BER of High-Speed OFDM Systems in The Presence of Offset Mismatch of TI-ADCs

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Motivation

- Time-interleaved analog-to-digital converters (TI-ADCs) are widely used for multi-Gigabit OFDM systems because of their high sampling rate and high resolution.
- In practice, offset mismatch (generated from the differential pairs of the opamps, capacitor mismatches etc.), one of the major mismatches of TI-ADCs, occurs between the parallel sub-ADCs.
- The general BER expressions for an OFDM system using QAM signaling or PAM signaling in the presence of offset mismatch have not been derived yet.

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TI-ADCs Model

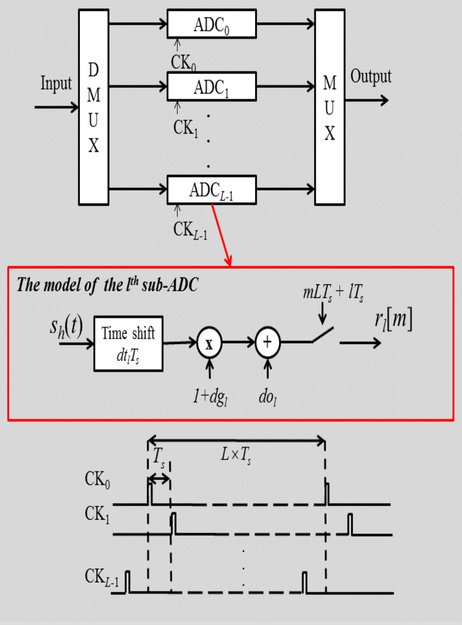

Fig. 1: Block diagram of a TI-ADC and the model of the mismatches in the l^{th} sub-ADC

System Model

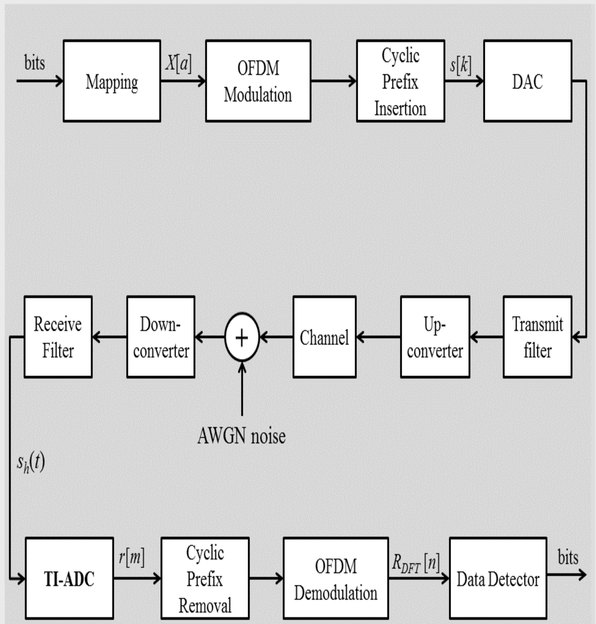

Fig. 2: Block diagram of OFDM system with a TI-ADC at the receiver

DFT Output

$$R_{DFT}[n] = \mathrm{H}_{eq}[\mathrm{n}]\mathrm{X}[\mathrm{n}] + \sum_{i} \mathrm{E}_{\mathrm{offset}}\,\delta\left[n - \frac{i}{L}N\right] + \mathrm{W}_{\mathrm{AWGN}}[n]$$

E_{offset} : error caused by offset mismatch, L: the number of sub-ADCs
N: the number of sub-carriers, δ[.]: the discrete dirac function

Offset mismatch causes:

- Complex-valued data-independent peaks to the iN/L ($i \neq 0$) sub-carriers
- Real-valued peak at frequency 0
- An error floor at high SNR if there is a sufficiently large offset mismatch

Table I
Simulation Parameters

Parameters	Reference values
N	2048
N_d	1706
N_{CP}	0
L	2, 4 or 8
E_s	1
Offset (do_l / A_0)	[0, 1, -0.59, -0.12, 0.31, -0.66, 0.41, -0.94]

