Lucerne University of
Applied Sciences and Arts

HOCHSCHULE
LUZERN

Technik & Architektur
CC Innovation in Intelligent
Multimedia Sensor Networks

Channel estimation based on frame control symbol re-encoding and re-mapping in IEEE Std. 1901-2010

Liset Martínez *et al.*
CC-ISN/Lucerne University of Applied Sciences and Arts
Department of Telecommunications/Technological University of Havana

Presented by Javier Moya. WSPLC Prague, September 2017

Table of contents

Table of contents

Table of contents

Table of contents

Table of contents

Table of contents

Table of contents

Table of contents

Table of contents

Table of contents

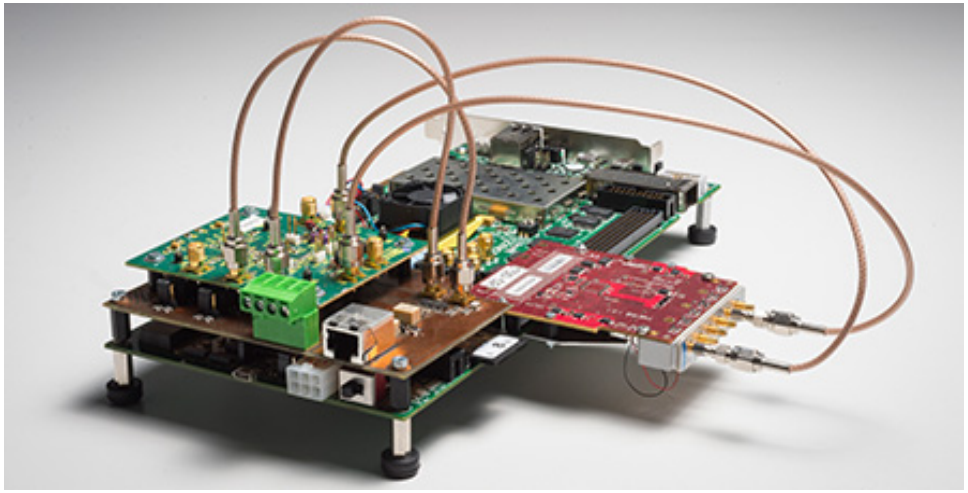
Lucerne University of
Applied Sciences and Arts
HOCHSCHULE
LUZERN
Technik & Architektur
CC Innovation in Intelligent
Multimedia Sensor Networks

Our PLC competence centre

Our PLC competence centre

What are we doing?

Our competence centre is developing their own PLC modem/technology, which is called PLUS



Our PLC competence centre

How are we doing it?

For the PLUS development we built our own model-based/FPGA design platform; we have learned that sometimes the design constraints the specification models

Lucerne University of
Applied Sciences and Arts
HOCHSCHULE
LUZERN
Technik & Architektur
CC Innovation in Intelligent
Multimedia Sensor Networks

Channel estimation in PLC

Channel estimation in PLC

Introduction and system model

- PLC channel: one of the most aggressive
- Channel estimation concept
- Channel estimation in PLC

Channel estimation in PLC

Introduction and system model

- PLC channel: one of the most aggressive
- Channel estimation concept
- Channel estimation in PLC

Channel estimation in PLC

Introduction and system model

- *Multi-path and high power level of noise*
- Channel estimation concept
- Channel estimation in PLC

Channel estimation in PLC

Introduction and system model

- PLC channel: one of the most aggressive
- Channel estimation concept
- Channel estimation in PLC

Channel estimation in PLC

Introduction and system model

- PLC channel: one of the most aggressive
- *CFR and NPSD are treated separately*
- Channel estimation in PLC

Channel estimation in PLC

Introduction and system model

- PLC channel: one of the most aggressive
- Channel estimation concept
- Channel estimation in PLC

Channel estimation in PLC

Introduction and system model

- PLC channel: one of the most aggressive
- Channel estimation concept
- *CFR est. methods are available in the literature*

