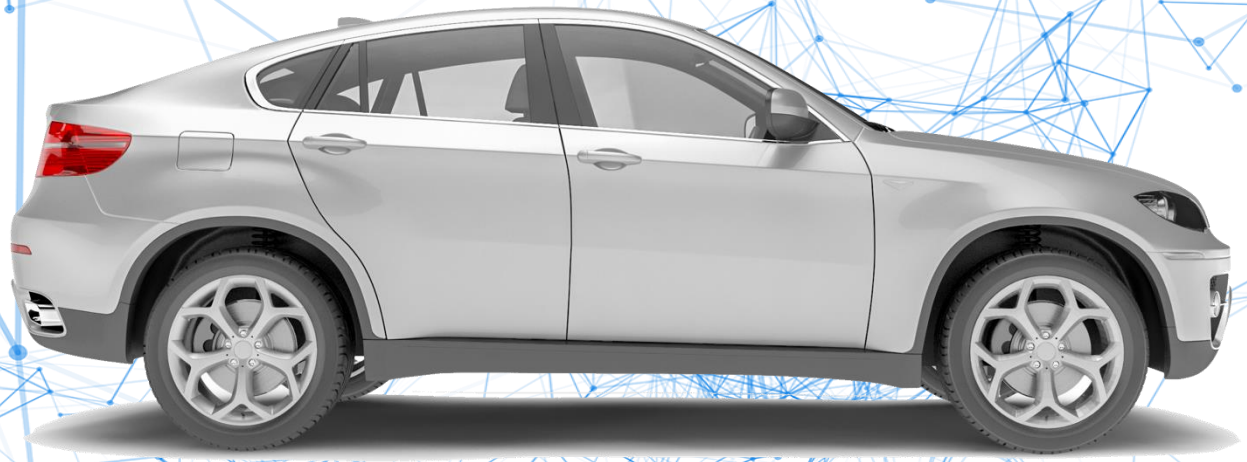

Nonlinear Precoding

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IEEE 802.3cy August 2021

Overview

- Transmit path includes the following typical functions
  1. Forward error encoding
  2. Interleaving
  3. Scrambler
  4. Gray mapping
  5. **Precoding**
  6. Modulation

- This presentation covers step 5: nonlinear precoding

Precoding and DFE Error Propagation

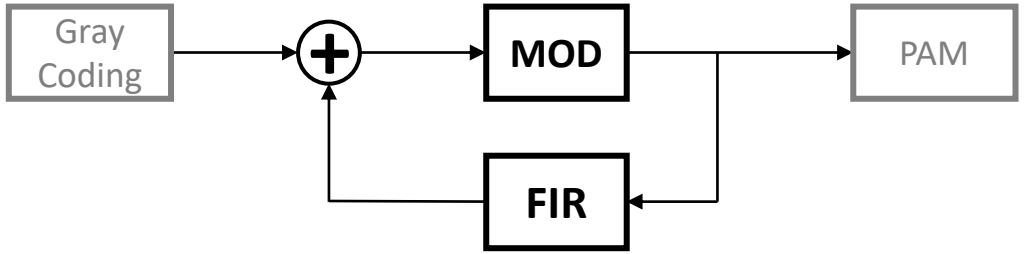
- The feedback path of DFE may cause a single slicer error to corrupt many subsequent symbols causing long error burst
- The higher error rate due to these error bursts is not predicted from SNR and a Gaussian assumption for noise
- Forward error correction can correct error burst at the expense of limiting its correction capability for other potential non-Gaussian error sources (Impulse noise, EMI, etc.)
- A simple nonlinear precoder can lower the probability and length of error bursts significantly without much impact on the complexity of the PHY

Precedence and References

Transmit nonlinear precoding is studied for and adopted in a number of 802.3 specifications. Here is a brief and partial list of contributions and standard text:

- 802.3bj: 100GBASE-KP4
  - subclause 94.2.2.6
  - https://www.ieee802.org/3/bj/public/sep11/parthasarathy_01_0911.pdf
- 802.3bs:
  - https://www.ieee802.org/3/bs/public/15_11/hegde_3bs_01a_1115.pdf
- 802.3cd: 50GBASE-R, 100GBASE-P
  - subclause 135.5.7.1
  - https://www.ieee802.org/3/cd/public/July16/hegde_3cd_01_0716.pdf
- 802.3ch: 2.5/5/10GBASE-T1
  - subclause 149.3.2.2.20
  - https://www.ieee802.org/3/ch/public/sep18/souvignier_3ch_02_0918.pdf
- 802.3ck
  - https://www.ieee802.org/3/ck/public/18_09/zhang_3ck_01a_0918.pdf
  - https://www.ieee802.org/3/ck/public/adhoc/jan02_19/lu_3ck_adhoc_01a_010219.pdf

Nonlinear Precoder Structure



In many practical cases the choice for FIR is extremely simple:

- Coefficients are either 0, -1 or +1
  - There is no need for multiplier in implementation of FIR
  - There is no expansion of the resolution in transmit data path
- There is only one non-zero coefficient
  - There is no accumulator in FIR

Precoder Options

Following the specifications in 802.3ch

- 4 fixed options
  - No precoding
  - $(1 - D^{-1})$
  - $(1 + D^{-1})$
  - $(1 - D^{-2})$
- The link-partner decides which option to choose and communicate that as part of InfoField exchange during training

Summary and Conclusions

- Nonlinear precoding is an effective mechanism to reduce DFE error burst
- It comes with little cost in PHY complexity
- It has been studied and adopted before in many applications
- The specification for nonlinear precoding may exactly follow that of 802.3ch

THANK YOU

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