Low Complexity SLM for OFDMA System with Implicit Side Information

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Outline

1. Introduction
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3. Experimental Results
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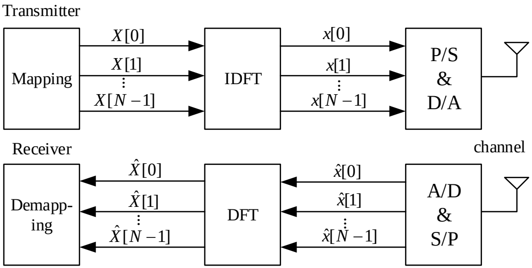
Outline

PAPR problem in OFDM system



System Model with N subcarriers

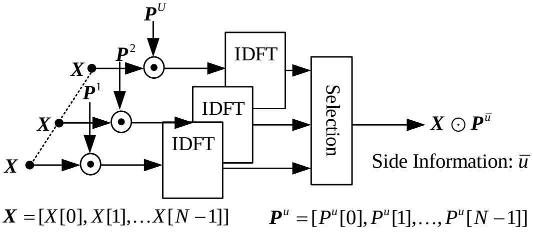
$$\mathrm{PAPR} = \frac{\max\limits_{n\in\{0,1,\ldots,N-1\}} \|x[n]\|^2}{\mathbb{E}\left[\|x[n]\|^2\right]}. \tag{1}$$

- N: number of subcarriers.
- $x[n]$: discrete-time samples.

- $x[n]$ asymptotically approximates to i.i.d. complex Gaussian.
- Orthogonal frequency division multiple access (OFDMA) inherits the advantages of OFDM while suffers from high PAPR.

PAPR reduction methods [1]

- With distortion:
  - filtering, clipping, peak windowing.
- Without distortion:
  - selected mapping (SLM), partial transmit sequence (PTS).

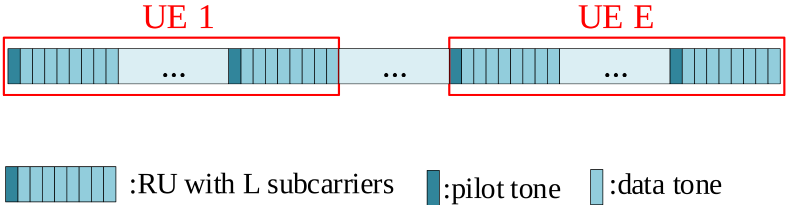


Transmitter of SLM

- simple and no distortion.
- require side information (SI).

OFDMA system

OFDMA system with M RU of equal length distributed to E UEs



- Subcarriers is divided according to RU.
- Each UE only receives its related subcarriers.

Related Works

Efforts to avoid SI transmission:

- Simplified maximum likelihood (ML) detection [2].
- Blind tone power difference modulation [3].
- Embedded SI transmission [4].
- Pilot-assisted SI transmission with ML detection [5].

These methods are not feasible for OFDMA PAPR reduction.

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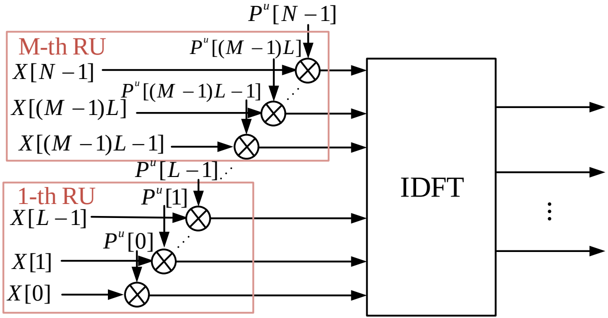
Proposed SLM scheme

Basic idea: SI is embedded in the phase rotation of each RU's pilot.

- $\mathbf{P}^u$ is split into M RU blocks.
- Each block is chosen from a RU specific dictionary.
- Dictionary size: Q phase rotation vectors with length L.

The u-th candidate sequence:

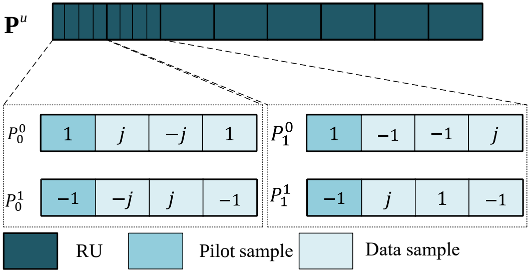


- $\mathbf{X}$ are divided according to RU.
- $\mathbf{P}^u$ is carefully designed for each RU.

No SI transmission is required for the proposed scheme.

Proposed SLM scheme

Example of $\mathbf{P}^u$ generated with $M = 8$ RUs, dictionary size $Q = 2$ and RU length $L = 4$.



