BER Analysis of High-Speed OFDM Systems in The Presence of Time-Interleaved Analog-to-Digital Converter's Offset Mismatch

Vo-Trung-Dung Huynh, Nele Noels and Heidi Steendam
Department of Telecommunications and Information Processing, Ghent University

Introduction

❑ Time-interleaved analog-to-digital converters (TI-ADCs) are widely used for multi-Gigabit OFDM systems due to its effectiveness in providing high band-width capability and eliminating inter-symbol interference.

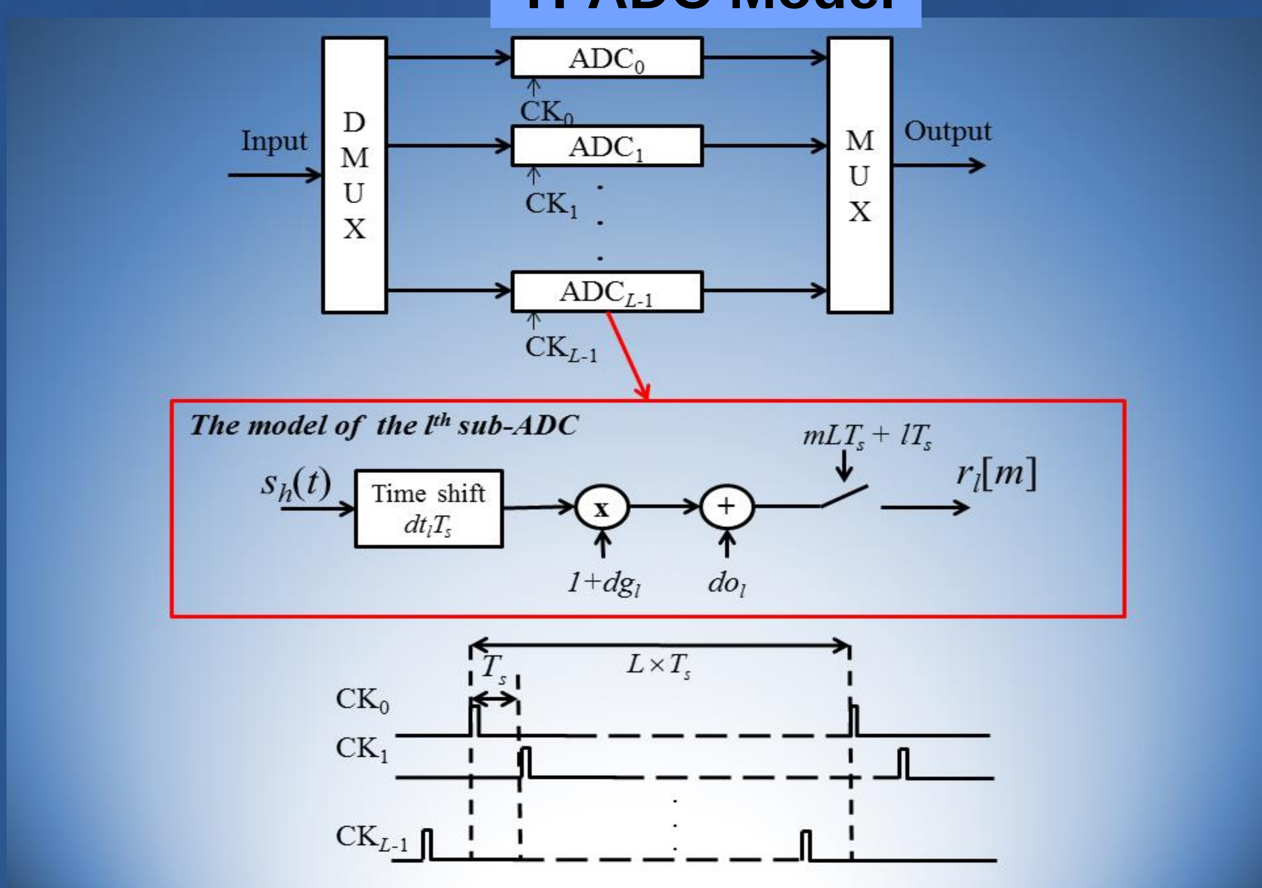
❑ In practice, offset mismatch (generated from the differential pairs of the opamps, capacitor mismatches etc.), one of the major mismatches of TI-ADCs, occurs between the parallel sub-ADCs.

❑ 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. → In this poster, we present such expressions.

