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A novel energy-efficient ICI cancellation technique for bandwidth improvements through cyclic prefix reuse in an OFDM system

Key words: Orthogonal frequency division multiplexing (OFDM); Fast Fourier transform (FFT); Cyclic prefix (CP); Inter symbol interference (ISI); Inter carrier interference (ICI); Maximum likelihood estimation (MLE)

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Motivation

1. OFDM is severely affected by the undesirable effects of frequency offset error (which generate inter carrier interference, ICI) due to the Doppler shift and local oscillator frequency synchronization errors.

2. There are many ICI cancellation techniques available in the literature, such as Self-Cancellation (SC), Maximum Likelihood Estimation (MLE)and windowing but they make tradeoff in bandwidth redundancy and system complexity.

3. OFDM seeks a bandwidth effective estimation technique to mitigate the effects of ICI.

Main idea

1. OFDM is generally engaged with more than 20% cyclic prefixing to avoid interferences. This resourceful 20% spectrum get waste and hamper the bandwidth efficiency of OFDM. So a scheme needs to be developed for either minimizing the wastage of available bandwidth or utilizing it for error estimation.

2. The proposed method make re-use of CP to estimate channel errors and eventually enhance the BER performance of OFDM system.

Method

1. ICI compensation is achieved by using CP (which is actually added to nullify the effect of ISI) instead of a dedicated replica of data.
2. That is why the symbol time and width are not doubled, unlike in the case of MLE. Hence, the bandwidth efficiency is increased and energy loss is reduced.
3. Simulation is done to observe the results of the proposed scheme to examine bandwidth effectiveness and energy efficiency.

Major results

1. Proposed Technique delivers more efficient results, as shown in table 1.

Table 1 Bandwidth efficiency and energy loss of ICI cancellation techniques

Technique	Cyclic prefix percentage	Bandwidth efficiency	Energy loss (dB)
MLE	0	0.50	3.00
SC	0	0.50	3.00
Proposed CP-based technique	25%	0.80	0.96
	20%	0.83	0.79
	15%	0.86	0.60
	10%	0.90	0.41

Major results (Cont'd)

2. A Comparative analysis is tabulated below, for different techniques at different SNR and CP values.

Table 2 BER analysis of ICI cancellation techniques at different SNRs

Technique	BER		
	SNR=5 dB	SNR=10 dB	SNR=15 dB
SC	0.406860	0.339355	0.229248
MLE	0.008027	0.006797	0.004290
Proposed CP-based technique			
20% CP	0.008113	0.006912	0.004607
15% CP	0.009461	0.008095	0.005433
10% CP	0.011570	0.009783	0.006646

Major results (Cont'd)

3. BER performances of MLE and the proposed CP-based technique come out to be very close to each other at 0.02 offset configuration and at 0.05 offset, refer fig 6, and fig.7.

4. Configuration. However, the proposed CP-based technique outperforms the standard OFDM and SC schemes with a huge margin.

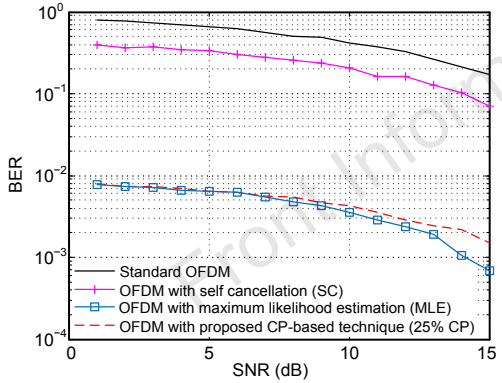

Fig. 7 BER vs. SNR for ICI cancellation techniques with 16 FFT at a 0.05 offset (25% CP)

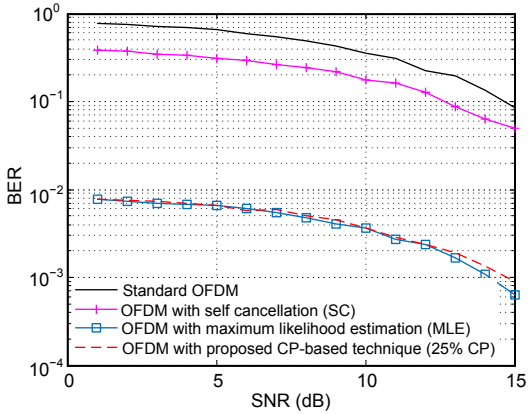

Fig. 6 BER vs. SNR for ICI cancellation techniques with 16 FFT at a 0.02 offset (25% CP)

Conclusions

1. Simulation results and statistical analysis advocate for the proposed technique as it produces BER performance results similar to those of the MLE technique but with no compromise on the bandwidth efficiency.

2. The proposed technique delivers much better BER results than SC and standard OFDM along with a 80% bandwidth efficiency (alternatively, we can say, less than 0.96 dB energy loss at 25% CP).

3. The proposed CP-based technique also restricts energy loss to a great extent, i.e., 0.96 dB (25% CP), 0.79 dB (20% CP), 0.60 dB (15% CP), and 0.41 dB (10% CP) as compared to 3 dB loss in the SC or MLE technique.