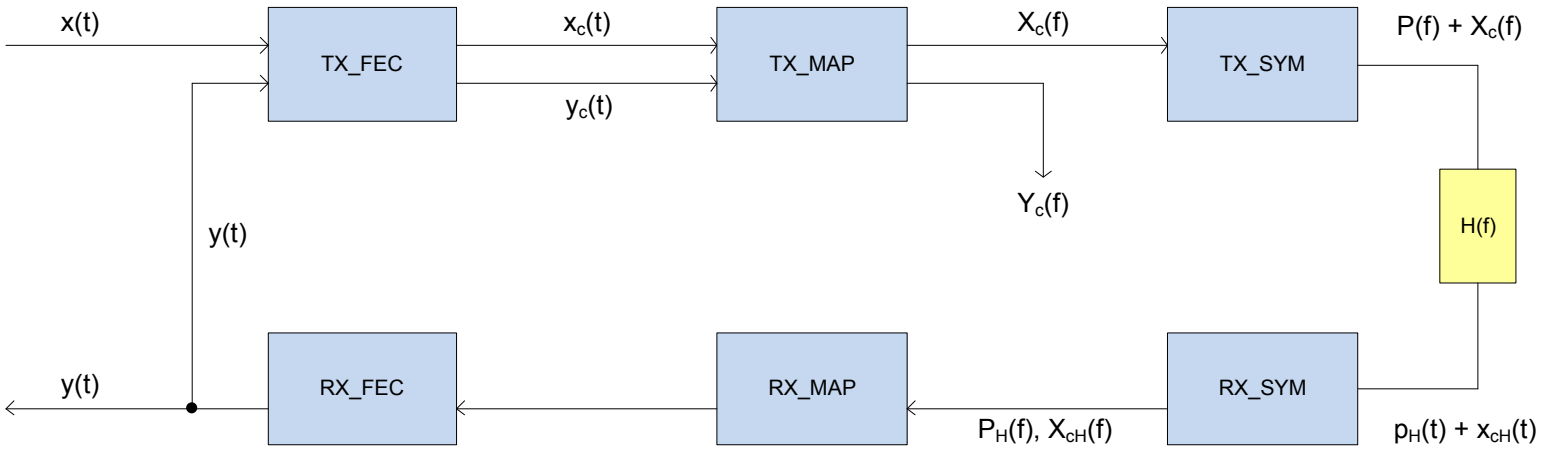
Channel estimation in PLC

Introduction and system model

- PLC channel: one of the most aggressive
- Channel estimation concept
- *NPSD estimation methods proposal*

