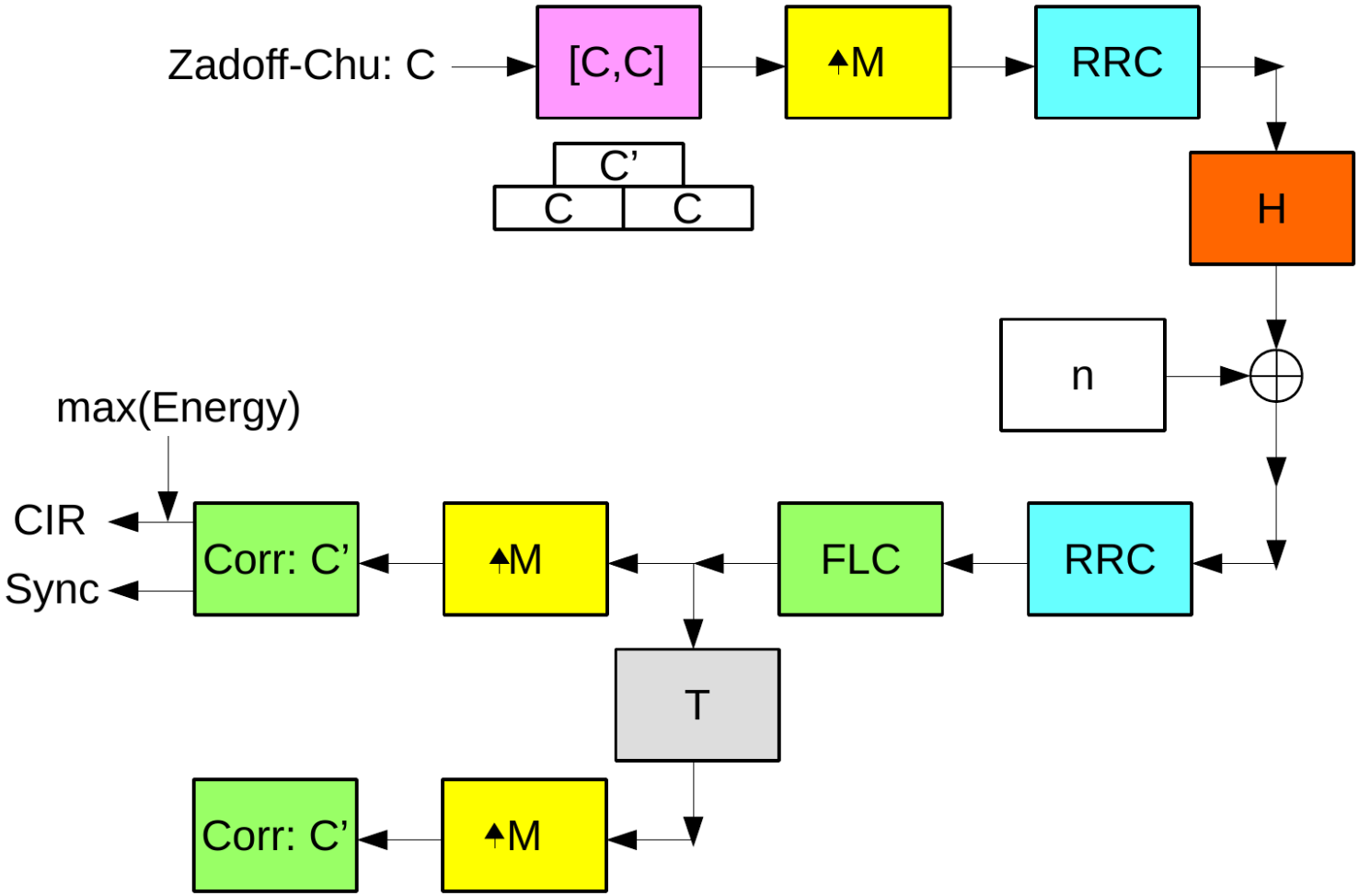

Figure 3: Proposed Synchronization & Channel Estimation scheme.