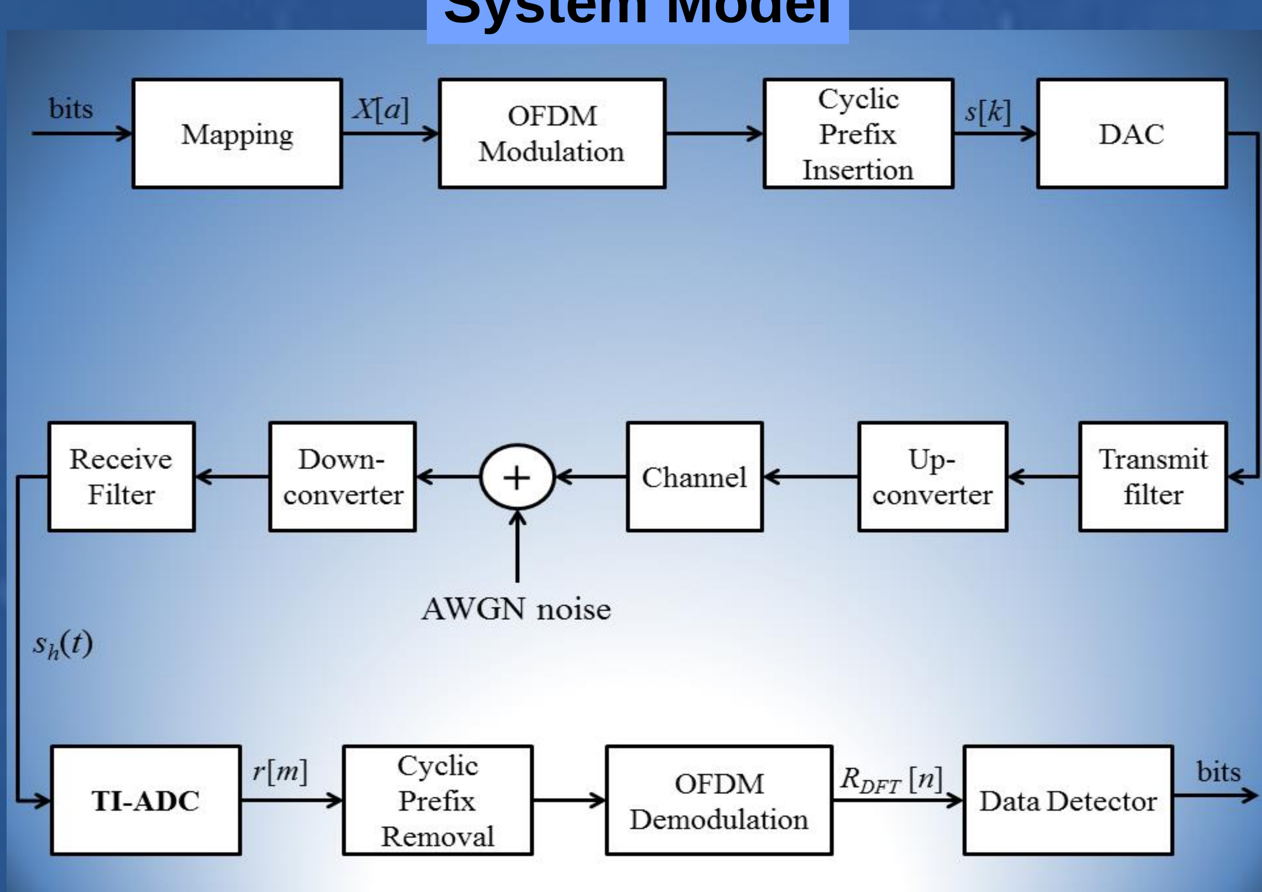
❑ Our finding also shows that at large SNRs, a large offset mismatch causes the error floor in the BER performance, which is essentially independent of the modulation order and the type of modulation.

TI-ADC Model & System Model

TI-ADC Model



System Model



DFT Output

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

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

Offset mismatch causes [1]:

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

Bit Error Rate Analysis

❑ **General BER:**

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

❑ **The error floor:**

$$BER_{QAM,\max} \approx BER_{PAM,\max} = \frac{K}{2I_d}$$

K: the number of offset-mismatch tones occurring in the data (relative to the number L of sub-ADCs).
I_d : the number of data sub-carriers

