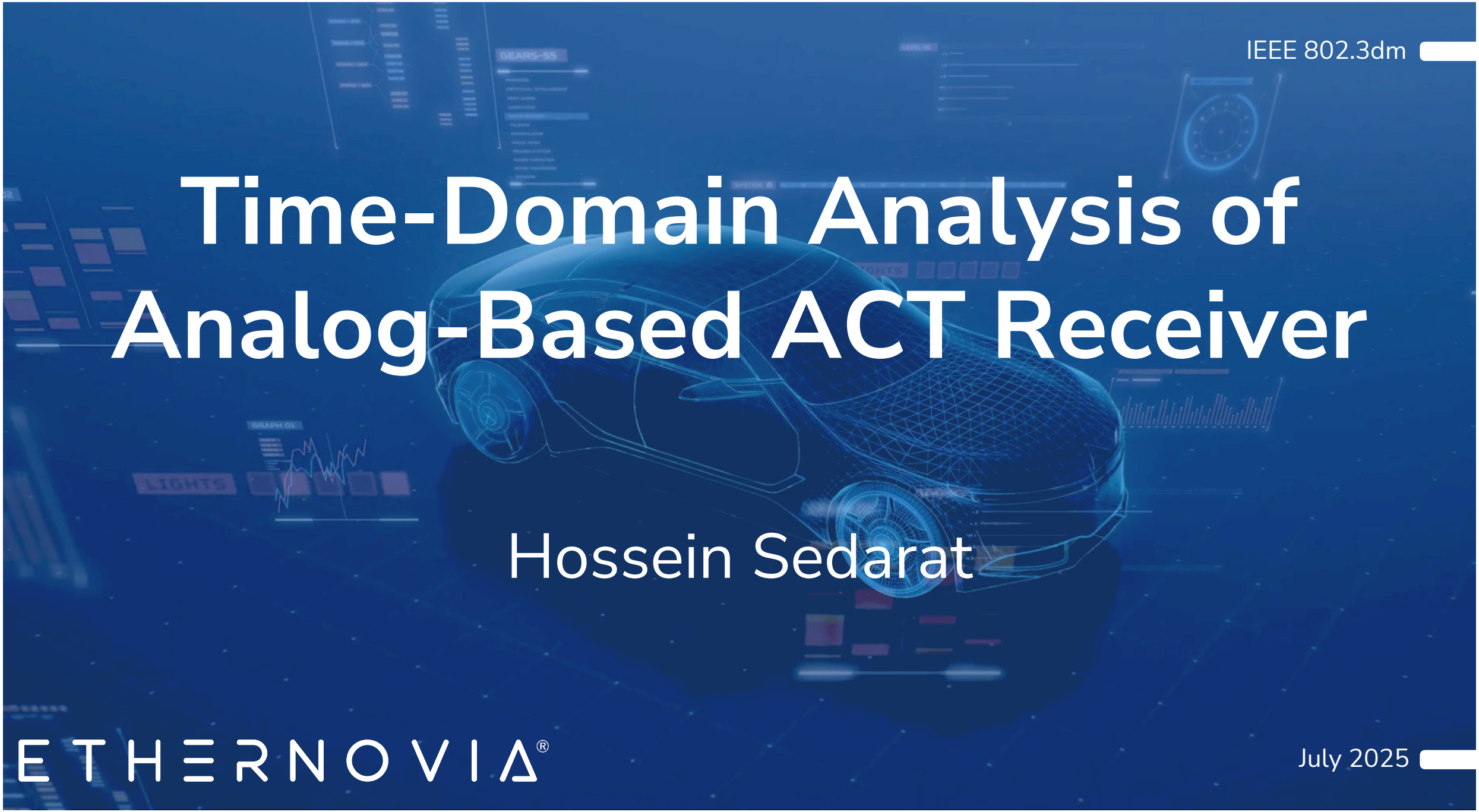

IEEE 802.3dm

Time-Domain Analysis of Analog-Based ACT Receiver

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Background

- Partial list of contributions showing the simplicity of the upstream ACT receiver
  - https://www.ieee802.org/3/dm/public/adhoc/062625/jonsson_3dm_02_06_26_25.pdf
  - https://www.ieee802.org/3/dm/public/0325/sedarat_3dm_02_202503.pdf
  - https://ieee802.org/3/dm/public/0125/sedarat_3dm_202501.pdf
  - https://ieee802.org/3/dm/public/0125/jonsson_3dm_01b_01_20_25.pdf
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  - https://ieee802.org/3/dm/public/0924/sedarat_3dm_202409.pdf
  - https://ieee802.org/3/dm/public/0924/jonsson_razavi_3dm_01_09_15_24.pdf
  - https://ieee802.org/3/dm/public/0924/jonsson_3dm_01_09_15_24.pdf
  - https://ieee802.org/3/dm/public/0724/sedarat_3dm_202407.pdf
  - https://ieee802.org/3/dm/public/0524/sedarat_3dm_02_202405.pdf
- Many present time-domain analysis
- Many (if not all) do not require digital signal processing with ADC

