Asymmetric modulation scheme

Contribution to 802.3dm Task Force

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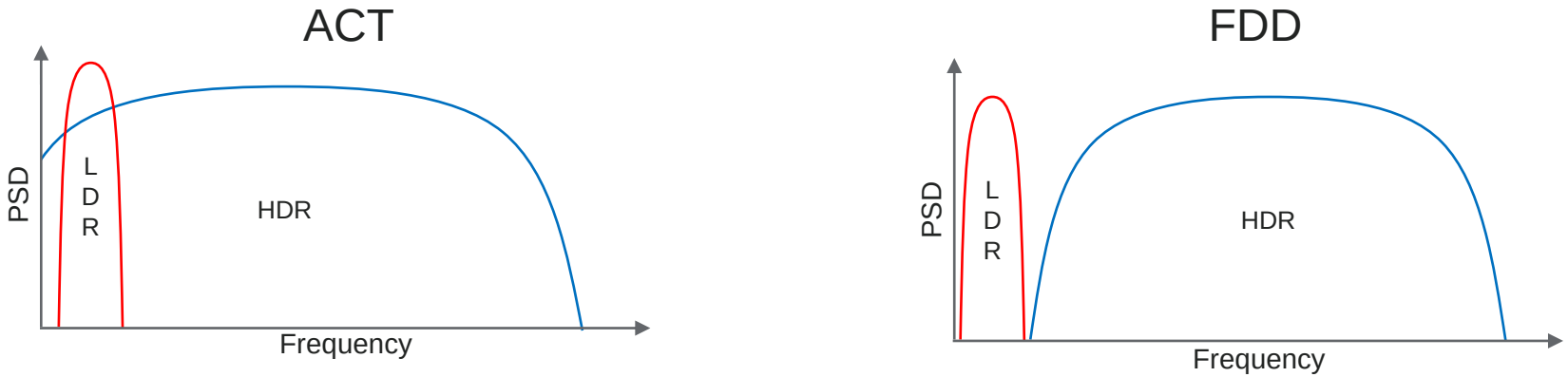
Introduction

- Modulation scheme for IEEE 802.3dm is proposed
- The modulation reuses as much as practical from IEEE 802.3
- The low data rate (LDR) modulation is based on simple Differential Manchester Encoding (DME)
- The proposed modulation allows for fast standards development
- The proposed modulation allows for fast development of new silicon for IEEE 802.3dm, by leveraging existing IEEE 802.3ch solutions
- The proposed modulation allows very simple camera PHY implementations

Asymmetric Concurrent Transmission (ACT)

A New Modulation Scheme

Asymmetric Concurrent Transmission (ACT)



- The modulation scheme proposed in this presentation is called Asymmetric Concurrent Transmission (ACT)
- The ACT has full spectral overlap of the two transmit directions, but utilizes the relatively narrow bandwidth of the Low Data Rate (LDR) signal
- This is different from Frequency Division Duplexing (FDD), where there is little or no overlap between the two transmit directions

High Level Description

- The proposed ACT modulations support asymmetric data rates with 2.5Gbps, 5Gbps, and 10Gbps in the High Data Rate (HDR) direction and 100Mbps in the Low Data Rate (LDR) direction
- The proposed modulation scheme is based as much as practical on 802.3ch (Clause 149)
- The HDR modulation is the same as defined in 802.3ch (Clause 149)
- The LDR modulation is based on Differential Manchester Coding, similar to Clause 147 and Clause 168 (802.3da), but with higher symbol rate
- The intent is to leverage existing 802.3 standards as much as practical