Simulation Results: SISO (1)

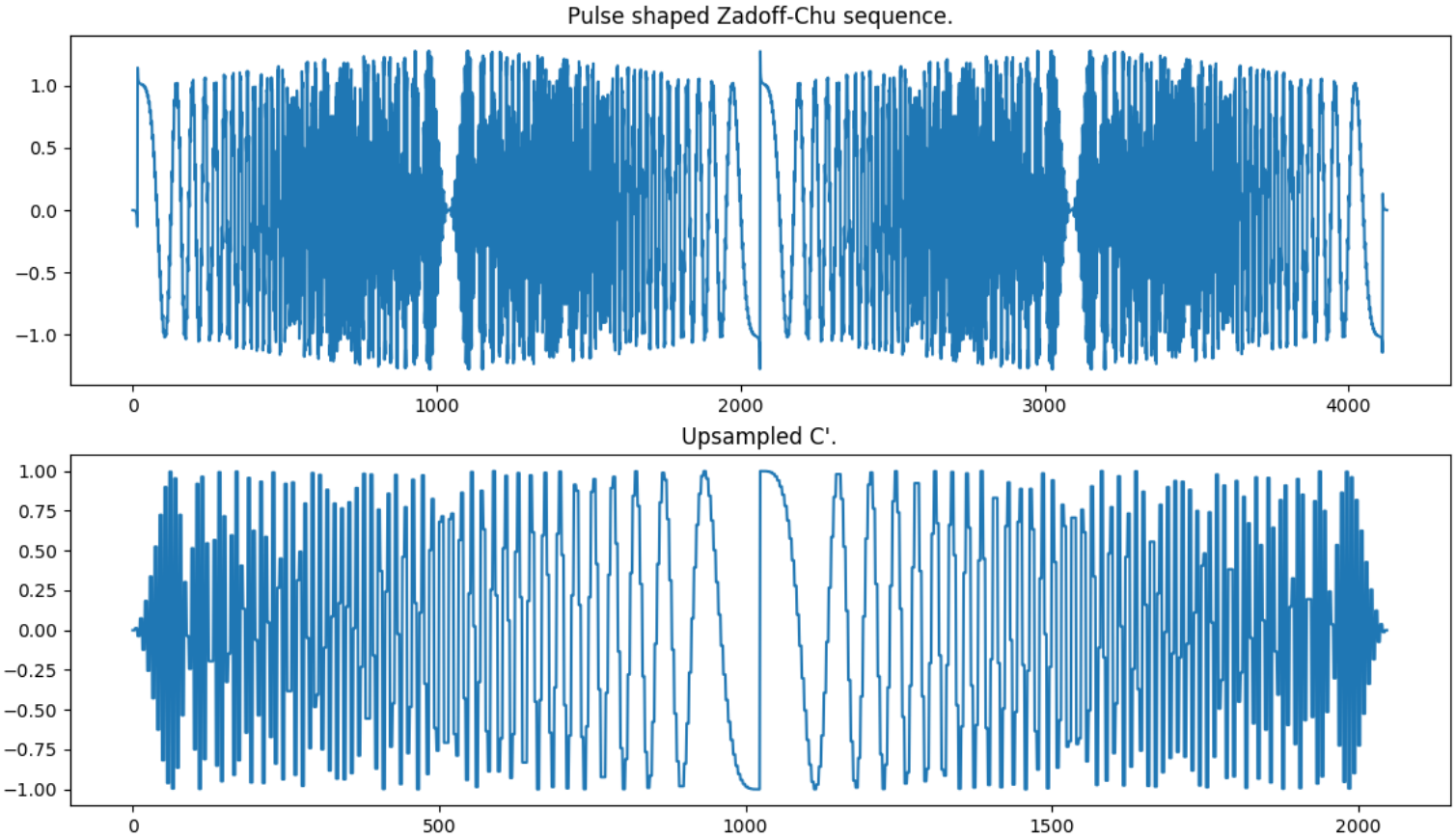

Figure 4: Upsampled frames: C and C'.