Overview

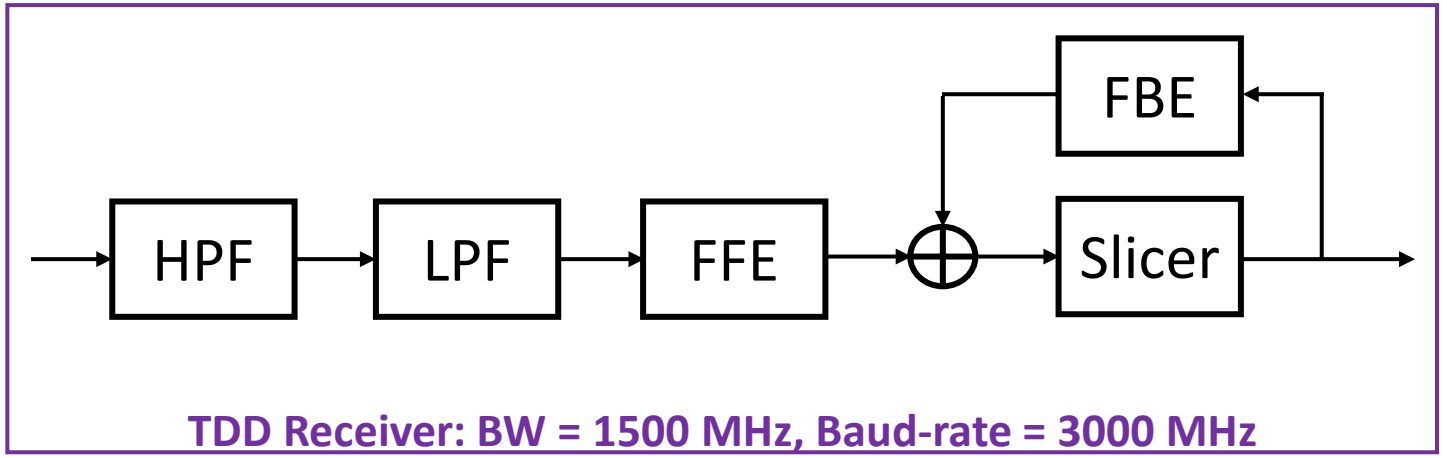
Further analysis of the ACT upstream receiver:

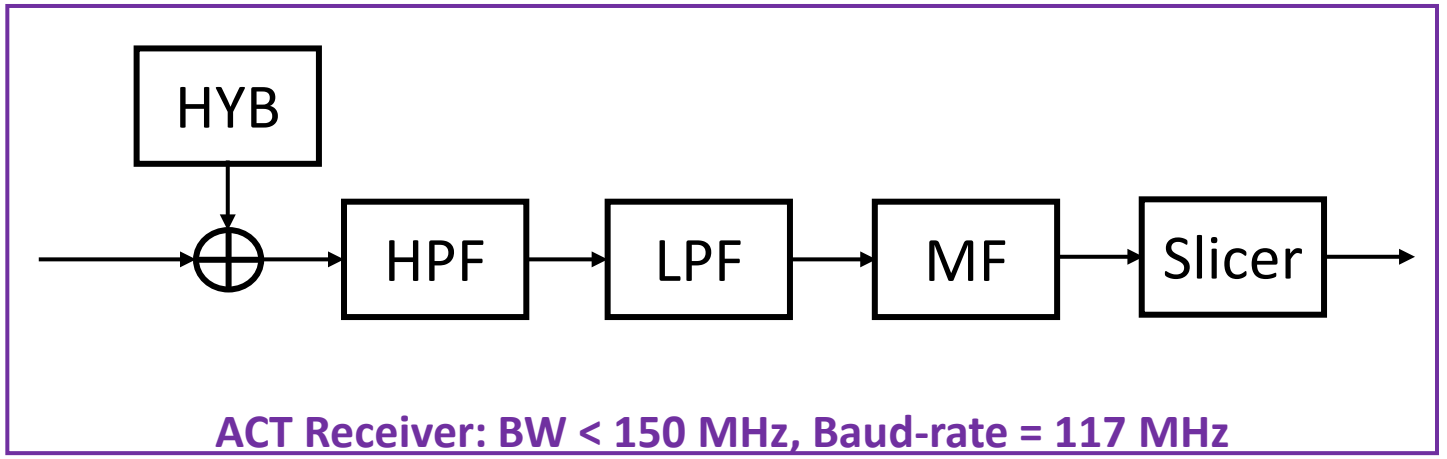
- Analog-based receiver
- Time-domain analysis
  - More conservative echo channel models
  - More realistic model of Hybrid canceller
- Address and clarify points made in slide 7 of Chini_2505

