IEEE 802.3dm

LDR Receiver in ACT
Equalization and Echo Cancellation

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Overview

Presenting an analysis of the LDR receiver requirements in ACT:

- Noise budget
- Echo cancellation
- Equalization
- Analog front-end

Includes the effects of

- Baseline wander (Chini 09/24)
- Double reflections due to MDI limited return loss (Ahuja 11/24)
- Echo and hybrid (Dalmia 11/24)

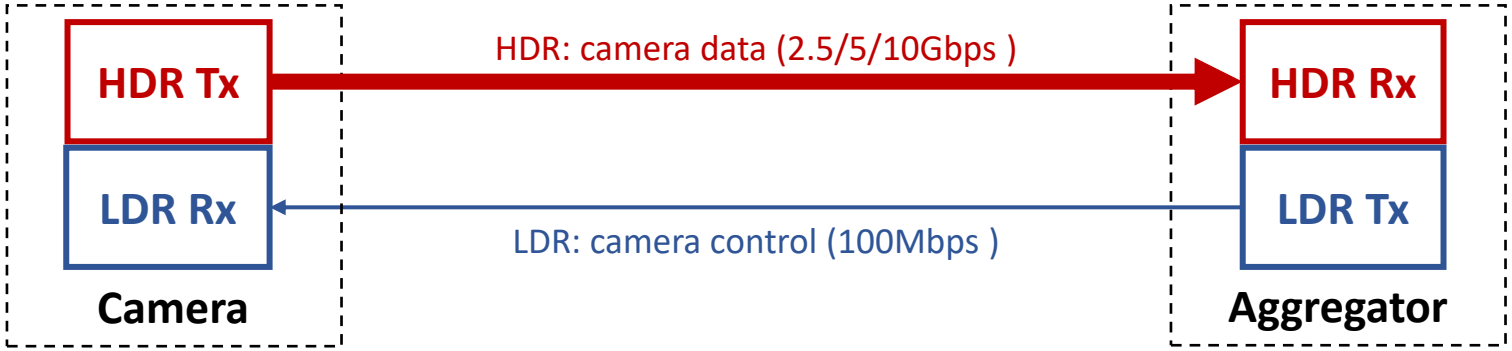
ACT Signalling

LDR - Low data rate direction:

- Baud rate = 5625 / 48 MHz
- Modulation = PAM2 with Differential Manchester Encoding (DME)

HDR - High data rate direction:

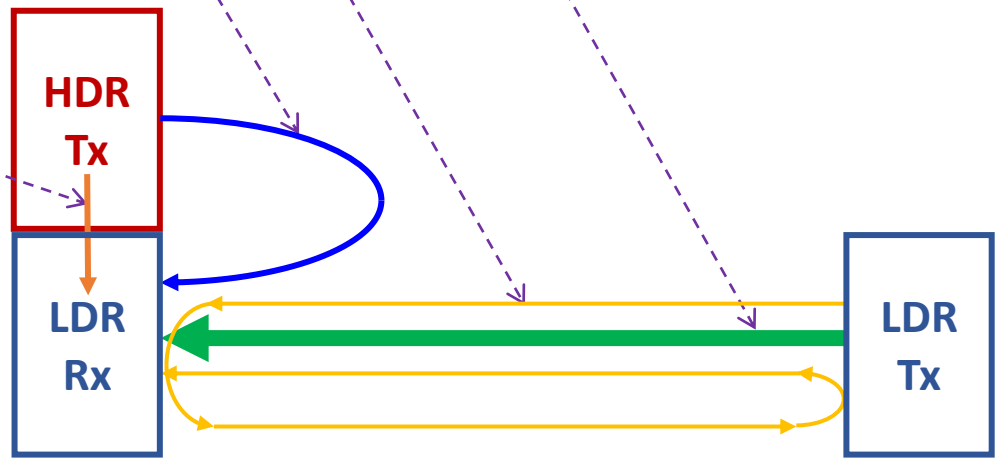
- Baud rate = S × 5625 MHz
  (S = 1, 0.5, and 0.25 for 10, 5, and 2.5Gbps)
- Modulation = PAM4



