Objectives Affecting PHY Design Choices for 10SPE Automotive

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Foreword

- Study group is formed under IEEE 802.3 to develop a Project Authorization Request (PAR) and Criteria for Standards Development (CSD) responses for 10Mb/s Single Twisted Pair Ethernet (10SPE) including optional power.

- Industrial applications of up to 1000m/1200m as well as automotive applications of up to 15m/40m are considered.

- The aim of this presentation is to discuss major objectives that may affect and shape PHY design for automotive applications.

- Cost reduction compared to 100BASE-T1 is suggested as one of major objectives for automotive applications. Other objectives allowing larger market appeal and adoption needs to be considered.

Cost Objective

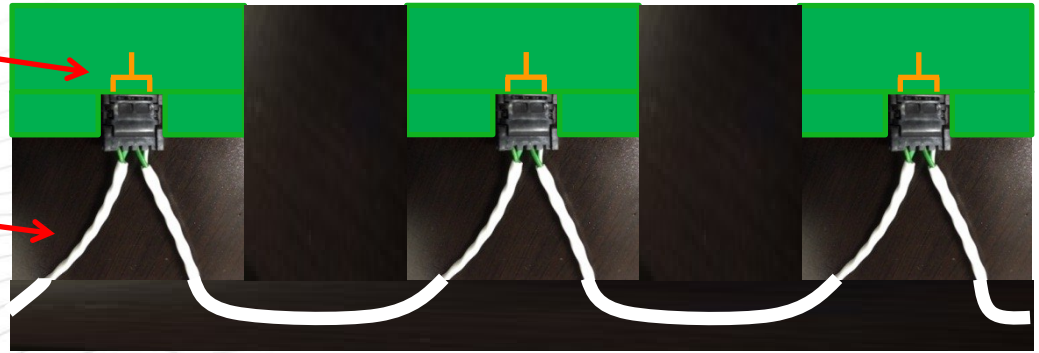
- For automotive applications, 10SPE is targeting 50% cost of 100BASE-T1. Some cost objectives are related to a product spec and not necessarily limited by IEEE PHY spec but they need to be considered for overall cost analysis. Some of the cost items that need to be considered are;
  - Wire and connector (Jacket and insulation types, core size, etc.)
  - Network topology options (affects wiring and components weight and cost)
  - Switch cost in case of using switched network topology
  - On board components (CMC, Voltage regulators, power supply filtering, clock reference, need for local management and processors versus network manageable solutions, etc.)
  - Package size and type
  - Silicon size and cost (*needs to be weighed relative to all other costs*)
  - Power delivery method and level (PoDL as compared to separate power cable)

Wiring Objective

- Wiring topology depends on networking technology and application requirements.
  - Differential impedance of the cables (E.g.. 100Ohm -20/+10Ohm (FlexRay) / 120Ohm -25ohm/+20ohm(CAN))
  - Point to Point (E.g. up to 15m/40m with up to 4 in-line connectors). May be characterized by Insertion Loss, Return Loss, Mode conversion and Cross talk of link segment.
  - Multi Point (E.g. daisy chain or bus, up to 10 segments with total length below 40m). May be characterized as *cascades of multiple point to point segments*.
  - Flexible bus topology (e.g. passive star, stubs). May be characterized by S-parameter modeling of multiple point-to-point segments in various arrangements

Join the lines on the board for BUS or 2-port PHY for daisy chain

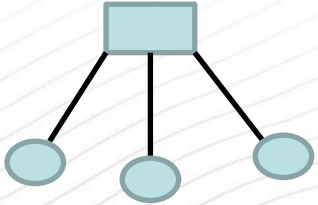
Cascades of point to point segments



Network Fault Tolerance Objective

- If one or more nodes on a network have fault (or are powered off), the rest of the network should be able to continue communication (fault tolerance, partial network)
  - Redundancy in network routing may not be a cost effective and/or practical solution for automotive.
  - Both switched and bus network architectures may be affected by fault in the head end and the end nodes. Solutions are available to make each topology more resilient to faults as per objectives.