High-Level Receiver Architecture

- HPF: high-pass filter to remove low frequency transients
- LPF: to remove out of band noise
- FFE: Feed-forward equalizer
- FBE: Feedback equalizer
- MF: DME matched filter
- HYB: hybrid canceller

FBE is a discrete filter while all others may be implemented in digital or analog domain

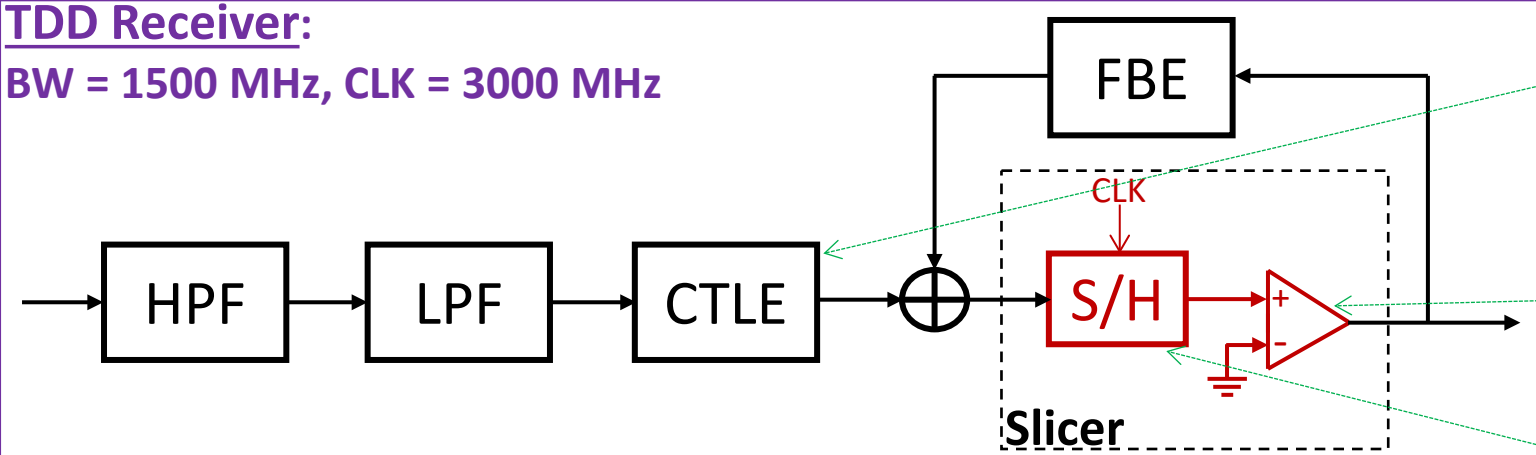




Analog-Based Receiver

TDD Receiver:

BW = 1500 MHz, CLK = 3000 MHz



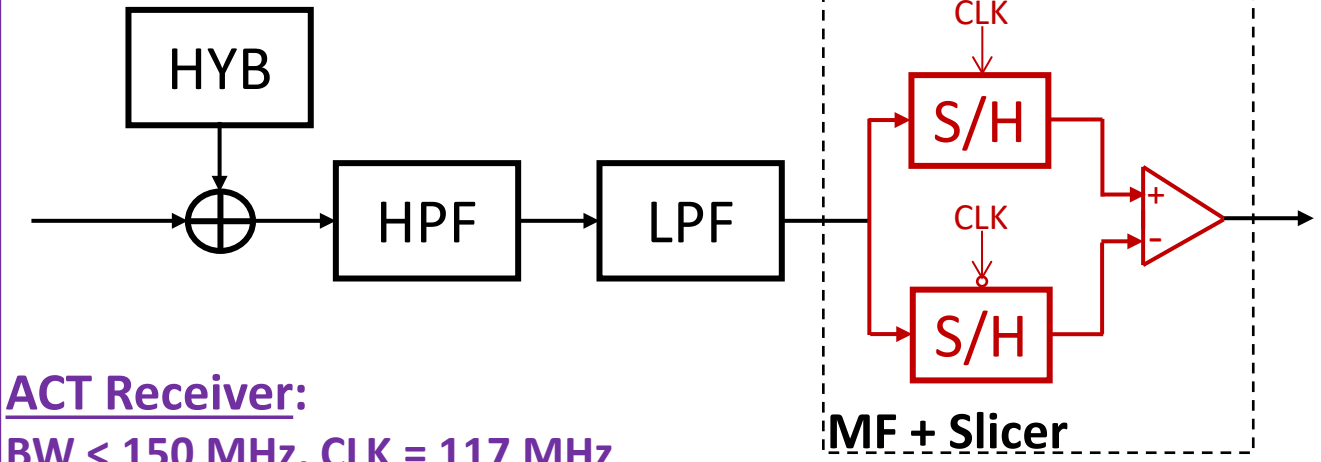
CTLE: Continuous-Time Linear Equalizer is an analog implementation of the FFE