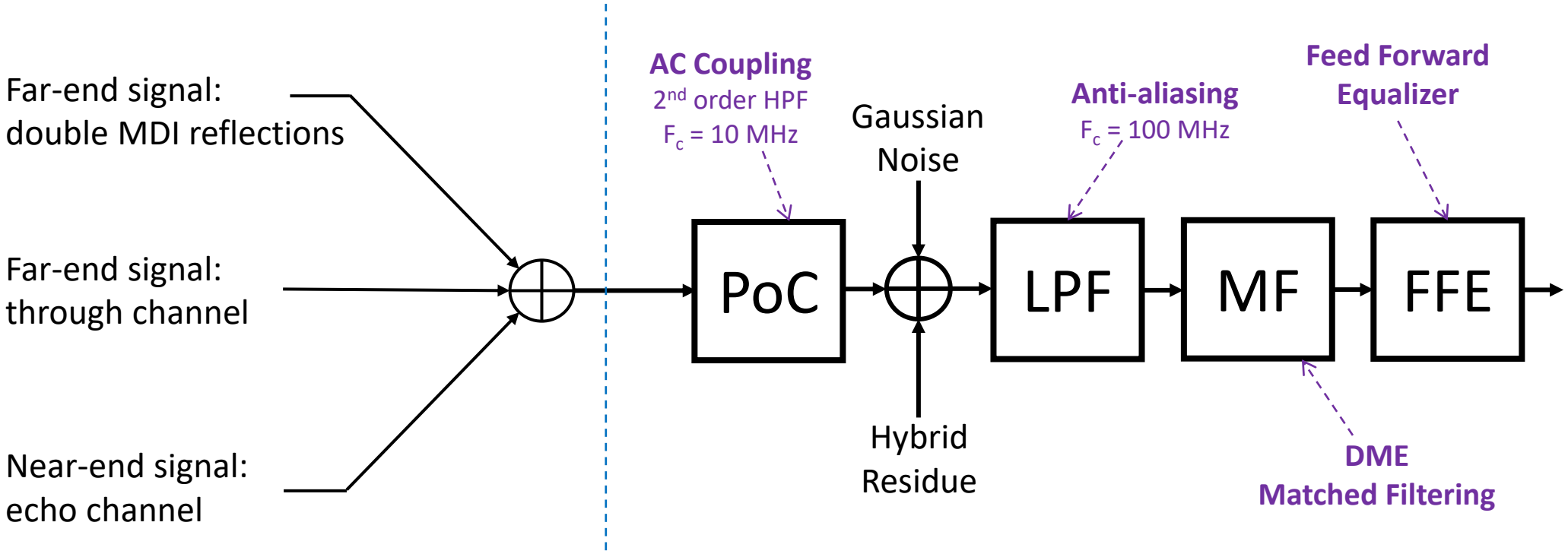
Focus of this presentation is **LDR Rx**

LDR Receiver Signal Components

- Direct signal from link-partner going through insertion loss
- Double (or more) reflections from MDI going through multiple channel loss
- Echo
- Hybrid residue
- External disturbers
  - EMI
  - Burst noise
- PHY self-noise