Simulation Results: SISO (2)

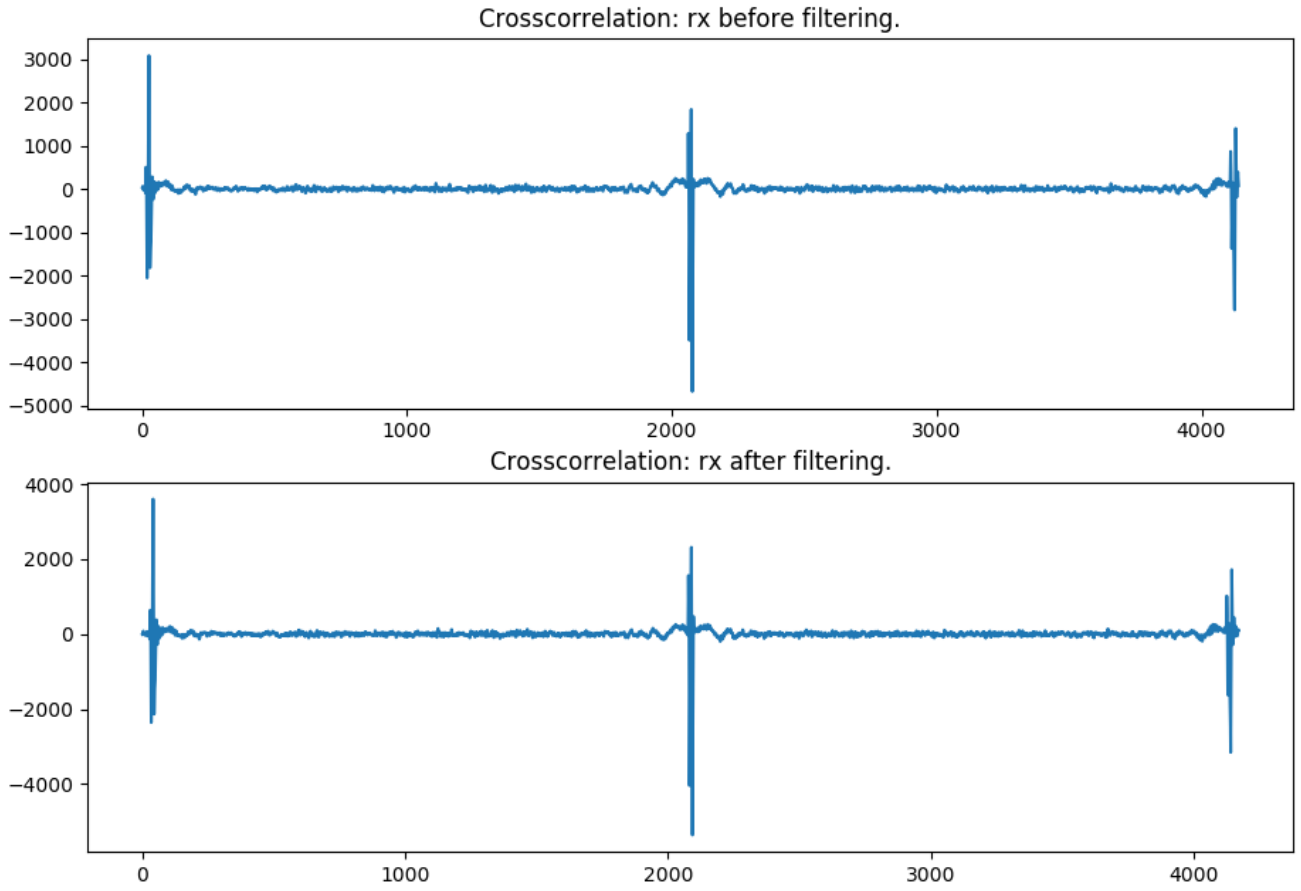

Figure 5: Cross-correlation of the received frame with C'.