Channel estimation in PLC

Introduction and system model



In general: $Y(f) = [H(f) * X(f)] + N(f)$

Channel estimation in PLC

Channel frequency response (CFR) estimation

Many CFR est. methods are available in the literature

- Blind methods
- Pilot-tones or pilot-symbols aided
- Direct sequence
- Others

Channel estimation in PLC

Channel frequency response (CFR) estimation

Many CFR est. methods are available in the literature

- Blind methods
- Pilot-tones or pilot-symbols aided
- Direct sequence
- Others

Channel estimation in PLC

Channel frequency response (CFR) estimation

Many CFR est. methods are available in the literature

- Blind methods
- Pilot-tones or pilot-symbols aided
- Direct sequence
- Others

Channel estimation in PLC

Channel frequency response (CFR) estimation

Many CFR est. methods are available in the literature

- Blind methods
- Pilot-tones or pilot-symbols aided
- Direct sequence
- Others

Channel estimation in PLC

Channel frequency response (CFR) estimation

Many CFR est. methods are available in the literature

- Blind methods
- Pilot-tones or pilot-symbols aided
- Direct sequence
- Others

Channel estimation in PLC

Channel frequency response (CFR) estimation

Many CFR est. methods are available in the literature

- Blind methods
- Pilot-tones or pilot-symbols aided
- Direct sequence
- Others

Channel estimation in PLC

Channel frequency response (CFR) estimation

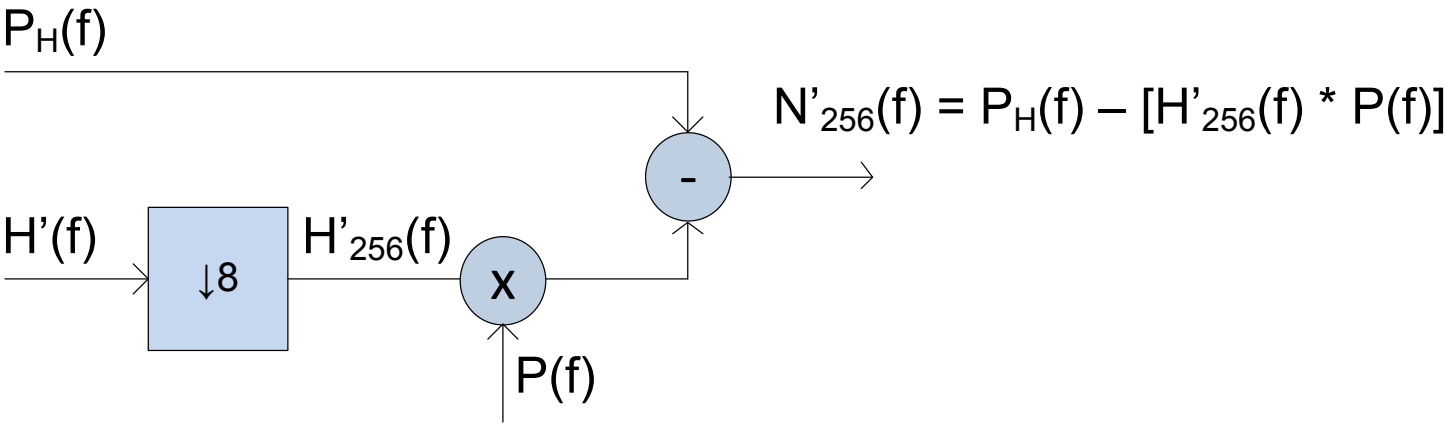
Many CFR est. methods are available in the literature

- Blind methods
- *Preamble-based LMMSE: $H'_P(f)$*
- *FC-based LS: $H'_{FC}(f)$*
- Others