High Data Rate (HDR) Modulation

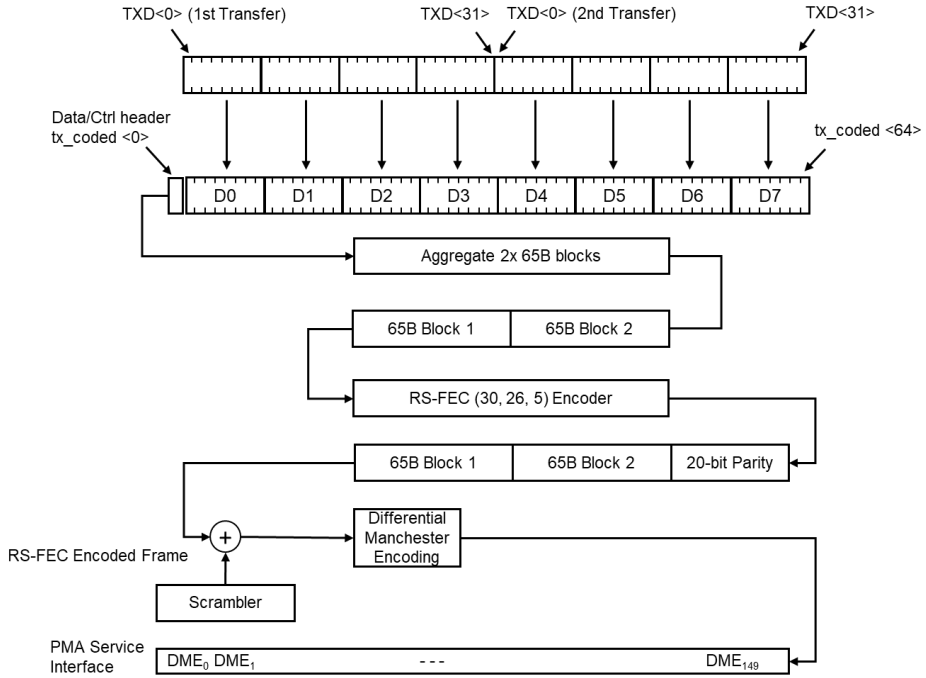
- **The HDR modulation is identical to the 802.3ch modulation described in Clause 149**
- The modulation includes the following components:
  - PCS service interface (XGMII) according to Clause 46
  - PCS Transmit function according to Clause 149.3.2.2, including RS-FEC, RS-FEC superframe, round-robin interleaving , Scrambler, Gray Mapping, Selectable Precoder, and PAM4 Mapping
  - PCS Receive function according to Clause 149.3.2.3
  - Test-pattern generators according to Clause 149.3.3
  - Side-stream scrambler polynomials according to Clause 149.3.4
  - PMA training frame according to Clause 149.3.4
- New clauses, to reflect asymmetric data rates and coax cables, are needed for
  - Clause 149.3.7 on Detailed functions and state diagrams
  - Clause 149.3.8 on PCS management
  - Clause 149.7 on Link segment characteristics
  - Transmitter power spectral density (PSD) and power level according to Clause 149.5.2.4

Low Data Rate (LDR) Modulation

- The LDR modulation uses Differential Manchester Encoding (DME), similar to the modulation described in Clause 147 and in draft Clause 168 (802.3da)
- The modulation consist of
  - Constant carrier signal
  - Two level Differential Manchester Encoding (DME) at 117.1875 MBd (1406.25/12)
  - Side-stream scrambler polynomials according to Clause 149.3.4
  - Reed-Solomon (30,26) FEC code, with 5 bits per RS symbol
  - RS-FEC frame consisting of two 64B/65B blocks and 20 parity bits

LDR PCS Framing and Modulation

- The LDR (100Mbps) data path uses the XGMII interface, but with lower clock rate
- 64 bits (8 Octets) are aggregated and encoded in 64B/65B blocks
- Two 65B blocks are encoded using Reed-Solomon (30,26) FEC, with 5 bits per RS symbol (Note1)
- The RS-FEC encoded frame is then scrambled and encoded using Differential Manchester Encoding

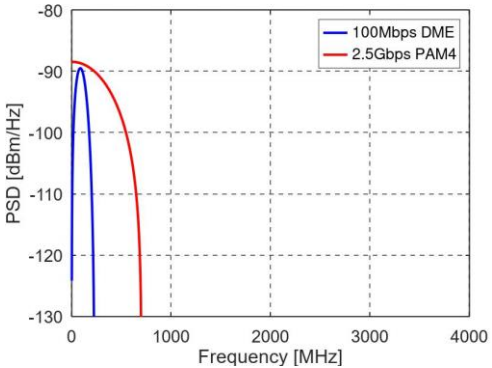


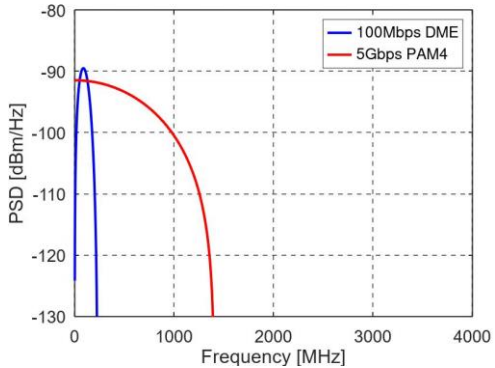
Note1: There is no OAM field in this framing scheme