STAR

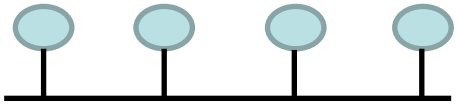


- Head end fault may affect the network, dependent on the fault
- End nodes fault do not affect other nodes
- Cable fault affects one node only

DAISY CHAIN

- Any node or cable fault affects other nodes

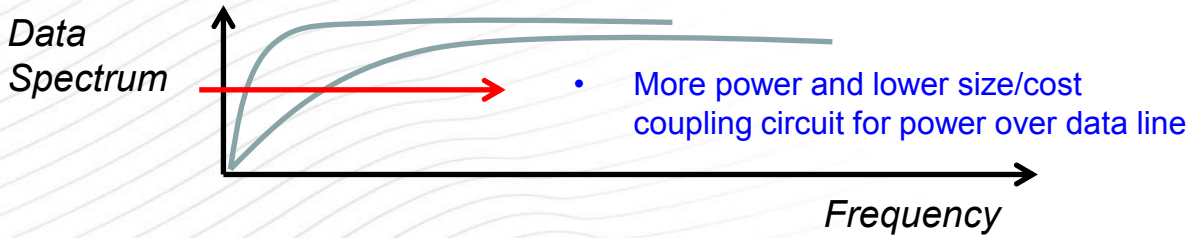
BUS



- One node failure may not affect other nodes.
- Cable fault may affect part of the network

Power over Data Line Objective

- Do not preclude to apply Power over Data Line (PoDL) as specified in P802.3bu
- Power can be delivered along with data over the same cable. A cost effective solution however depends on modulation type, duplexing method and BW used for data.
  - Power level requirement needs to be specified. For higher power levels, data modulations with less DC content are preferred or sometimes required.
  - Cost and size of coupling circuits are reduced if data BW is further pushed out of DC. Also helps duplexing using TDD as compared to echo cancellation (if point to point topology is decided)



BER Objective

- BER requirement for some of 802.3 10Mbps specifications are;
  - Clause 11 10^{-8}
  - Clause 15 10^{-9}
  - Clause 16 10^{-7}
  - Clause 18 10^{-10}
  - If we estimate BER with at least 10 error events. We need 10 seconds to estimate BER of 10^{-7} and 2 hours 47 minutes to measure 10^{-10} at 10Mbps data rate.
  - Automotive requires a BER of 10^{-10} for data operation
  - BER performance depends on cable and alien noise types and level. Achieving BER better than 10^{-10} may not be difficult if not considering for alien noise in automotive. PHY is designed with extra noise margin to allow alien noise. BER objective needs to be tied to defined channel and noise types and levels that are relevant to automotive 10SPE. Note that many standard EMC tests for automotive are short period and may not measure BER performance.
  - Packet loss versus link loss with strong pulse noises.

Other Objectives

- **OAM**
  - Do we need a control channel in addition to data channel (e.g. remote management of nodes with no local processor) ?
  - OAM would be beneficial, e.g. as well to forward Wake-up events for partial networking
- **Latency**
  - For a selected Ethernet packet size and including switch latency (if switched network). For how many switched nodes ?
  - Re-transmission in case of error (e.g. TCP added latency) ?
- **EMC**
  - May be harder to meet in bus topology
  - For automotive, higher noise levels at low frequencies (< 5MHz)
  - Need to satisfy peak emission limits below 30MHz → Some limits may be tighter

Other Objectives (cntd.)

- **Cable bundling**
  - Cross talk effect in case of bundling with other data links in automotive, i.e. coupling effect of 100BASE-T1, CAN, etc. onto 10SPE. Is there any part of spectrum with less alien cross talk?
- **Electrical faults tolerance**
  - Short to GND and power rails
  - Short of wires of the same pair
  - Open of wires of the same pair
  - PHY Quality measures for link monitoring, diagnostics and early warning
  - Recovery time after fault is removed (link recovery if lost)
- **Data rate at MII**
  - Options are;
    - Full Duplex with symmetrical data rate for send/receive
    - Full Duplex with flow control (pause command) and configurable asymmetric data rate for send/receive
    - Half Duplex
  - If multi point, back bone data rate versus individual nodes?

Summary

- Some major objectives that shape PHY design choices were discussed. In order to narrow down PHY design options, the objectives need to be well defined and questions are to be answered.

- Cost of total solution needs to be considered in PHY design where silicon cost may be a small portion. Wiring layout, fault tolerance, BER and Latency expectation, power over data line and EMC are major defining factors for automotive 10SPE.

Thank You!