LDR Receiver Model



FEC and other receiver blocks protect against burst noise and EMI

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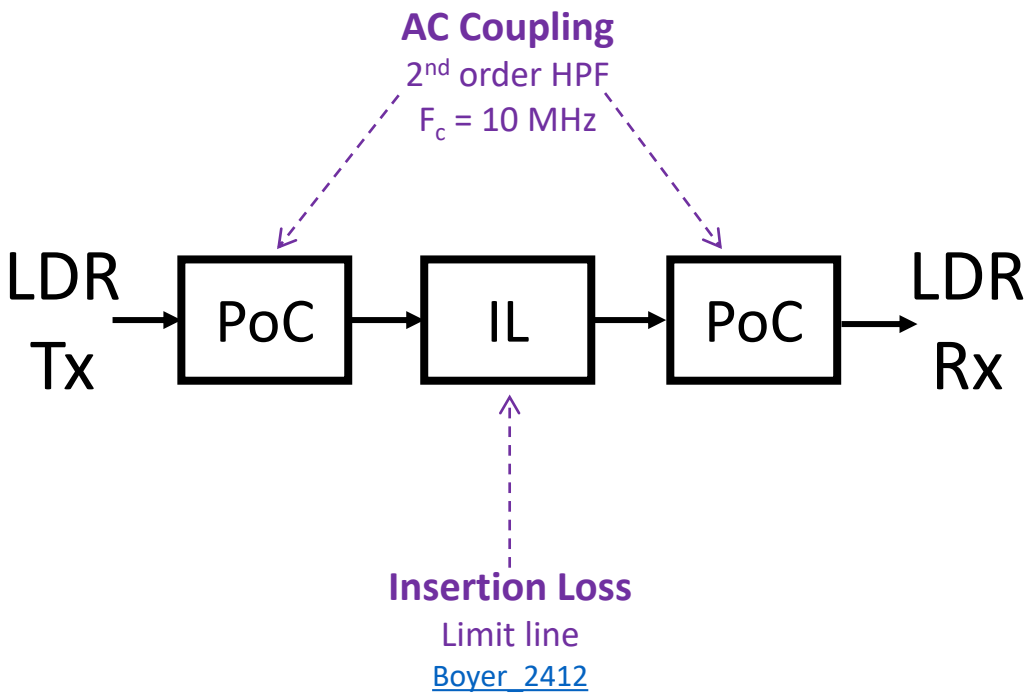
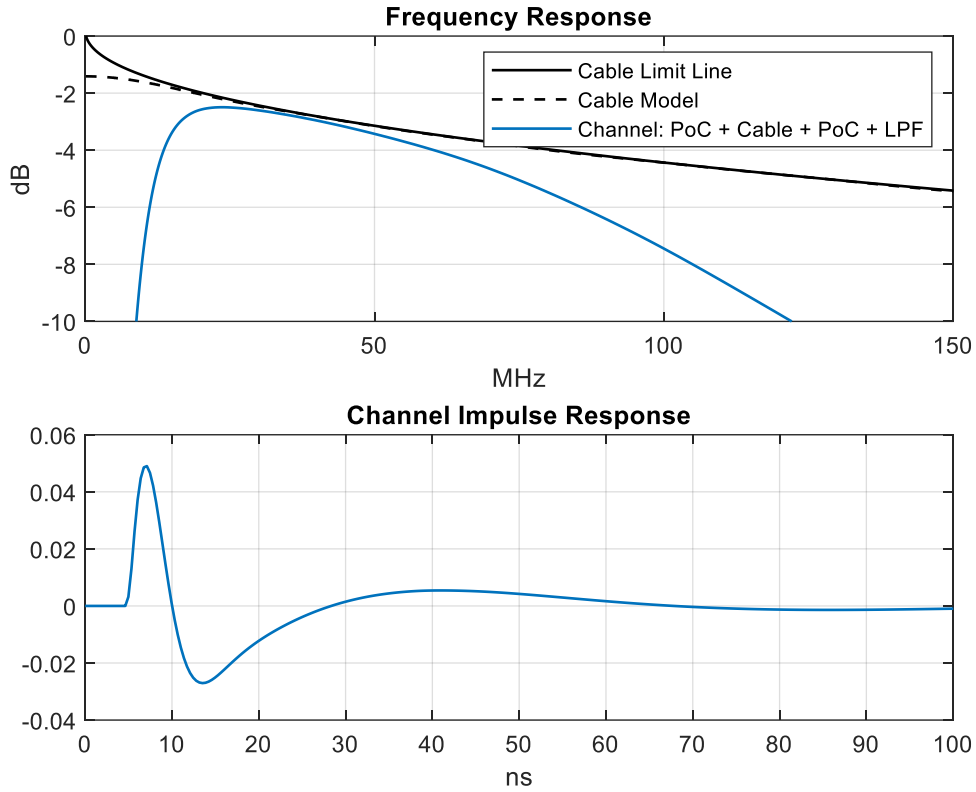
Through Channel