Channel estimation in PLC

Noise power spectral density (NPSD) estimation

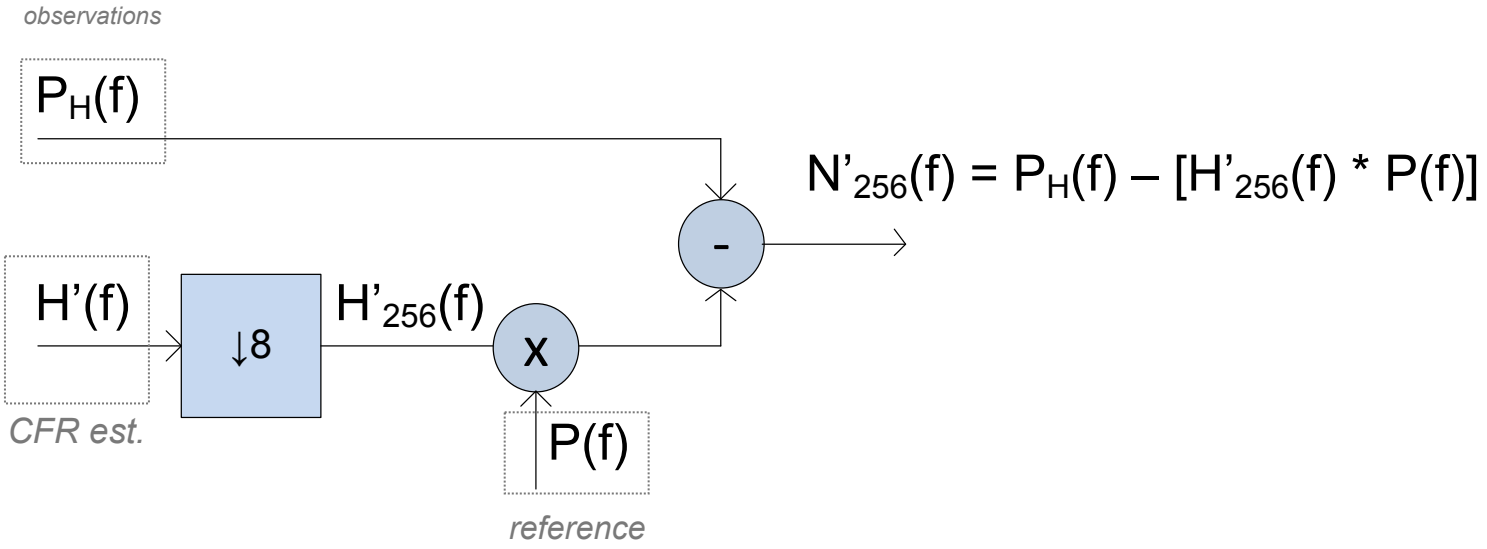
Preamble-based (pilot-tones LMMSE)



Channel estimation in PLC

Noise power spectral density (NPSD) estimation

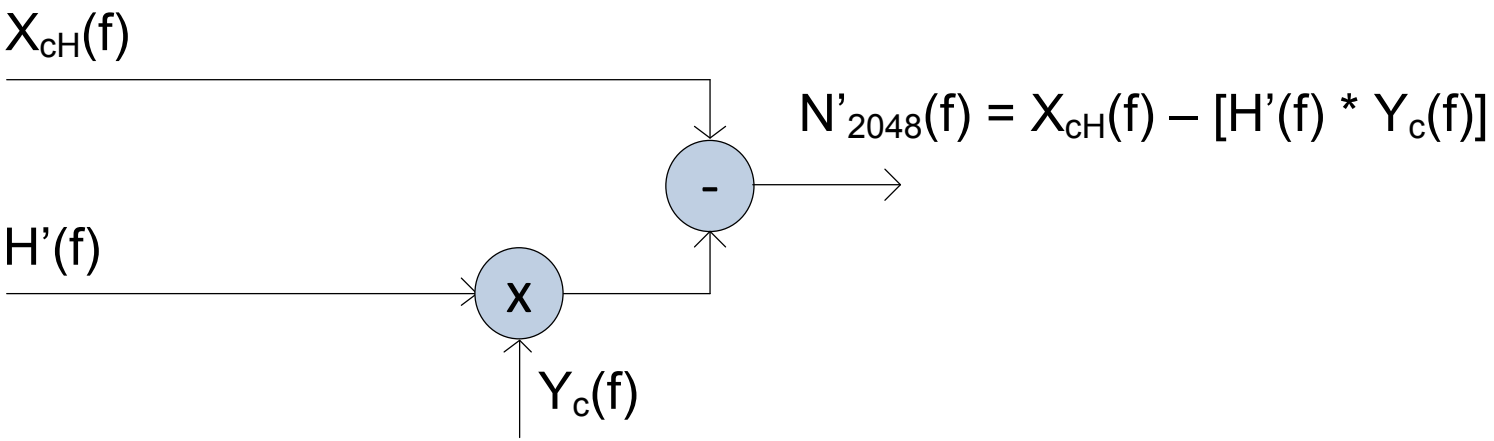
Preamble-based (pilot-tones LMMSE)