Analog comparator

S/H: Sample-and-Hold

ACT Receiver:

BW < 150 MHz, CLK = 117 MHz



Matched filter and slicer may easily be implemented in analog with S/H and comparator

ACT receiver does not require ADC and digital signal processing

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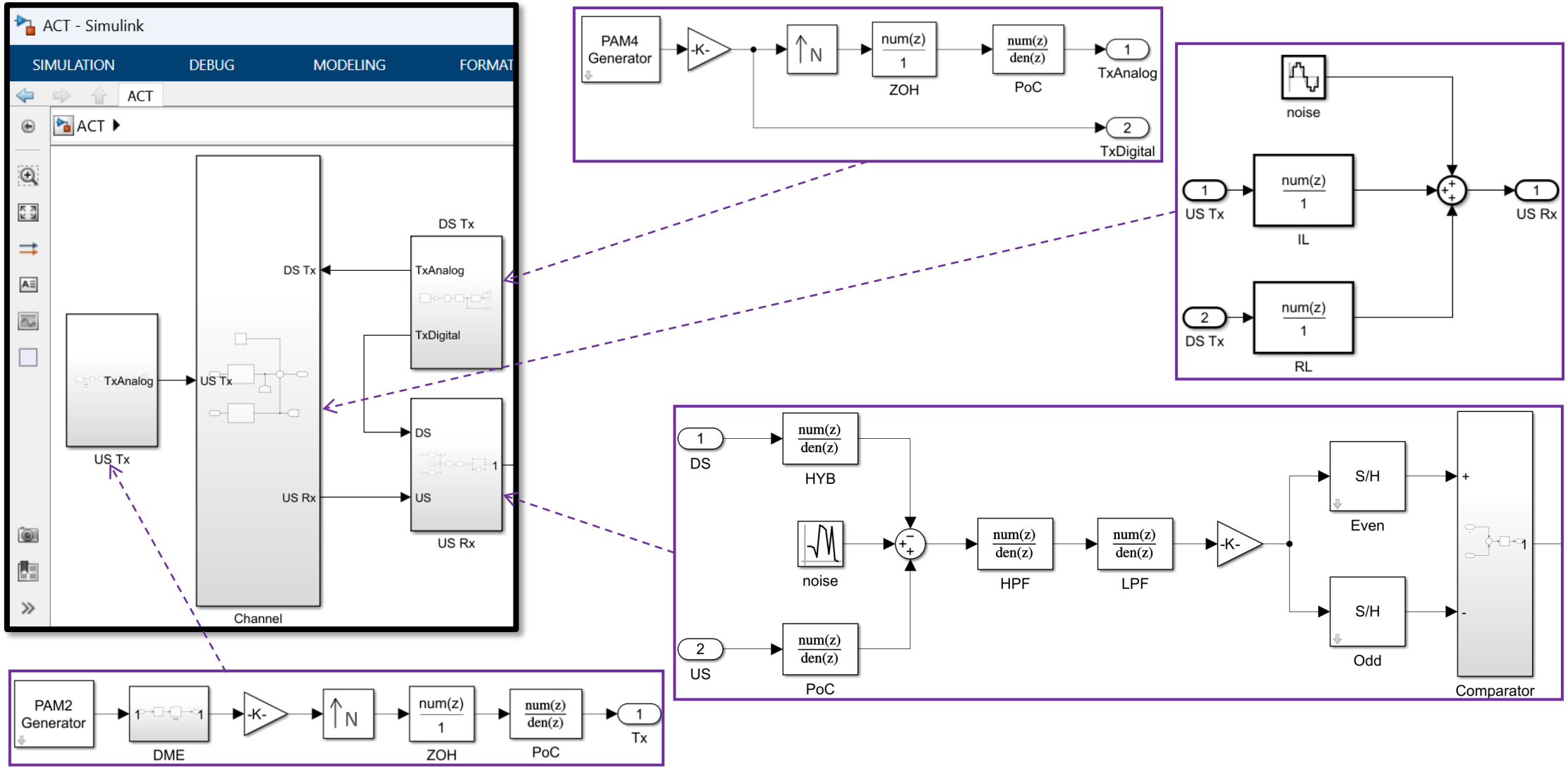
Time-Domain Simulation Environment