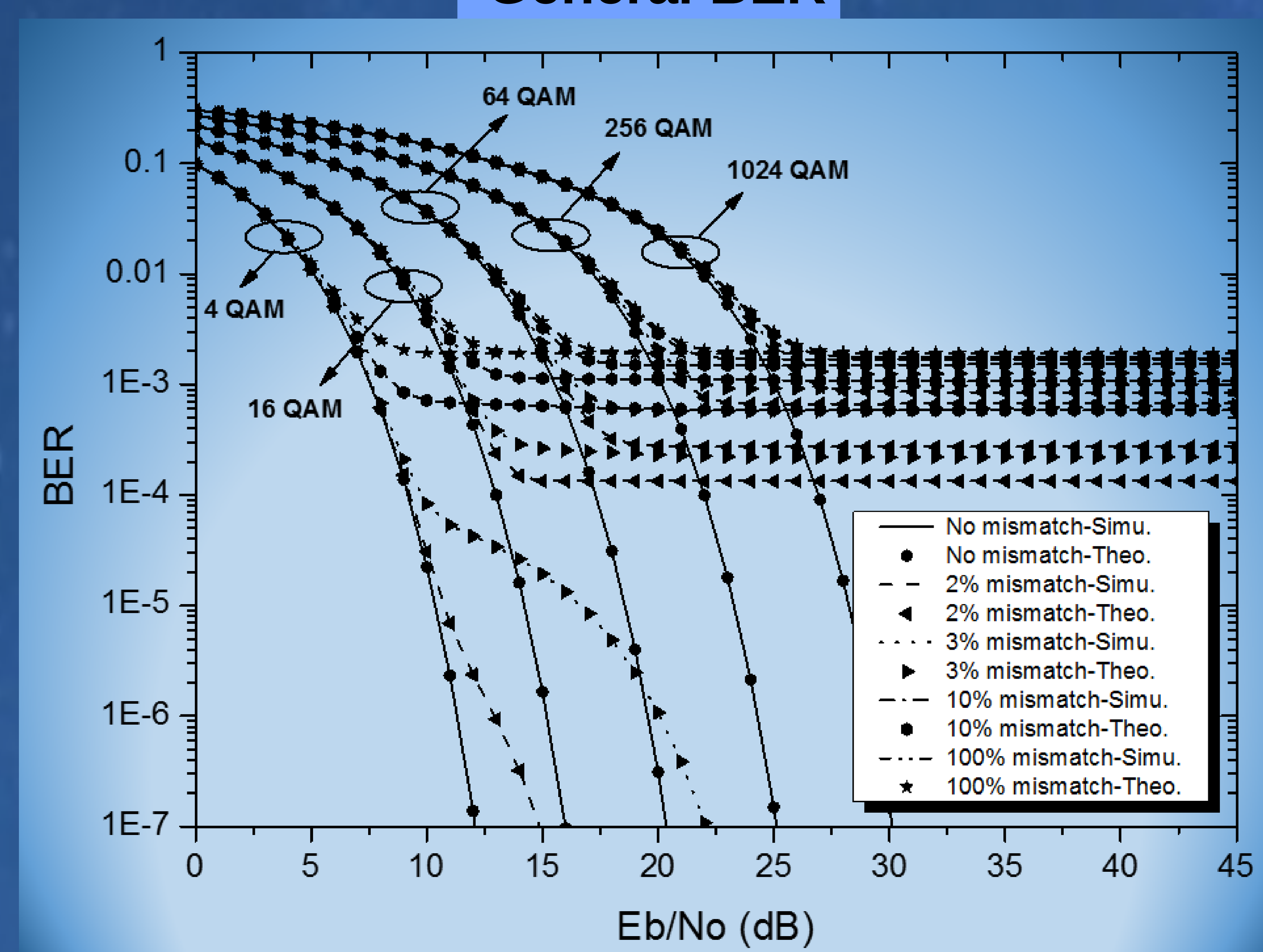
Numerical Results

Table I
Simulation Parameters

Parameters	Reference values
N	2048
I_d	1706
N_{CP}	0
L (K)	2, 4 or 8 (K=1, 3 or 7)
E_s	1
Offset (do_l / A_0)	[0, 1, -0.59, -0.12, 0.31, -0.66, 0.41, -0.94]