Channel estimation in PLC

Noise power spectral density (NPSD) estimation

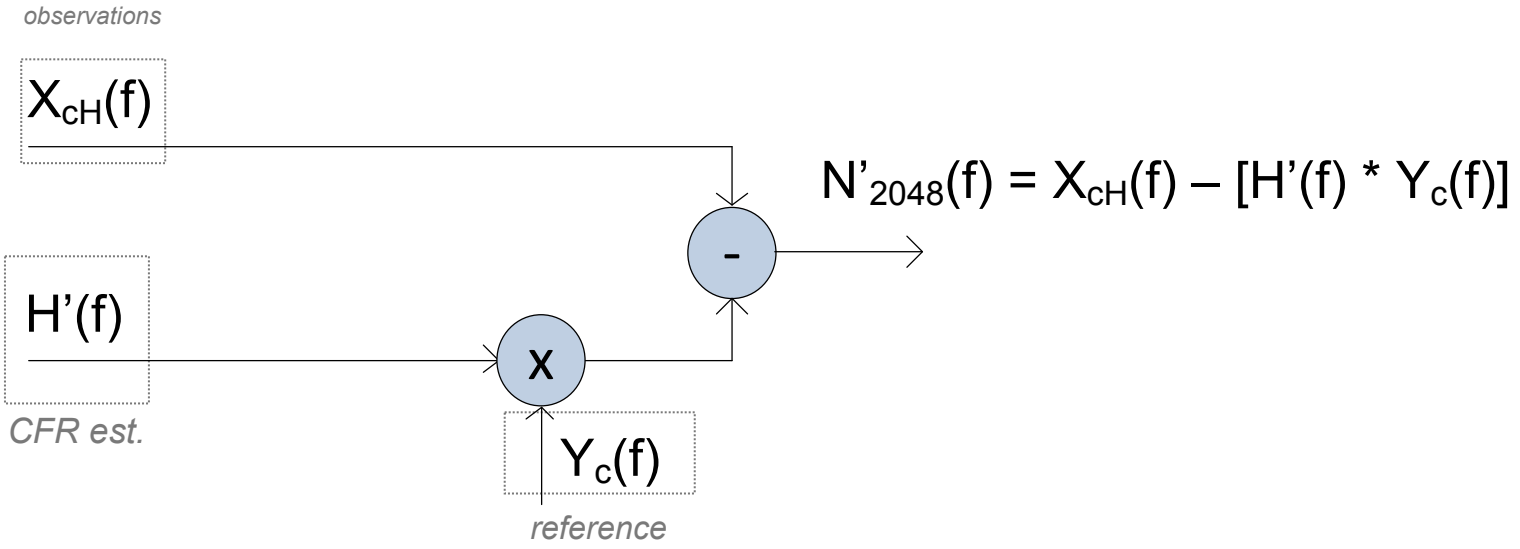
FC-based (direct sequence LS)