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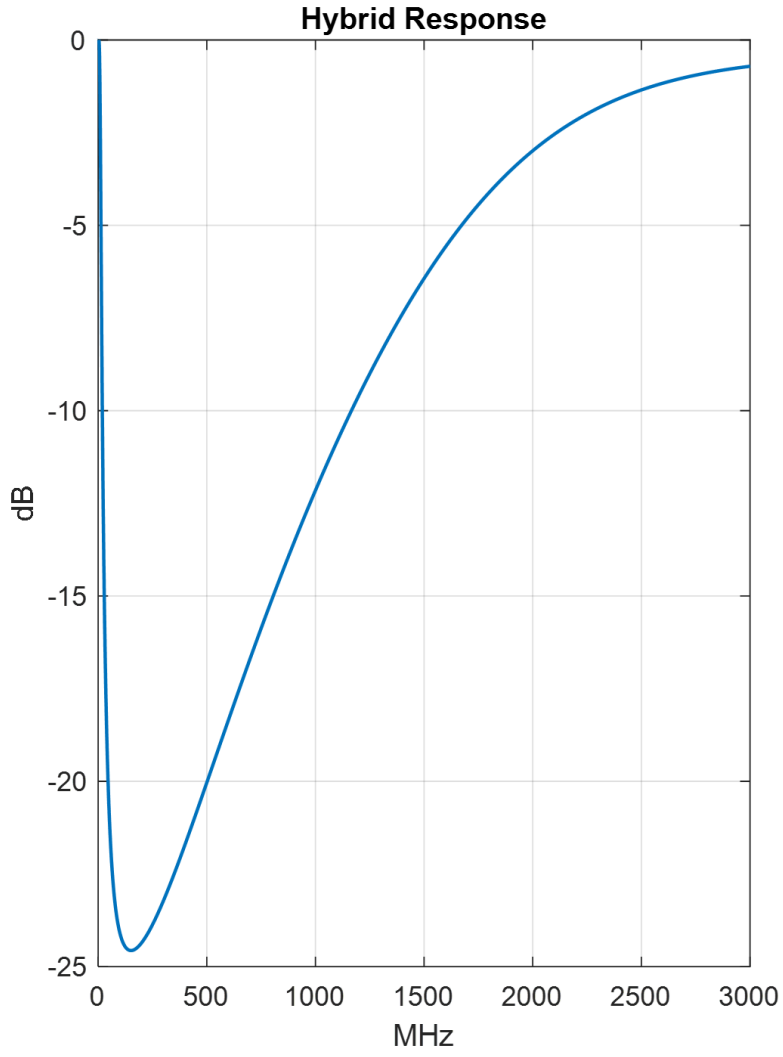
PHY Filter Responses

- PoC: 2nd order, Fc = 10MHz
- HPF: 1st order, Fc = 40 MHz
- LPF: 2nd order, Fc = 100MHz
- Hybrid:
  - Poor cancellation at low frequency due to PoC circuit
  - Poor cancellation at high frequency due to parasitics
  - Limited in-band cancellation



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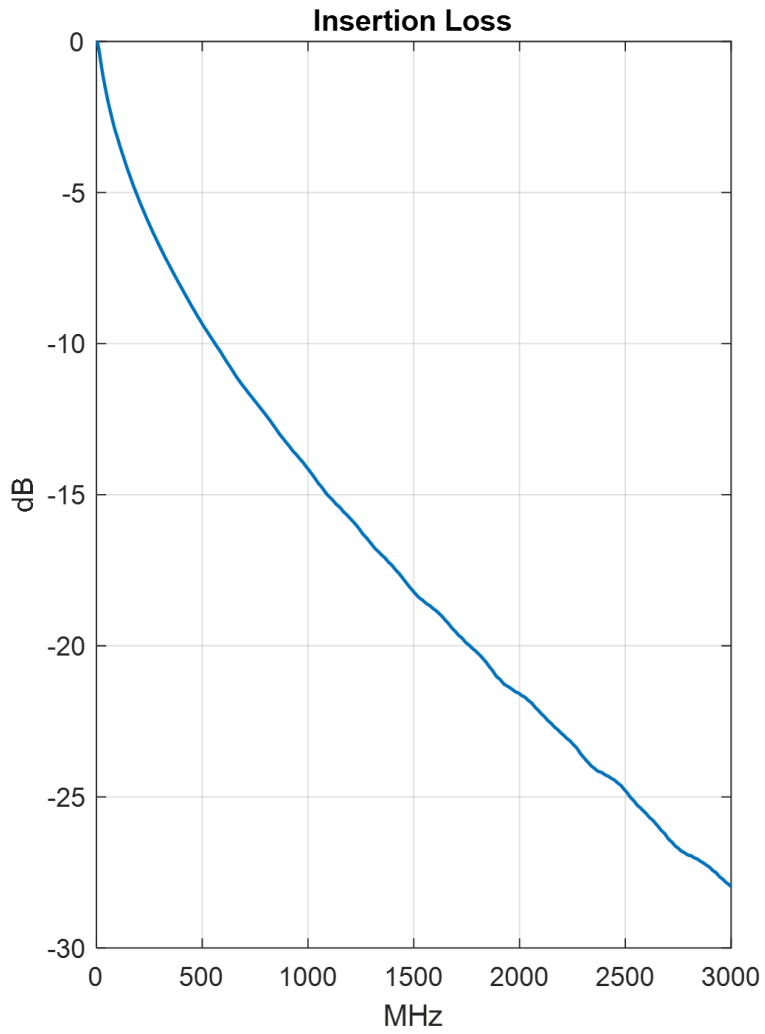
Channel Response