- The dictionary of the first RU: $\mathbf{P}_0^0$ and $\mathbf{P}_0^1$.
- $\mathbf{P}_0^0$: one to one correspondence with its pilot sample.
- $\mathbf{P}^u$: a combination of 8 dictionaries.

Such phase rotation vector set can be generated if:

$$Q^M > U. \tag{2}$$

Theoretical Analysis

- PAPR performance is evaluated by the complementary cumulative distribution function (CCDF),

$$\Pr(\mathrm{PAPR_S} > \tau) = \prod_{u=1}^{U} \Pr(\mathrm{PAPR}_u > \tau) = \left(1 - (1 - \exp(-\tau))^N\right)^U . \tag{3}$$

- $\mathrm{PAPR_S}$: PAPR of proposed SLM scheme.
- PAPR_u: PAPR of the u-th sequence.

PAPR reduction performance is not deteriorate compared with the conventional SLM.

- The proposed detector is **maximum likelihood optimal with low complexity**.

Detection complexity analysis

- Computational complexity:

Algorithm	$\times$ (%)	$+$ (%)
proposed	$6QM + 4M + 6CN_d + 4N_d$	$5QM + 2M + 5CN_d + 2N_d$
SLM in [5]	$6UM + 4M + 6CN_d + 4N_d$	$6UM + 2M + 5CN_d + 2N_d - U$
modified SLM of [5]	$6UM + 4M + 6CN_d + 4N_d$	$5UM + 2M + 5CN_d + 2N_d$

* $\times$ means real multiplication, $+$ represents real addition.

- C is the size of modulation scheme Ω.

- When $N = 512$, $M = 32$, $U = 32$, $Q = 4$, $\Omega =$ QPKS, the number of UEs is 4.
- saved **81.819**% $\times$, **83.174**% $+$ compared to [5].
- saved **27.273**% $\times$, **28.455**% $+$ compared with the modified algorithm of [5].

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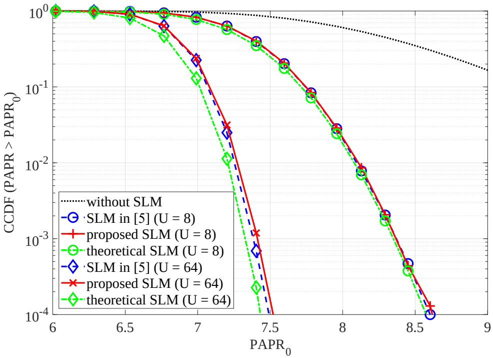
PAPR performance

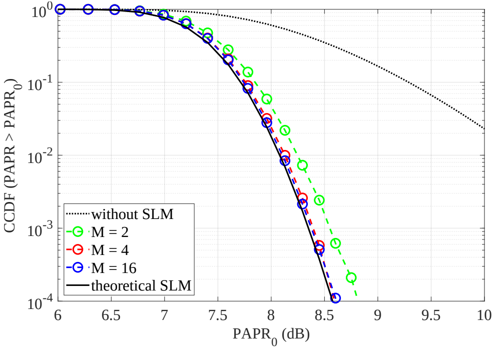


Compare PAPR with difference U.

- Experimental setting:
  - $N = 512$,
  - $M = 8$,
  - $L = 26$,
  - $\Omega =$ QPSK.

- **Conclusion**: PAPR performance is close to the theoretical analysis.

PAPR performance

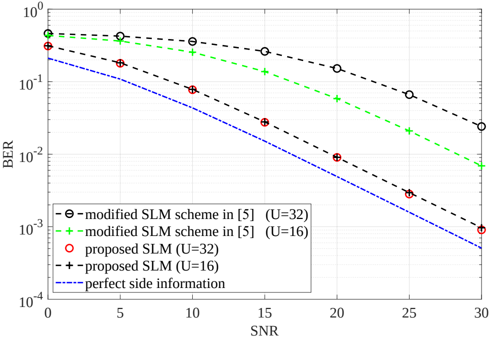


Compare PAPR with different sizes of RU.

- Experimental setting:
  - $N = 512$,
  - $\Omega = \text{QPSK}$,
  - $U = 8$.

- **Conclusion**: The fine-grained division yields better PAPR reduction performance.

BER performance



BER with different U.

- Experimental setting:
  - $N = 512$,
  - $\Omega = \text{QPSK}$,
  - $M = 8$, and 8 UEs, each UE equipped with a RU.

- **Conclusion**: The proposed scheme is more robust to noise compared with the modified scheme of [5].

Outline

Conclusions

- We propose a SLM scheme to reduce PAPR of the OFDMA system.
- The proposed scheme does not require SI transmission.
- The detection of the proposed scheme is simple, and the complexity is low.
- PAPR reduction and BER performance is satisfactory.

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спасибо 谢谢

GRACIAS

THANK YOU

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