Channel estimation in PLC

Noise power spectral density (NPSD) estimation

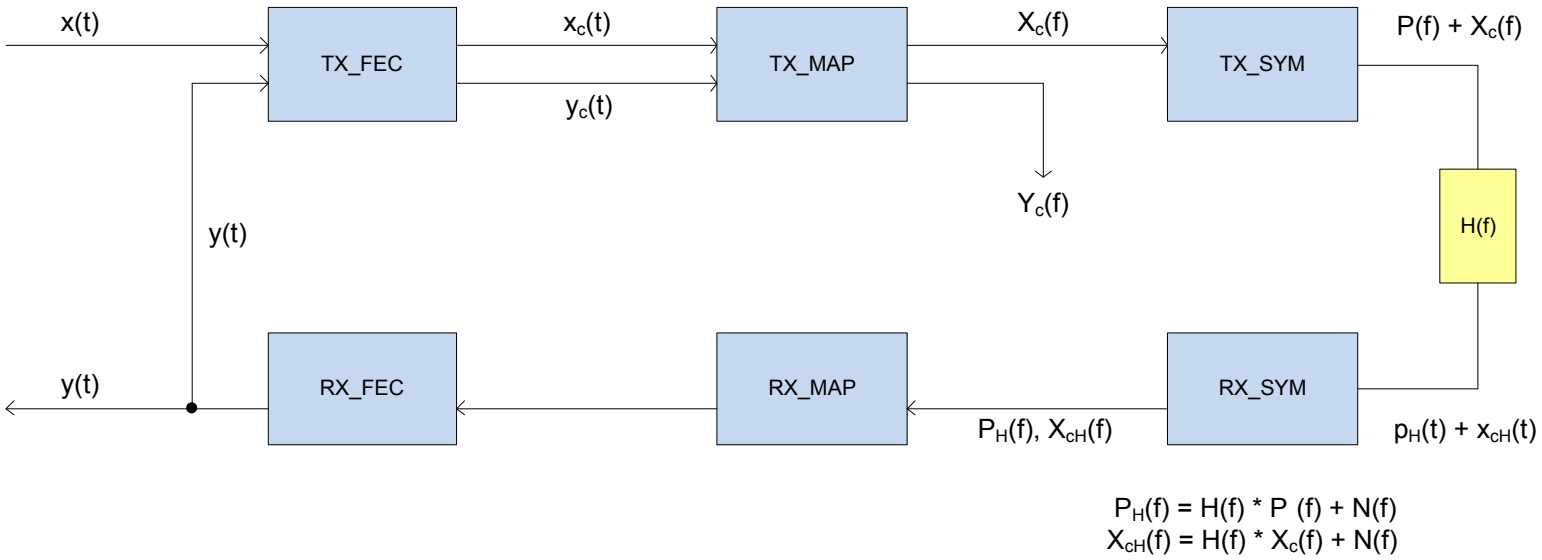
FC-based (direct sequence LS)



Channel estimation in PLC

Noise power spectral density (NPSD) estimation

Preamble- vs. FC-based



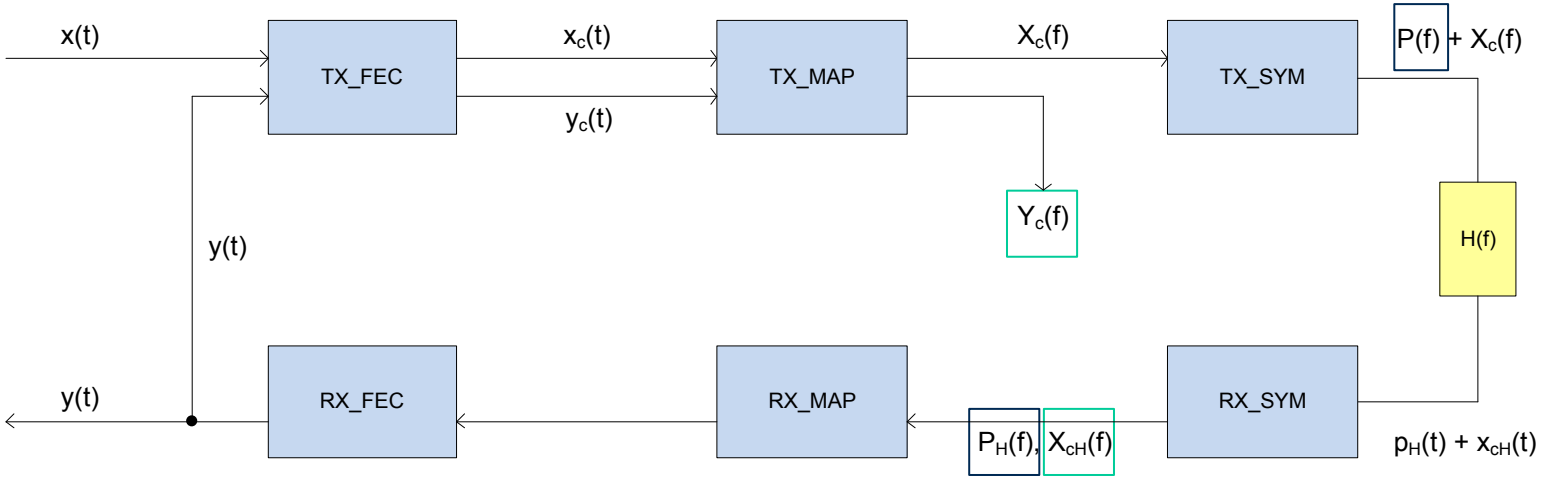
$N'_{256}(f) = P_H(f) - [H'_{256}(f) * P(f)]$ for Preamble-based