Simulation Results: SISO (2)

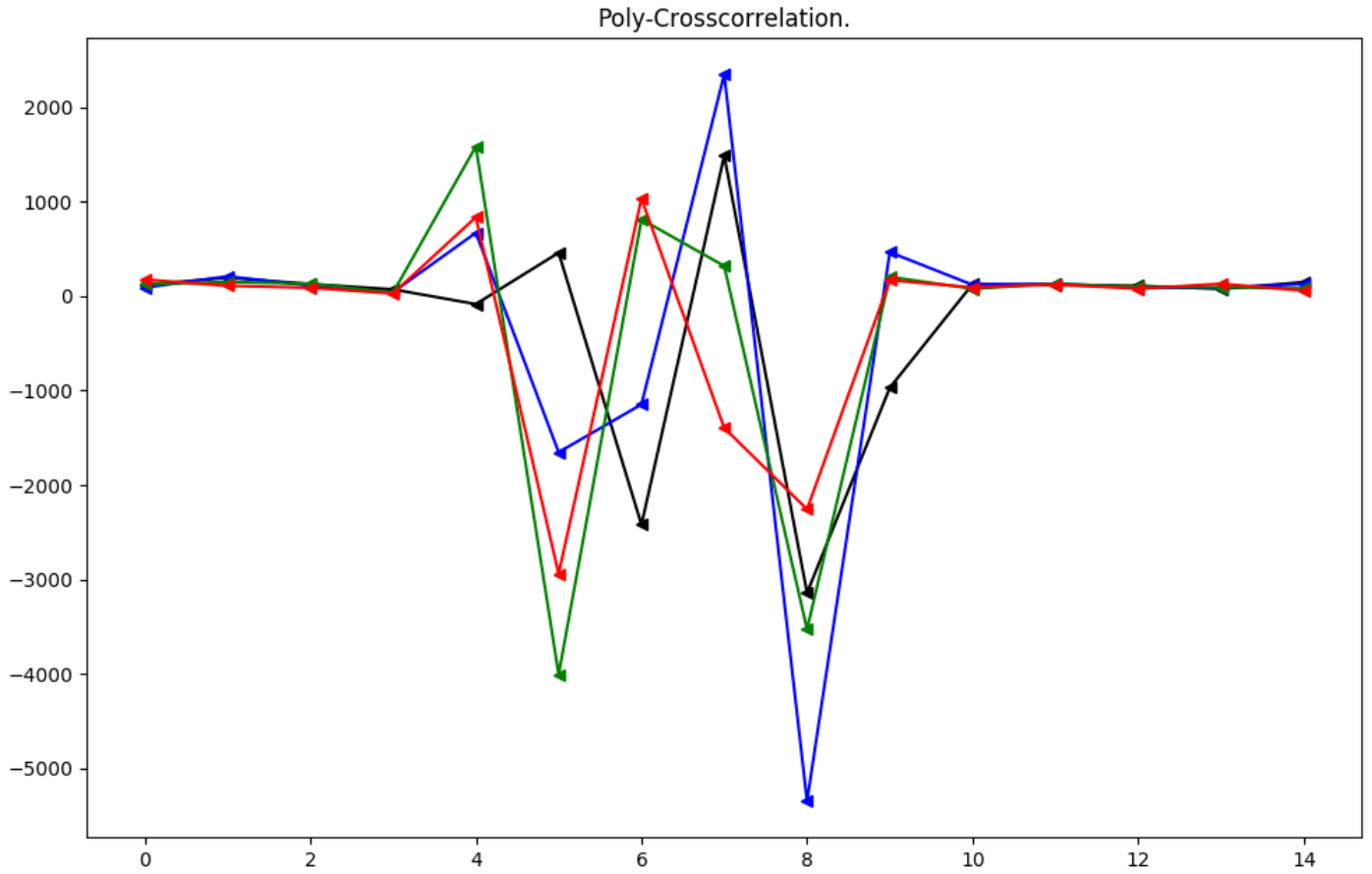

Figure 6: Polyphase-Cross-correlation of the received frame with C'.

