Uplink and Downlink PHY Complexity Analysis Based on IEEE 802.3ch Channel Parameters

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Outline

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- Channel
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- Recommendation

Overview

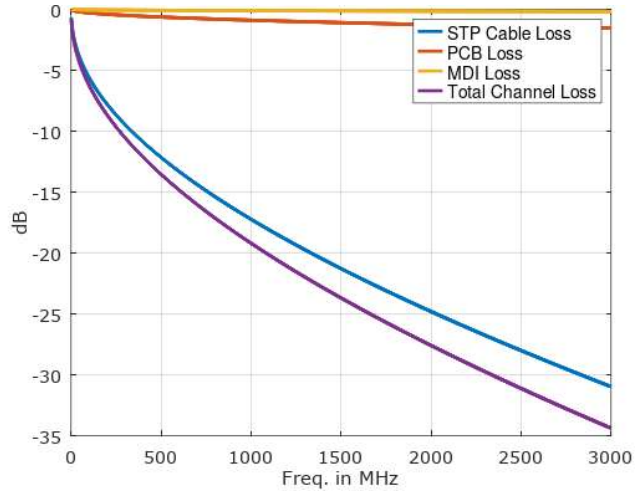
- There have been many contributions on IEEE 802.3dm potential solutions such as enabling EEE [1] through existing .3ch PHY, TDD [2,3], ACT [4], and GMSLE [5]
- Rigorous PHY analysis [6,7] and comparison [5] among the solutions have been presented/discussed in the task force
- Among the existing solutions, downstream (Camera to ECU) PHY complexity looks close to each other, except for the echo cancellation
- The main differences that exist in the task force is for the upstream (ECU to Camera) link
- This contribution explores the feasibility of low power and low complexity upstream PHY

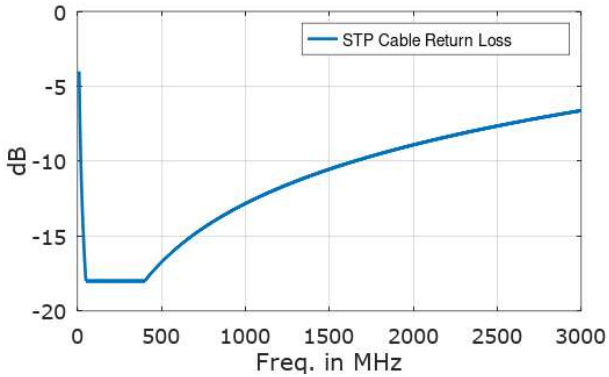
Assumptions

- Upstream data rate = 100Mbit/s
  - Overhead = 25%
  - Modulation = DME
  - Baud Rate = 250MBaud
  - Bandwidth = 125MHz
- Max. Downstream data rate = 10Gbit/s
  - Overhead = 12.5%
  - Modulation = PAM4
  - Baud Rate = 5625MBaud
  - Bandwidth = 2.8GHz
- BER = 10^{-12}

Channel Consideration

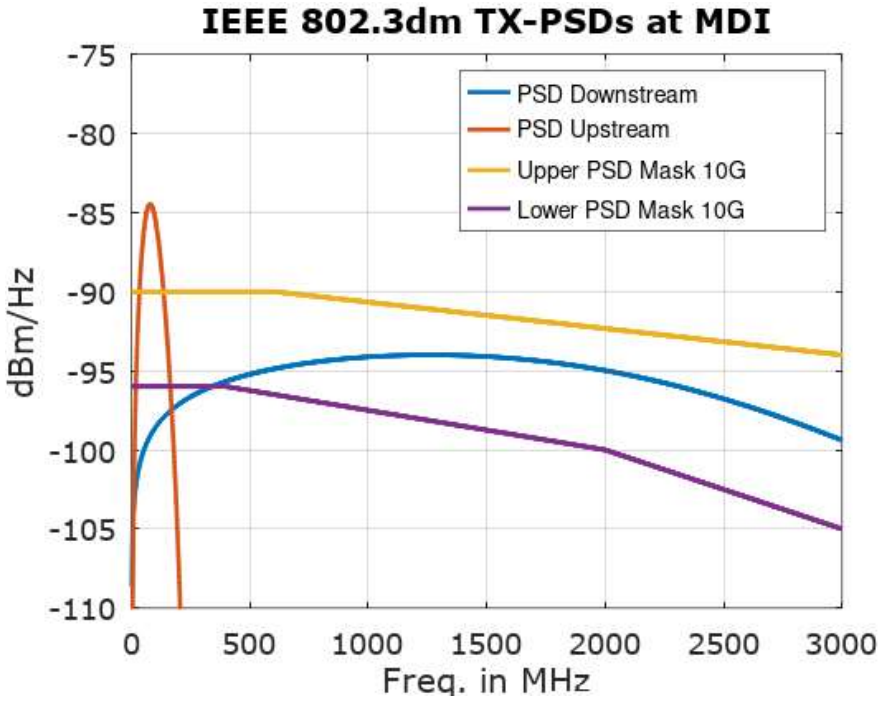
- Insertion loss (IEEE 802.3ch)
  - 15m STP cable loss
  - MDI loss
  - PCB loss
  - @125MHz = ~6dB loss
  - @2.8GHz = ~33dB loss
- Return loss is based on agreed new limit line in the task force