$N'_{2048}(f) = X_{cH}(f) - [H'(f) * Y_c(f)]$ for FC-based

Channel estimation in PLC

Noise power spectral density (NPSD) estimation

Preamble- vs. FC-based



$P_H(f) = H(f) * P(f) + N(f)$
$X_{cH}(f) = H(f) * X_c(f) + N(f)$

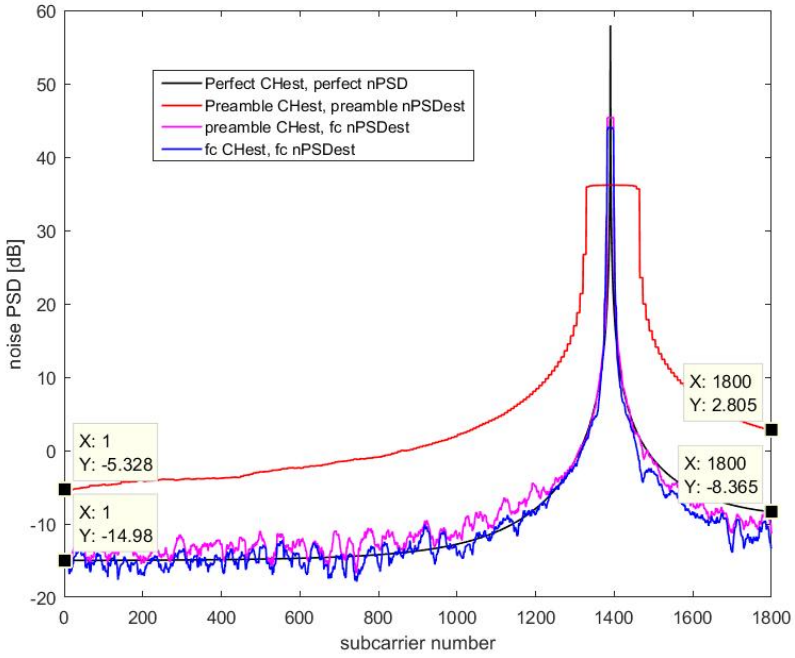
NPSD *observations* *CFR est.* *reference*

$N'_{256}(f) = P_H(f) - [H'_{256}(f) * P(f)]$ for Preamble-based
$N'_{2048}(f) = X_{cH}(f) - [H'(f) * Y_c(f)]$ for FC-based