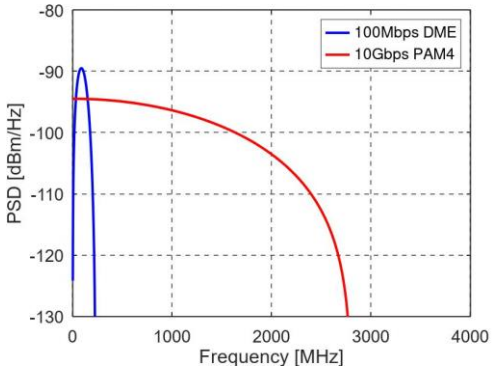
Nominal Transmit Power

- The LDR total transmit power can be lower than the HDR total transmit power, because there is less insertion loss at lower frequencies
- The Power Spectral Density (PSD) in dBm/Hz is lower for the higher data signals, even if the total transmit power across all frequencies is higher (see plots)
- Because coax is single ended, the power for the coax is 3dB lower than STP power

Data Rates	HDR Nominal Transmit Power	LDR Nominal Transmit Power
STP	0dBm	-6dBm
Coax	-3dBm	-9dBm

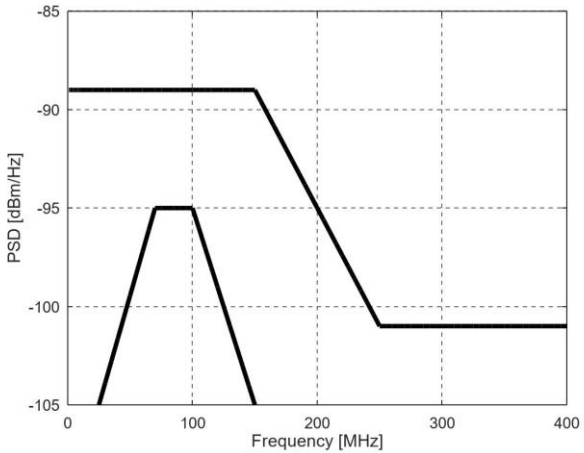






Transmit Signal PSD Limits

LDR PSD Mask



HDR PSD Mask

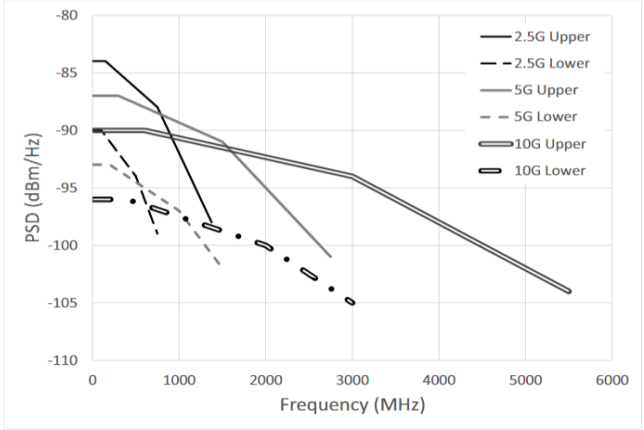
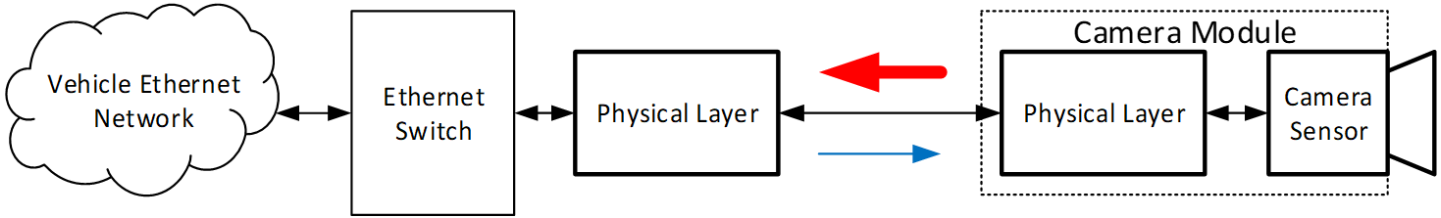