TX-PSD @ MDI

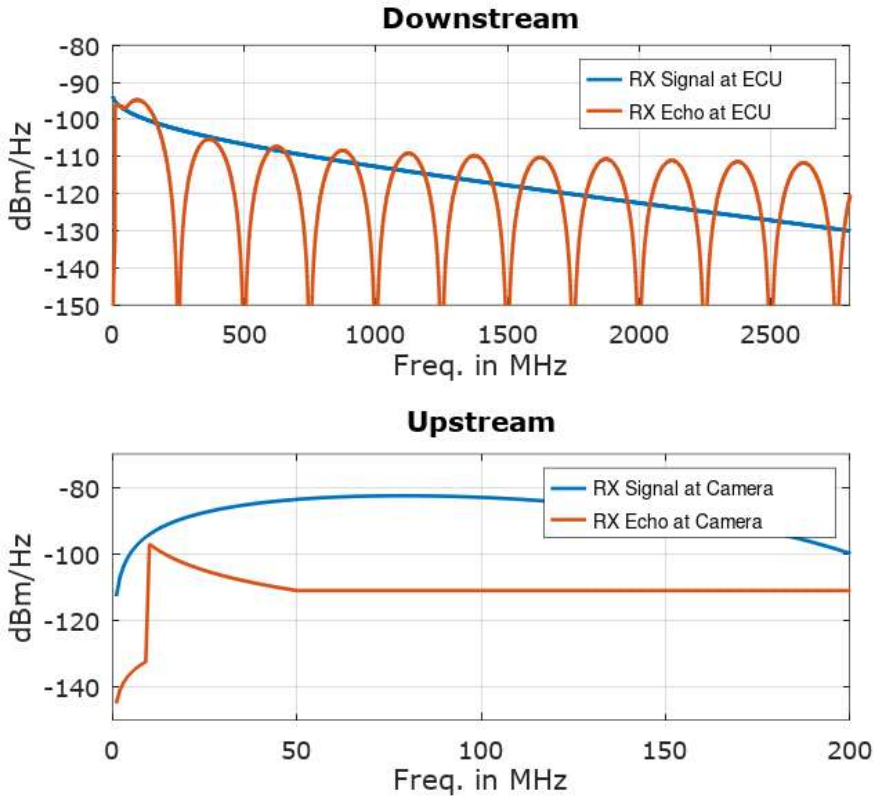
- Upstream/Downstream 1Vpp
- High Pass Filter (first order) effect due to PoDL inductors = 30MHz
- Low Pass Filter (2nd order‡) Butterworth filter 100MHz and 2.8GHz



‡Note: The order of filter can be achieved more than 2nd order for the upstream to suppress the side lubes