- Cable model meets the latest proposal for limit line on insertion loss
  - 24 dB loss at 3 GHz
- Additional 4 dB for loss of PCBs
- Total loss **28 dB** at **3 GHz**



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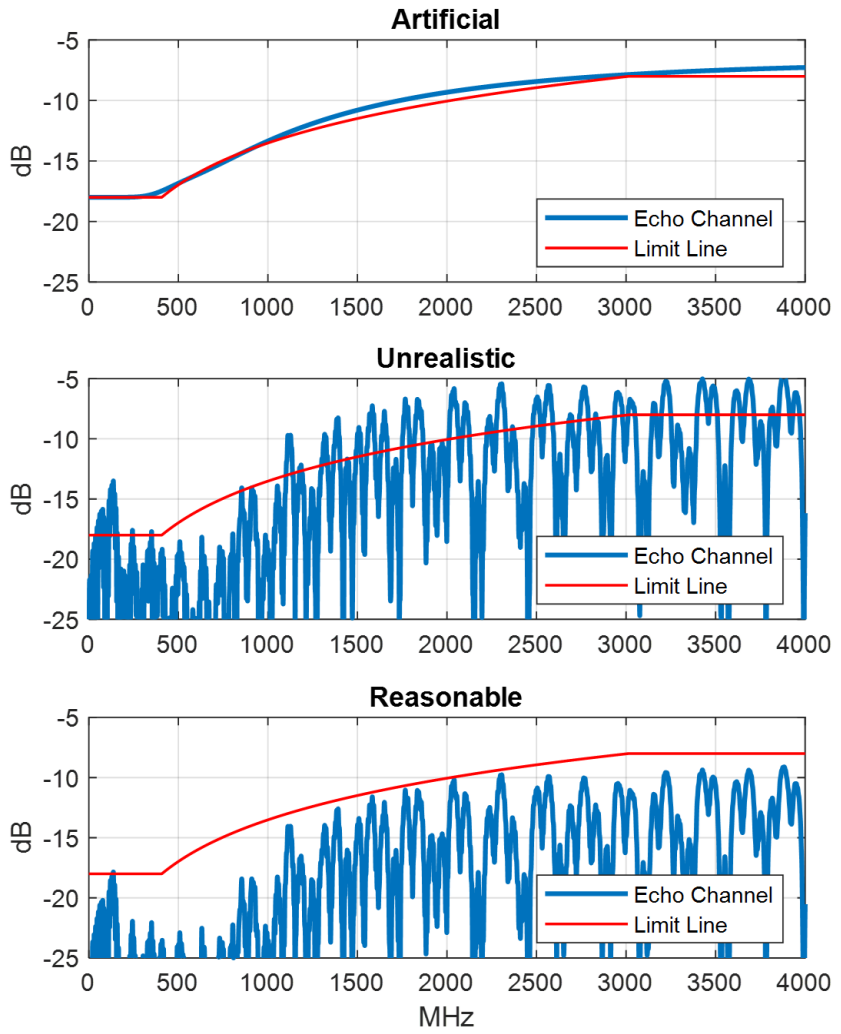
Echo Response

With the latest proposal for limit line on return loss, considered three extremely powerful echo channels:

1. Artificially generated channel meeting, or exceeding, limit line at all frequencies

2. Unrealistically strong echo channel labelled as “Ugly” in Ragnar_202504

3. Reasonably bad echo channel touching limit line by scaling the “Ugly” channel



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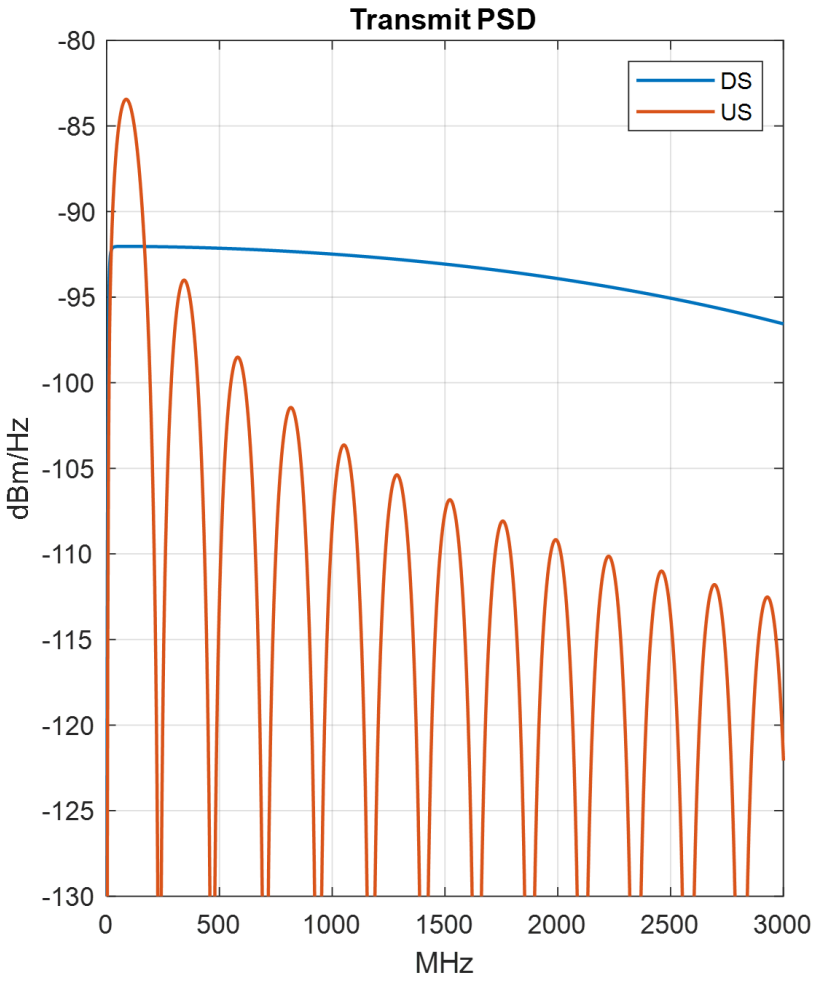
Transmit Power