Simulation Results: SIMO (1)

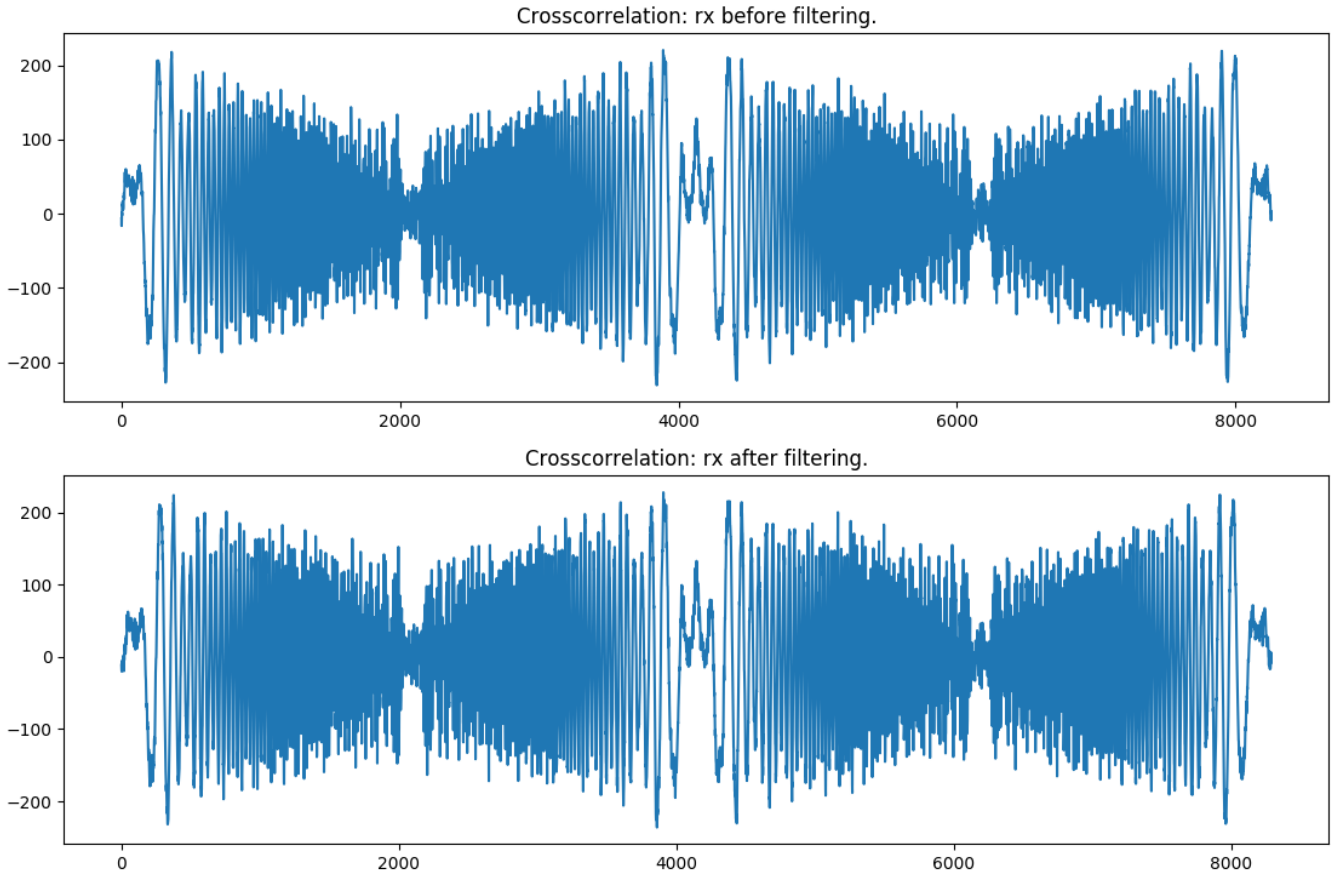

Figure 7: Cross-correlation of the received frame with C'.