N_d : the number of the modulated sub-carriers, N_{cp} : cyclic prefix length
E_s : the average symbol energy, A_0 : the RMS value of the TI-ADC input

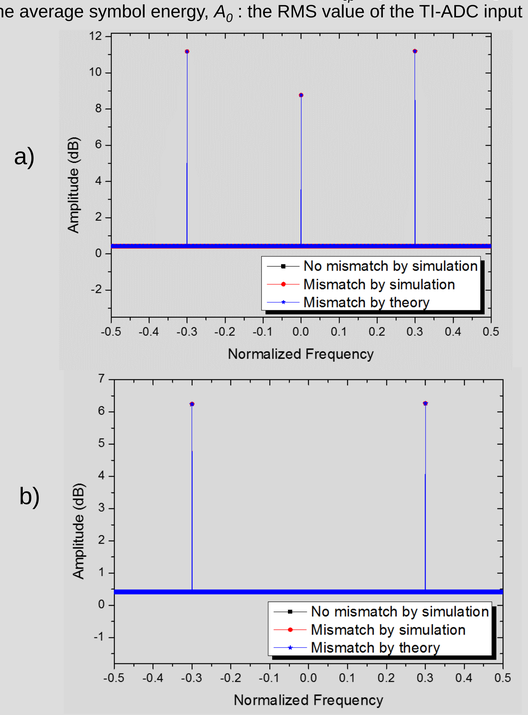

Fig. 3: DFT output: a) Real part, b) Imaginary part (L = 4, 4-QAM, SNR = 20 dB, 10% mismatch)

*Normalized frequency: frequency normalized to sub-carrier spacing

BER

$$BER = \Pr_{no\,mis.}\, BER_{no\,mis.} + \Pr_{\Re\{peak\}}\, BER_{\Re\{peak\}} + \Pr_{\Im\{peak\}}\, BER_{\Im\{peak\}}$$

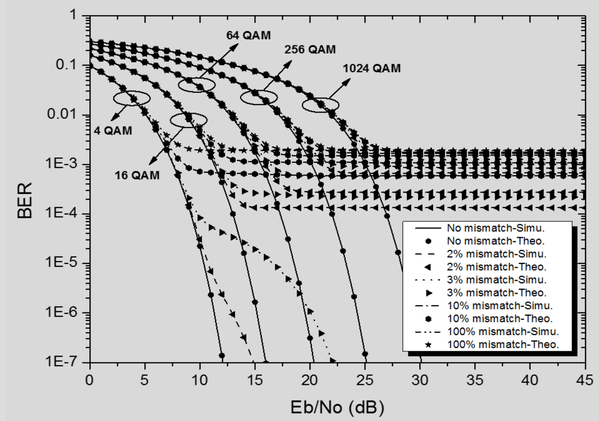

Fig. 4: BER of QAM constellations with Gray code mapping in AWGN channel (L = 8)

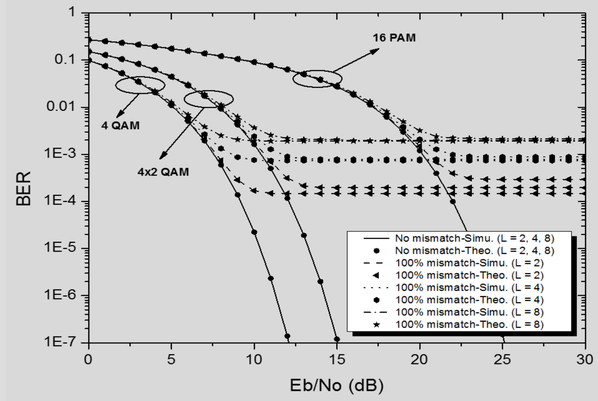

Fig. 5: BER of QAM and PAM constellations with Gray code mapping in AWGN channel (L = 2, 4, 8)

Conclusions

- The theoretical results are in excellent agreement with the simulation results → The accuracy of the derived expression confirmed
- Using higher modulation order leads the BER to an error floor faster (even with a small offset mismatch)
- The maximum error floor dependent of L: it increases as L increases
- Possible to extend to other types of channels (i.e., Rayleigh multipath channel etc.) and other types of bit assignments