Following the latest transmit power specifications in Sedarat_202505, and considering extreme imbalance in transmit power:

- Upstream: minimum power of -3 dBm
- Downstream: maximum power of 2 dBm

➔ Worst condition with the lowest signal-to-echo power ratio



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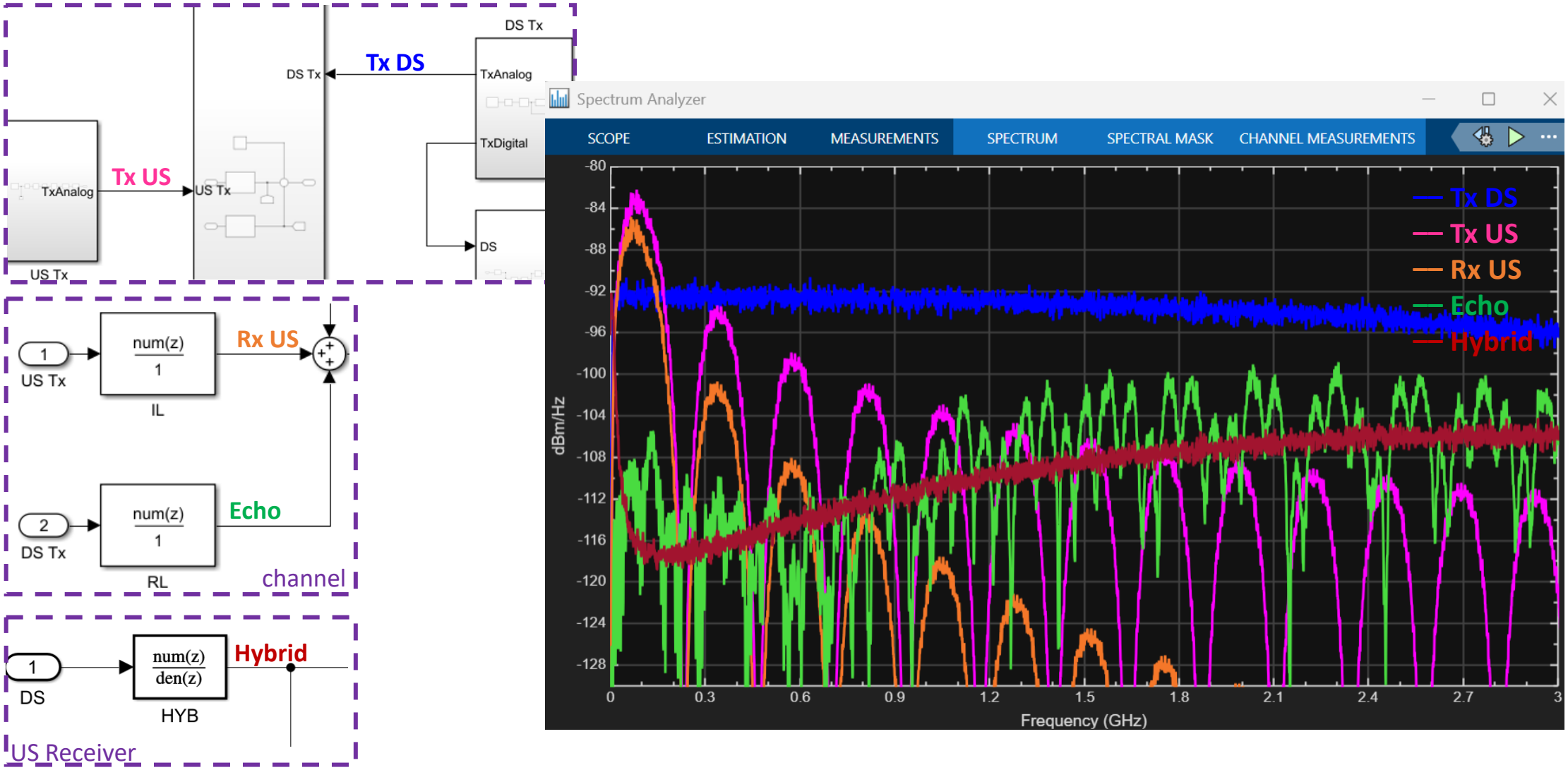
PSD of Signal Components