Simulation Results: SIMO (2)

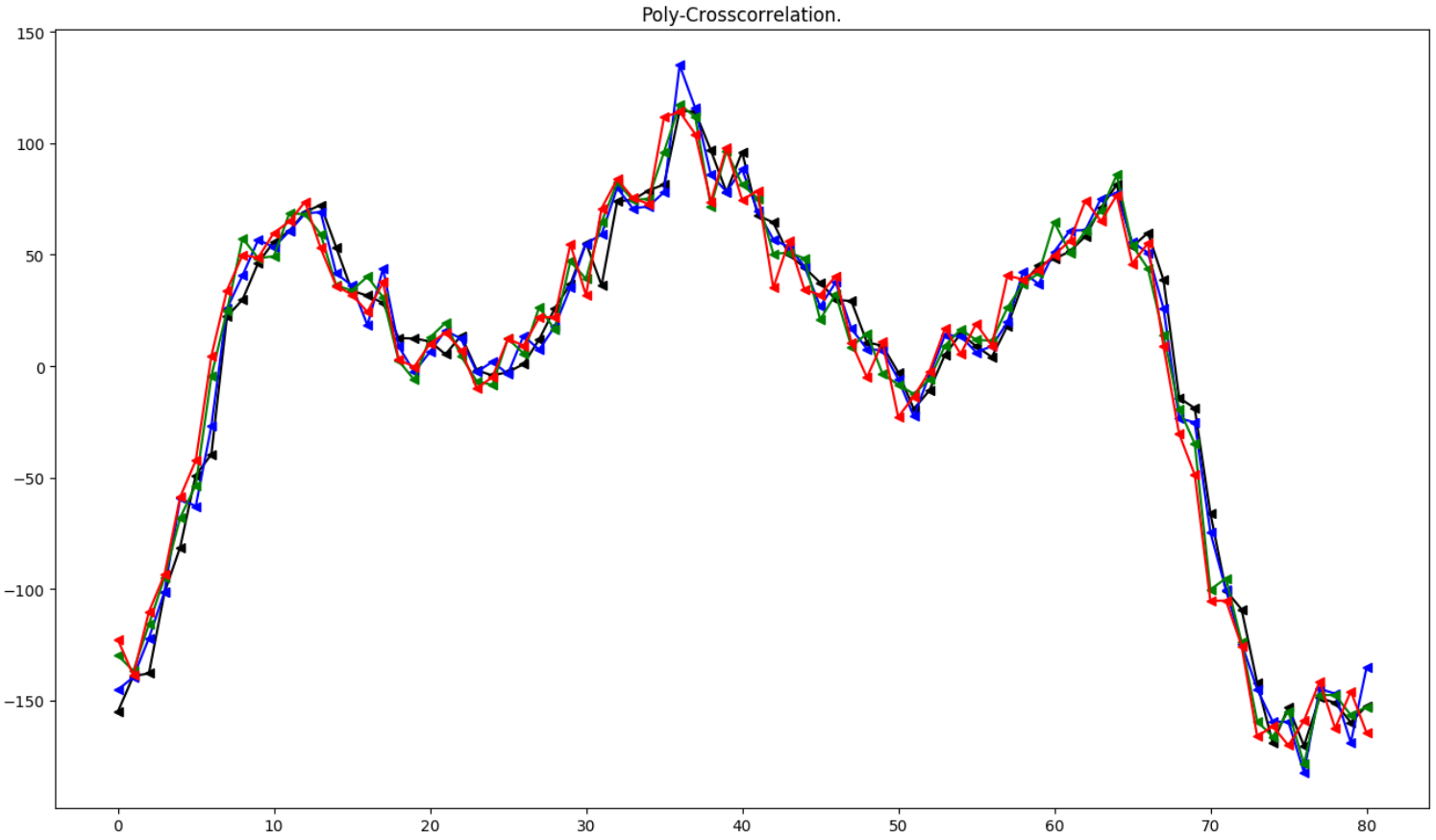

Figure 8: Polyphase-Cross-correlation of the received frame with C'.