Cable model is slightly worse than limit line

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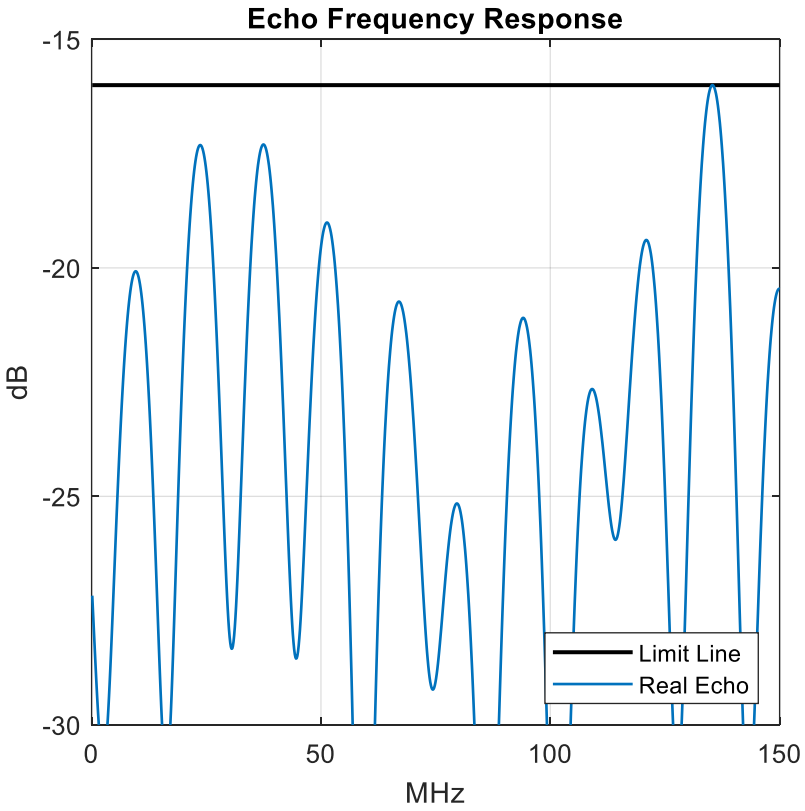
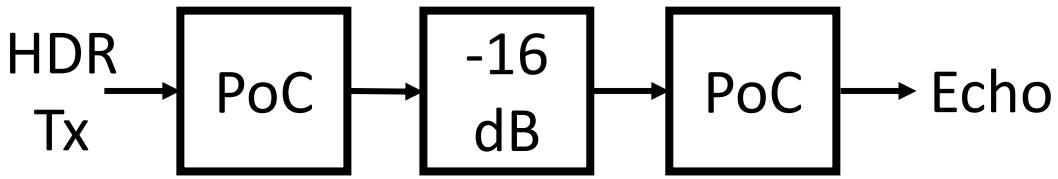
Echo Channel

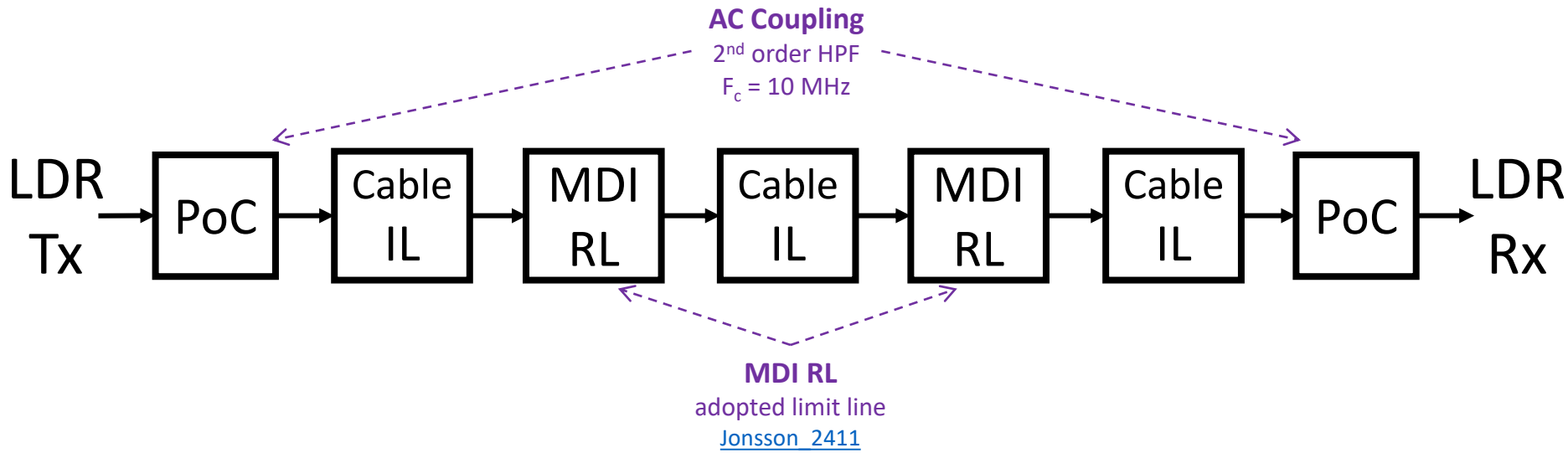
- Assuming RL limit line proposed in Boyer_2411
  - RL limit line represents an envelop for echo response
  - A real echo response is typically much weaker than the limit in many frequencies
- Assuming echo channel meets the limit lime for all frequencies