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SNR and Eye Diagram

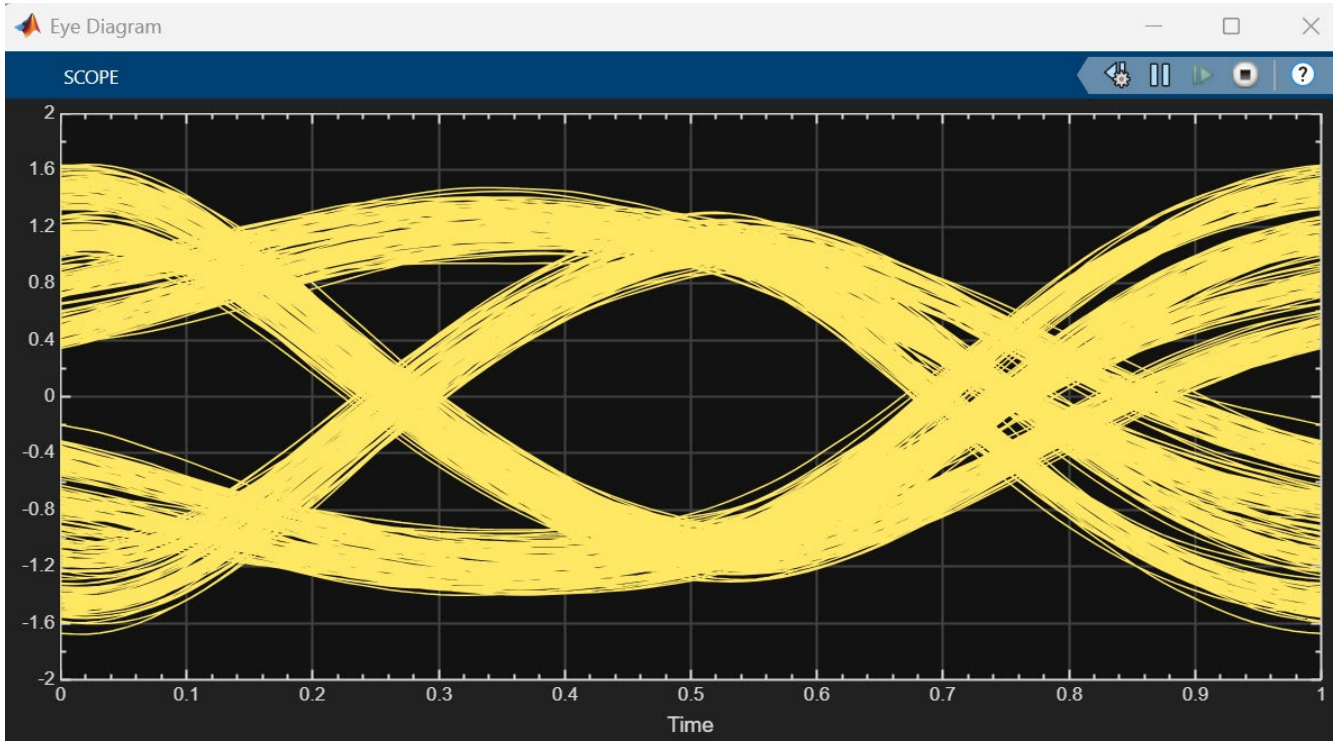
Echo Channel Type	SNR (dB)	Margin* (dB)
Artificial	22.6	5.6
Unrealistic	22.2	5.2
Reasonably Extreme	25.0	8.0

* FEC coding gain not included in SNR margin

Under the worst-case conditions:

- Insertion loss of 28 dB at 3 GHz
- Strongest echo channel
- Worst imbalance in transmit power
- Poor hybrid cancellation

Eye diagram with unrealistically strong echo channel



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Conclusions for ACT Upstream Receiver

- All-Analog receiver is possible
  - No need for ADC or digital signal processing
- Time-domain analysis confirms high operating margin
- No need for echo cancellation
- No need for equalization
- Very narrow bandwidth and very low clock frequency
- Very small dynamic range with trivial Analog signal path
- No baseline-wander effect
- Tolerant of simple and imperfect hybrid cancellation
- Not sensitive to MDI return loss and double-reflections


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Thank You