Figure 149–39—Transmitter power spectral density, upper and lower masks

Benefits of Proposed Solution

Network vs Camera Side



Network Side:

- Transmitting at 100Mbps
- Receiving 2.5, 5, and 10 Gbps
- **Ethernet integration is key**

Camera Side:

- Transmitting at 2.5, 5, and 10 Gbps
- Receiving 100Mbps
- **Relative cost and power are key**

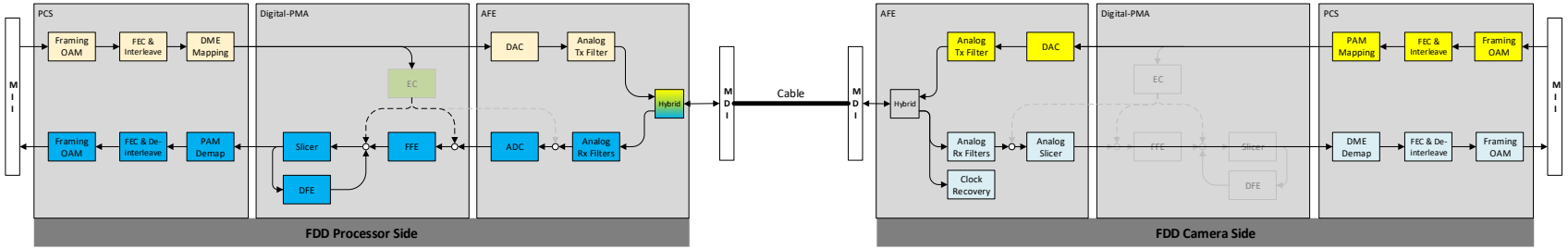
Benefits of Reusing 802.3ch for HDR

- This will allow faster standard development
  - The Task Force can leverage existing text from Clause 149
  - This will make the starting point a high-quality standards text
- There exist multiple interoperable silicon implementations of the 802.3ch standard
  - This will speed up the availability of silicon solutions for 802.3dm
  - This will make interoperability easier to achieve
- The PAM4 modulation used in 802.3ch is well suited for the channels identified for 802.3dm
  - The resulting bandwidth is a good match for existing qualified automotive cables
  - Much of the work done outside of IEEE 802.3 can also be leveraged for 802.3dm
- Easy to implement multi mode 802.3ch and 802.3dm switch PHY

Benefits of Using DME for LDR

- This will allow faster standard development
  - The Task Force can leverage existing text from Clause 147 and Clause 168 (802.3da)
  - The text describing the DME modulation is very simple
- The proposed DME scheme is very low complexity
  - This will make interoperability easier to achieve
  - This allows very simple camera receiver implementation
  - This allows very low power camera receiver
  - This makes integration into camera sensors a practical option
  - The DME frequency characteristics allows better PoC and better noise immunity
  - The DME embedded clock signal allows more robust timing recovery
- Adding the proposed DME to existing IEEE 802.3ch solution is very simple
  - This will speed up the availability of silicon solutions for 802.3dm

Example Implementation



Processor Side

- The receive path can reuse IEEE 802.3ch implementation
- The transmitter path is very simple to implement
- If echo cancelation is used, it can be implemented with very low complexity

Camera Side

- The transmit path can reuse IEEE 802.3ch implementation
- The receive path is very simple to implement
- There is no need for digital signal processing or complex timing recovery

Summary

- Specific modulation scheme is proposed to 802.3dm
- Asymmetric Concurrent Transmission (ACT)
  - Reuse Clause 149 (802.3ch)
  - Use DME for low data rate modulation
- The proposed scheme has several benefits
  - Reuse excising 802.3 specification as much practical
  - Easy migration path for existing 802.3ch PHY allows early adoption
  - Highly competitive solution
- This presentation is intended to generate discussion and collaboration

Collaborators Wanted

Essential technology, done right™