➔ Echo is modelled much stronger than reality





MDI Double Reflections



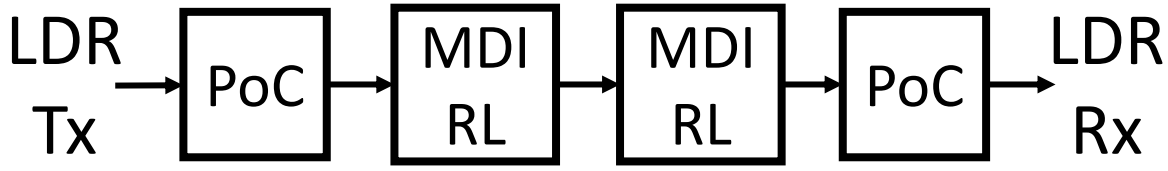
Double reflections are attenuated by 3x of cable loss

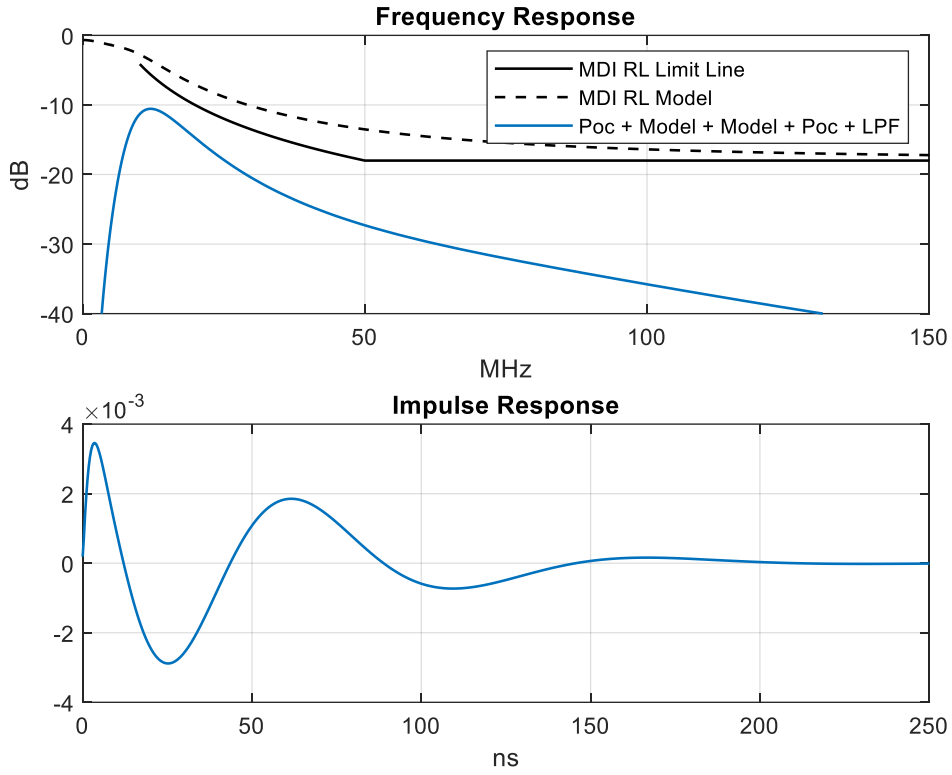
MDI Double Reflections: Model

In this analysis, double reflections are modeled very conservatively:

- The model for MDI RL is worse than the limit line
- While thru channel is assumed with maximum IL, double reflections are assumed to go through no loss