Channel estimation in PLC

Noise power spectral density (NPSD) estimation

Preamble- vs. FC-based



Channel estimation in PLC

Test case, results and conclusions

Test case

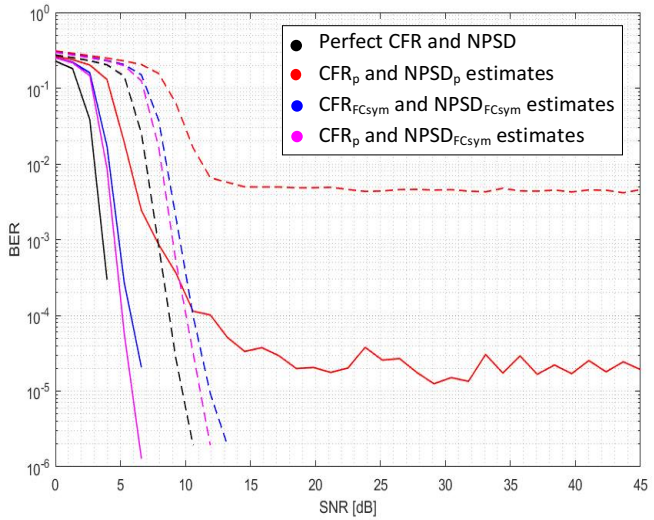
- CC-ISN simulation platform
- PB520 blocks (16/21)
- QPSK
- OPERA-2 CFR with AWGN plus -25 dB NBI

Channel estimation in PLC

Test case, results and conclusions

Results

BER simulations indicate that in the presence of a NBI, the accuracy of the NPSD estimation is critical

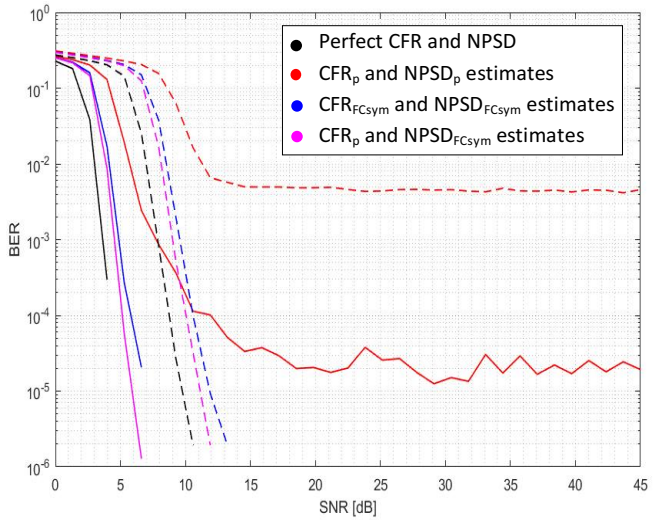


Channel estimation in PLC

Test case, results and conclusions

Results

On the other hand, the CFR estimation method does not have a big impact on the system performance



Channel estimation in PLC

Test case, results and conclusions

Due to the results shown, a proposal for data decoding in a IEEE1901 system has been presented:

Channel estimation method based on FC symbol re-encoding and re-mapping

1. Estimate the CFR and the NPSD based on the preamble sequence.
2. Recover FC bits.
3. ***IF*** Checksum error ***THEN***
4. Discard the frame.
5. ***ELSE***
6. Re-encode and re-map FC bits in order to obtain a new reference.
7. Re-estimate the NPSD based on the FC symbol.
8. Equalize the payload symbols with the preamble-based CFR estimate.
9. Compute the log-likelihood ratios for the bits in the payload and the FC symbol-based NPSD estimate.
10. Decode payload.
11. ***END***

Lucerne University of
Applied Sciences and Arts
HOCHSCHULE
LUZERN
Technik & Architektur
CC Innovation in Intelligent
Multimedia Sensor Networks

Overall conclusions

Overall conclusions

- For the PLUS development we built our own model-based/FPGA design platform; we have learned that sometimes the design constraints the specification models. This is the case for the channel NPSD estimation
- In this work, a HW-implementable-solution for the NPSD (thus the CFR) PLC-channel estimation has been presented, which is based on frame control symbol re-encoding and re-mapping

Lucerne University of
Applied Sciences and Arts

HOCHSCHULE
LUZERN

Technik & Architektur
CC Innovation in Intelligent
Multimedia Sensor Networks

Channel estimation based on frame control symbol re-encoding and re-mapping in IEEE Std. 1901-2010

Liset Martínez *et al.*
CC-ISN/Lucerne University of Applied Sciences and Arts
Department of Telecommunications/Technological University of Havana

Presented by Javier Moya. WSPLC Prague, September 2017