Simulation Results: SIMO/Split (1)

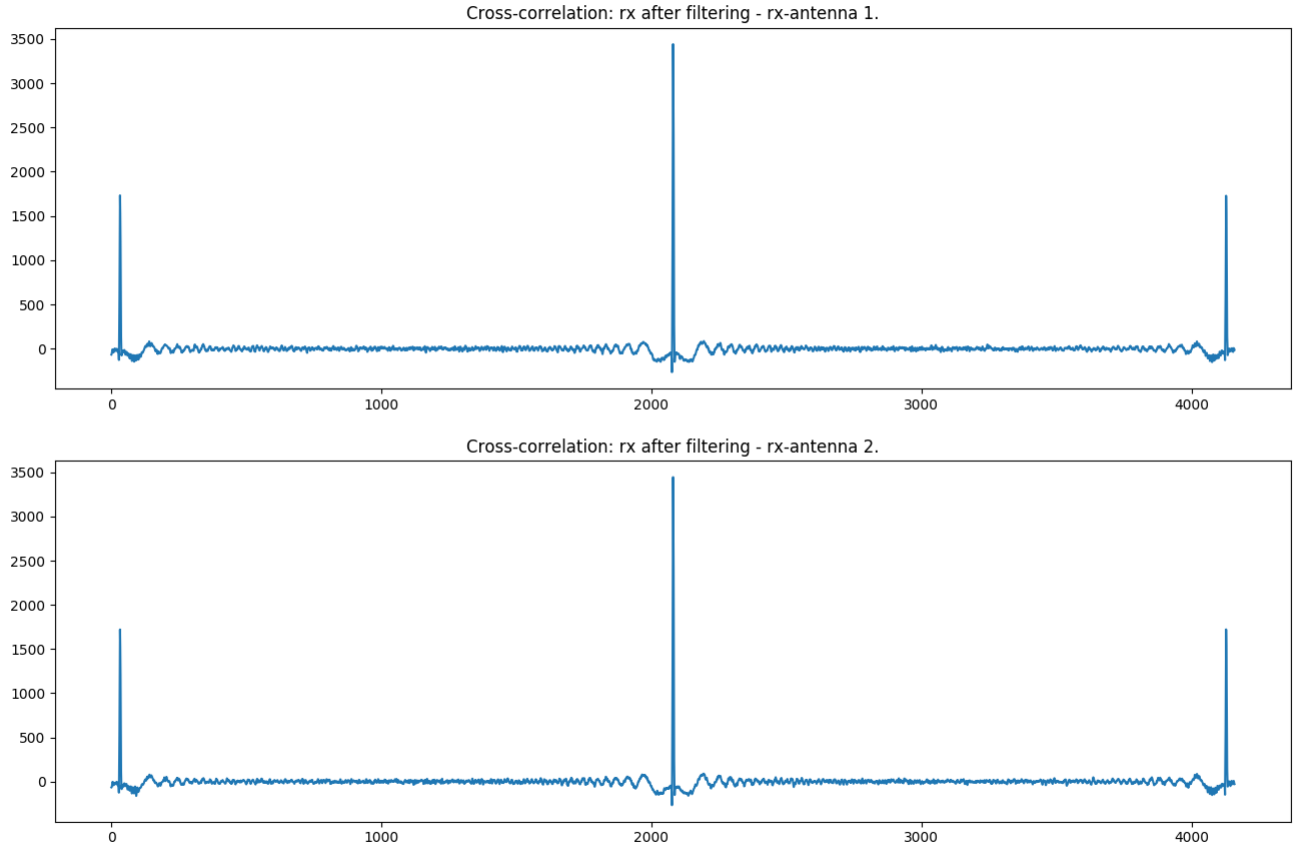

Figure 9: Cross-correlation of the received frame with C' - split reception antennas.