➔ Double reflections are modelled much stronger than the reality





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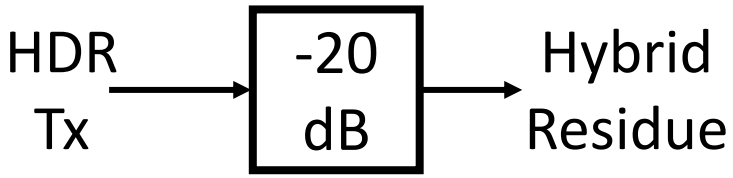
Hybrid

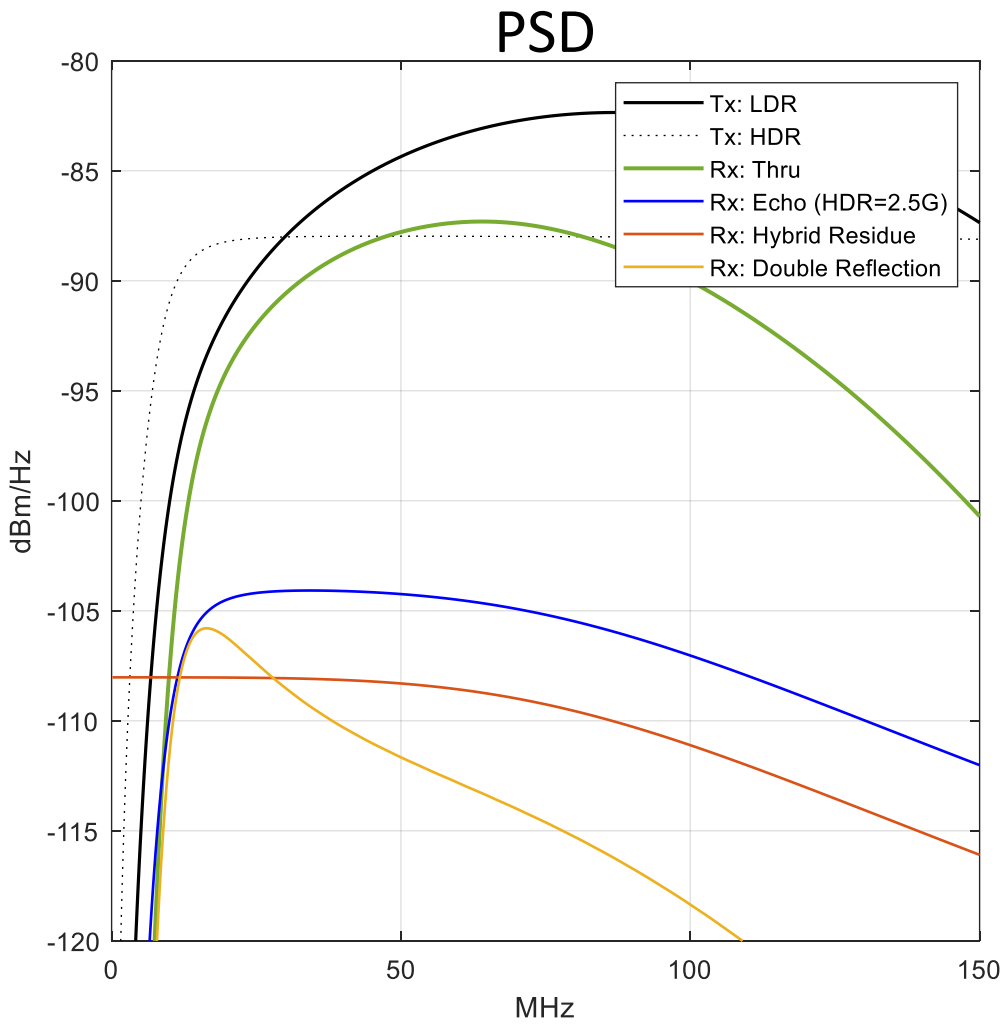
Assuming moderate hybrid rejection of no more than 20 dB within the bandwidth of LDR receiver



Signal and Disturbers

- LDR Tx power = -2 dBm
  (250 mv pk)
- HDR: 2.5 Gbps per 802.3ch
  (2.5G generates maximum echo)
- HDR Tx power = 0 dBm

Component	Power (dBm)
Rx Signal (from LKP)	-8.7
Echo	-24.4
Hybrid	-28.2
MDI 2x Reflections	-31.0