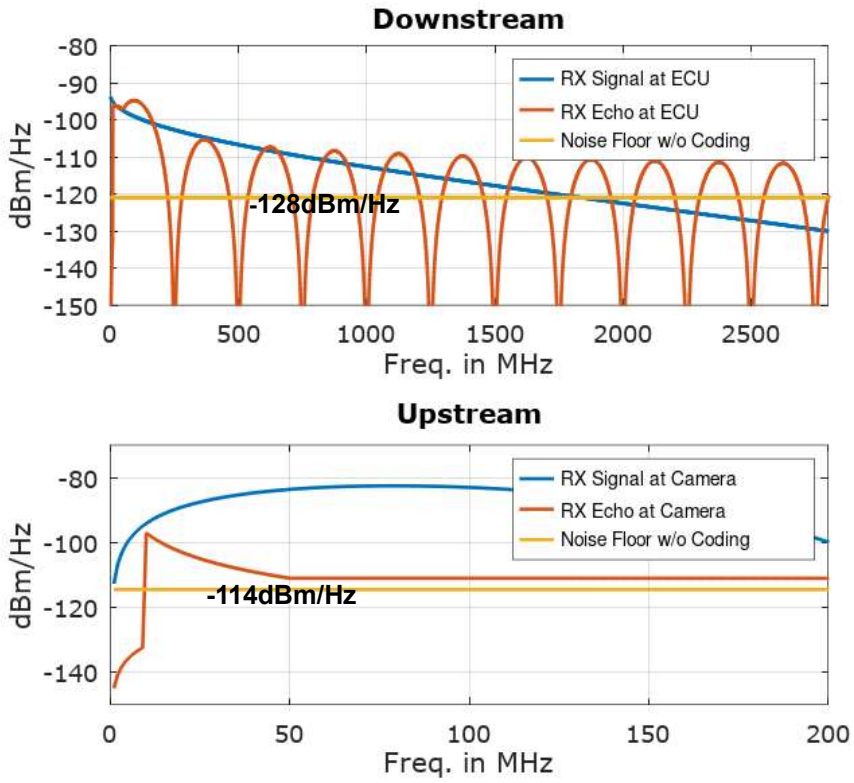
Received Signal

- Loss includes 15m cable + 2*PCB + 2*MDI losses
- Transmit signal passes through high pass and low pass filters



Decision Point SNR Analysis

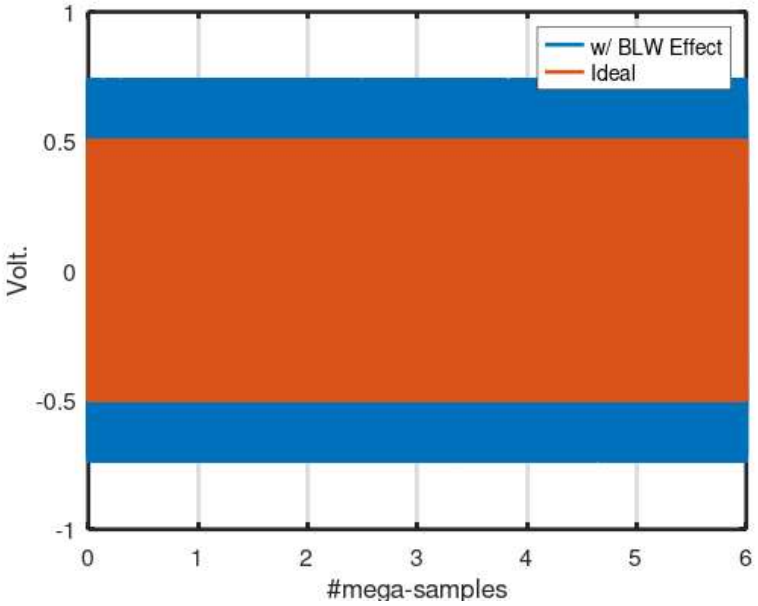
- Required minimum Slicer SNR
  - DME needs ~17dB
  - PAM4 needs ~24dB
- Upstream Receiver
  - Signal-To-Echo Ratio‡ = 25.2dB
  - This means 8dB SNR margin
    - → No need of echo cancellation at camera RX
- Downstream Receiver
  - Signal-To-Echo Ratio‡ = 10.2dB
  - This means -14dB SNR margin
    - → Echo cancellation is required at ECU RX



‡Note: This analysis does not include residual echo from Hybrid

Baseline Wander (BLW) Effect

- Smaller foot print of PoDL inductor is desirable for camera application
- However, this will increase the corner frequency of high pass filter
- Typical 30MHz high pass filter can increase the swing up to 45%
- This needs 0.5 ENOB of added complexity at RX with 5.4 ENOB for a complete BLW cancellation
- More realistic BLW cancellation adds <0.5 ENOB to RX complexity
  - ~ 5% added complexity on the receive front-end



Conclusion

- Low power and low complexity PHYs for upstream and downstream is feasible based on IEEE 802.3ch channel
- Analysis shows a sufficient SNR margin w/o echo cancellation
  - Ideally there is no need of echo cancellation at the receiver of camera side
- Baseline wander effect is higher at the receiver of camera side
- However, BLW effect can be managed with well proven techniques
- Added complexity (realistic) to the camera side receiver “front-end” is expected to be ~ 5%

Recommendations

- IEEE 802.3 working group has a history on “know-how” to implement full duplex communication on single pair cable using hybrid circuit
- Thus, ACT is the best way forward for the IEEE 802.3dm task force
  - To enable low power and low complexity PHY at camera node
- Adopt DME encoding for the upstream transmission
  - Enables low complexity receiver
- Have a channel code to correct burst error due to fast transient pulse for the upstream PHY

References

- [1] Evaluation of 802.3ch for Automotive Sensor PHY, KY-ANH TRAN.
- [2] TDD Proposal, Conrad Zerna.
- [3] Complexity and Integration of TDD-based PHY at the Camera Side, Ahmad Chini and Mehmet Tazebay.
- [4] Asymmetric Modulation Scheme, Ragnar Jonsson.
- [5] GMSLE FDD PHY Simulation Results and PHY Complexity, Jay Cordaro and Nick Chimento
- [6] LDR Receiver in ACT Equalization and Echo Cancellation, Hossein Sedarat.
- [7] Upstream PHY Latency, William Lo.

Thank You!