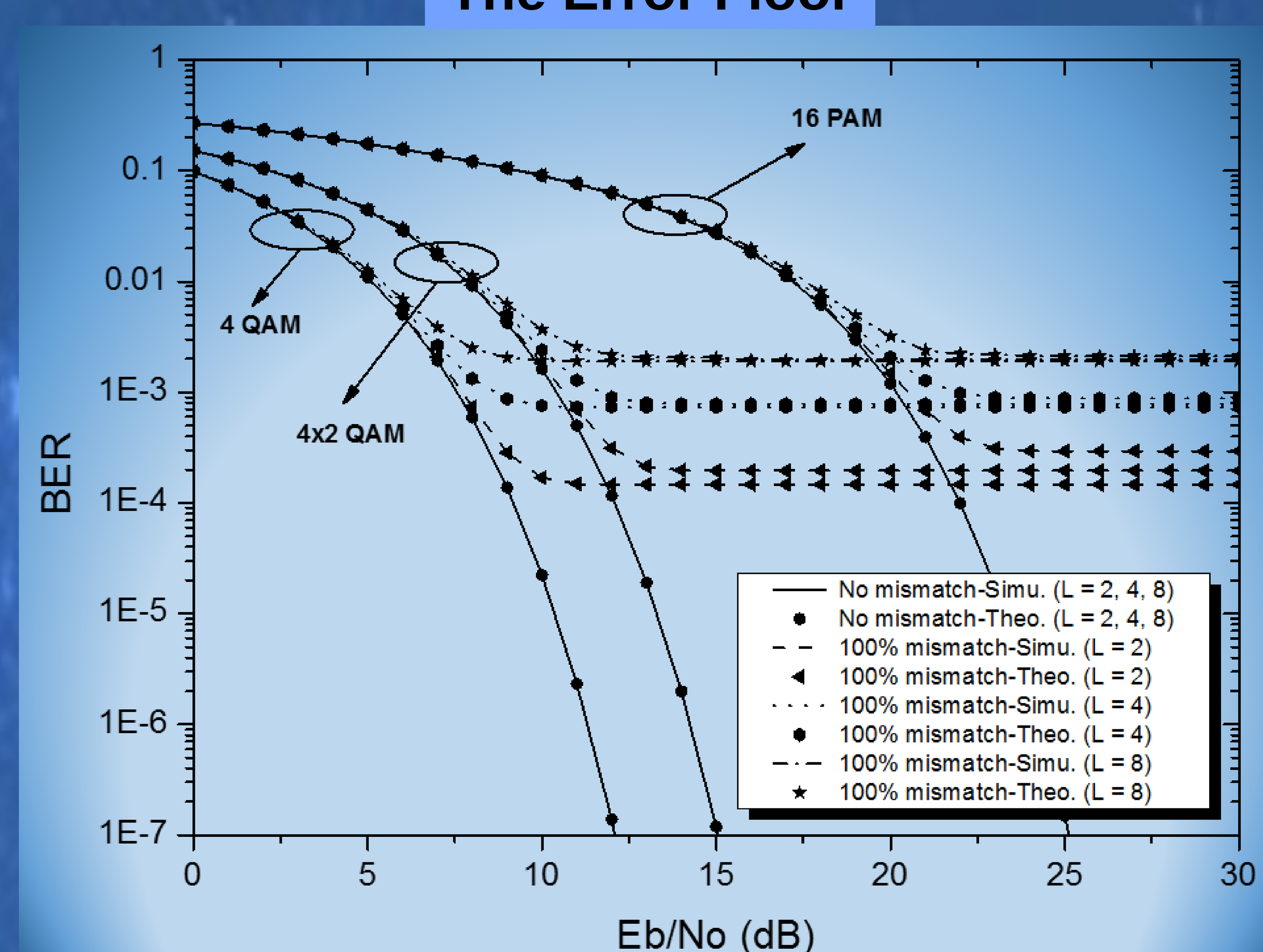
N_d : the number of the modulated sub-carriers
N_{cp} : cyclic prefix length
E_s : the average symbol energy
A_0 : the RMS value of the TI-ADC input

General BER



BER of QAM constellations with Gray code mapping in AWGN channel (*L* = 8)

The Error Floor



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

Conclusion

❑ The theoretical results are in excellent agreement with the simulation results → The accuracy of the derived expression confirmed.

❑ The maximum error floor is independent of the modulation order and type, but dependent of *L*: it increases as *L* increases.

❑ Possible to extend to other types of channels (i.e., Rayleigh multipath channel etc.).

Selected References

[1] V. Huynh, N. Noels, P. Rombouts, J. Armstrong, and H. Steendam, "Effect of Time-Interleaved Analog-to-Digital Converter Mismatches on OFDM Performance," *IEEE Inter. OFDM Workshop*, pp. 128-135, Aug. 2014.

[2] K. Cho, and D. Yoon, "On the General BER Expression of One- and Two-Dimensional Amplitude Modulations," *IEEE Trans. Comm.*, vol. 50, no. 7, pp. 1074-1080, Jul. 2002.

UNIVERSITEIT GENT | Erasmus Mundus | FWO VLAANDEREN

BelgoVietnam Symposium, Ghent-Belgium
19th October, 2015

The first author gratefully acknowledges the European Commission for his Erasmus Mundus scholarship. This research has been funded by the FWO Flanders and the Interuniversity Attraction Poles Programme initiated by the Belgian Science Policy Office.