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Time-Domain Simulation

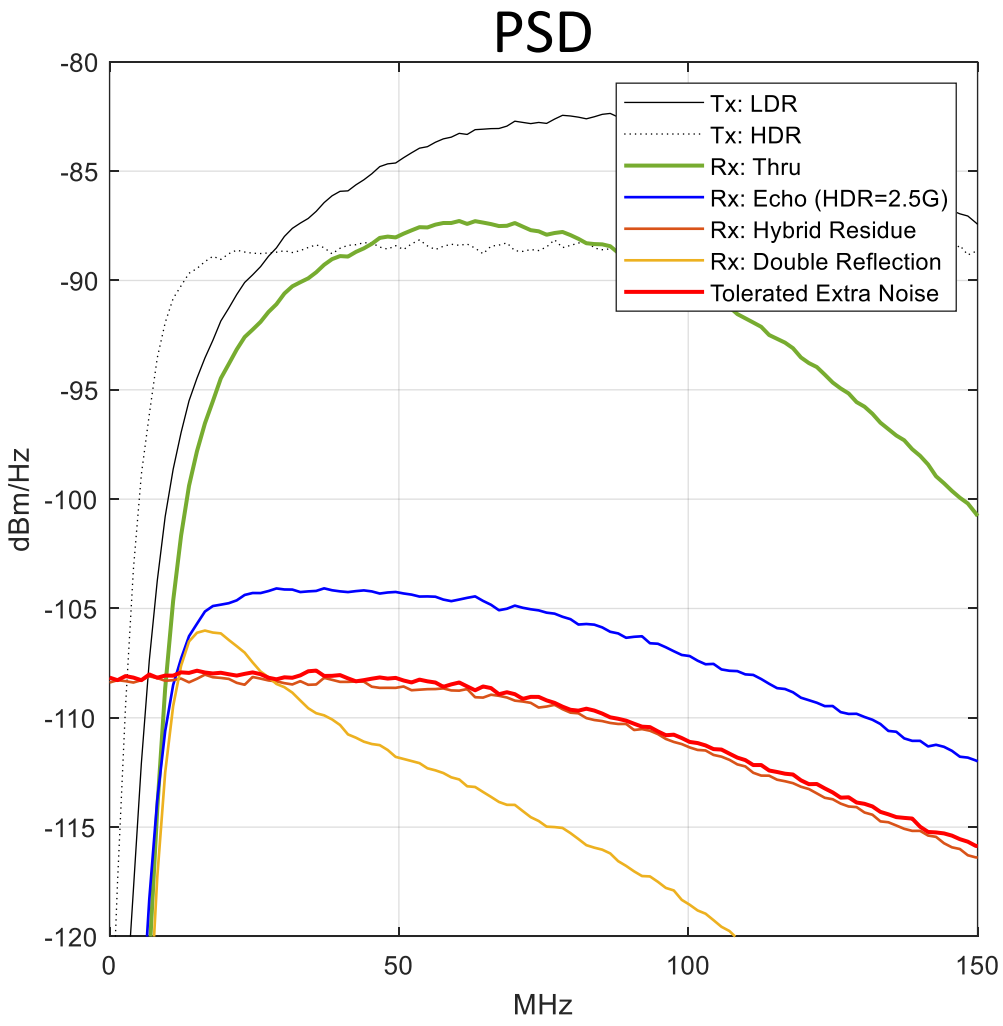
- Target BER = 10^{-12}
- Target SNR = 17 dB (decision point)
- Treating echo, hybrid residue and double reflections as noise

➔ Tolerated extra noise as high as:
  - PSD ≈ -108 dBm/Hz
  - SNR ≈ 19 dB

➔ No echo canceller

➔ Optional 3-tap FFE or simple CTLE

➔ Clock and bandwidth ≈ 117 MHz



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Summary

- With most difficult and very pessimistic conditions of
  - HDR: 2.5 Gbps with 0 dBm of transmit power
  - Maximum IL for through channel
  - No loss for double reflections
  - Flat echo response at minimum RL
  - PoC: Corner frequency at 10 MHz

➔ LDR receiver remains trivial:

- Low input SNR requirement of 19 dB
- Low bandwidth and clock frequency of ~117 MHz
- No echo cancellation
- Minimal equalization


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Thank You