Simulation Results: SIMO/Split (2)

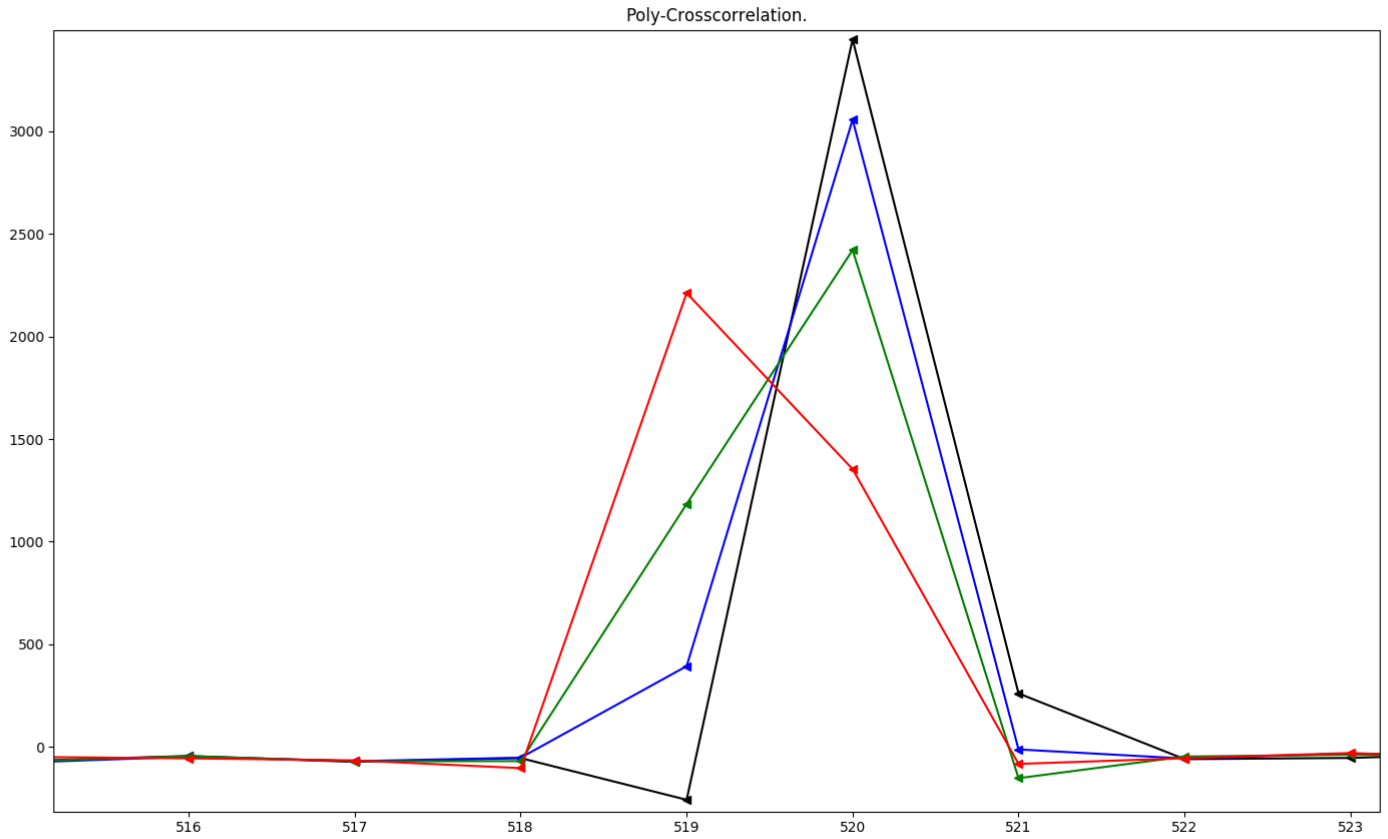

Figure 10: Polyphase-Cross-correlation of the received frame with C' - split reception antennas – antenna 1.

Concrete Issues

- Fix / adapt SIMO-simulation.
- Specify special channel simulations.
- Generalize current training setup.
  - Slice given Block-Toeplitz into transmit antenna Vector-Toeplitz matrices.
  - Find relevant correlation points and extract channel.

Prospects

- New:
  - Implement frequency and phase synchronization.
  - Exhaustive tests and comparisons
- Persisting issues:
  - Solve 1 dB offset for 2x2 scenario.
  - Implement different channels (COST, LTE).
- Near future:
  - Proof of concept with GNU Radio
  - Start writing

Any questions?

- Sources
  - Roth M. et al., 2017