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Alternative PoDL Architecture for Shielded Twisted One-Pair Cabling

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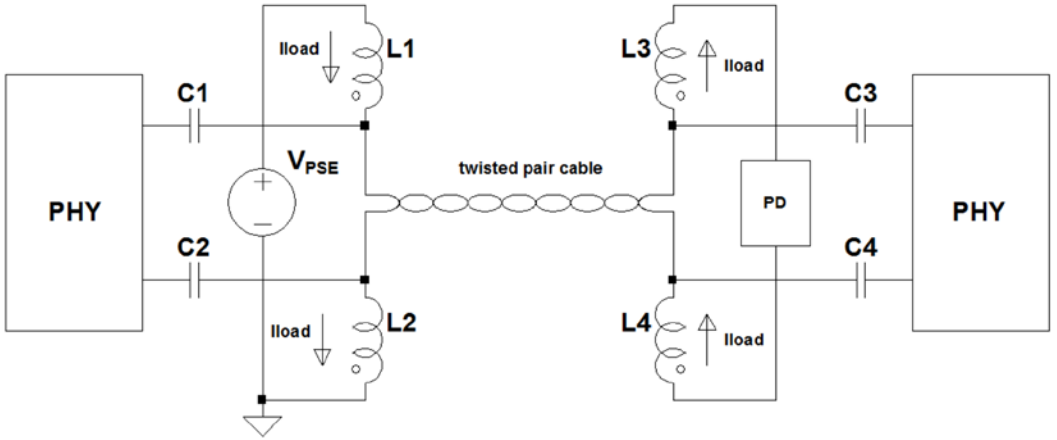
Presentation Objectives

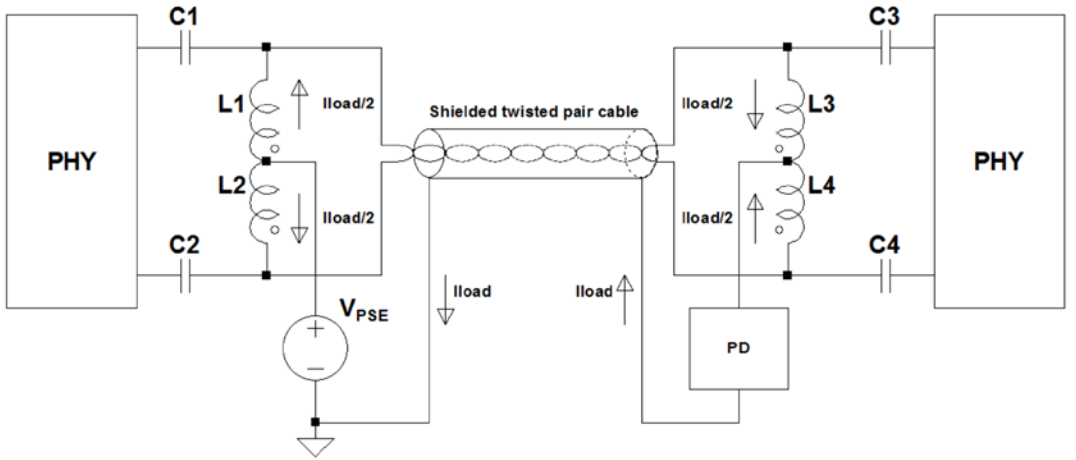
- Present an alternative power coupling architecture for one-pair Ethernet applications that use shielded twisted pair cabling
- Discuss pros and cons of this approach vs. the PoDL power coupling approach

Power Coupling Architecture Comparison

- Single twisted-pair cable PoDL
  - Relies upon balanced diplexers to merge AC and DC current onto twisted pair
  - Inductors must support full core flux developed by DC current
  - Cable resistance is $2\times R_{wire}$



- Single twisted-pair cable with shield
  - Uses center-tapped auto-transformer to merge common mode DC current with differential mode AC current onto twisted pair
  - Inductor core flux developed by DC current is cancelled to first order
  - DC current is returned on shield
  - Cable resistance is $0.5\times R_{wire} + R_{shield}$



Shielded Twisted Pair Cable Resistance Analysis

- Fieldbus Type A Cable with 18 AWG twisted pair conductors and foil shield plus tinned copper braid shield (65% coverage)
  - 18 AWG DC Resistance (nom): 19.2 Ω/km
  - Shield DC Resistance (max): 16.1 Ω/km
- Cable loop resistance of 18 AWG twisted-pair at 1km:
  - 2×19.2Ω = 38.4Ω
- Cable loop resistance of shielded same twisted-pair in configuration where load current is returned on shield:
  - 19.2Ω / 2 + 16.1Ω = 25.7Ω
- Cable loop resistance is reduced by 33% when load current is returned on shield
  - Available power to load can be increased by a factor 1/(1-0.33) = 1.49x

Comparison of Power Coupling Magnetics

- 470µH coupled inductor, shielded drum core, potentially suitable for PoDL diplexer approach
  - Package dimensions: 7.5mm by 7.5mm by 4.6mm
  - DCR per winding (max): 4Ω
  - Current in both windings that causes 40C rise from 25C ambient: 0.2A
  - Current in both windings that causes 30% reduction of OCL: 0.23A
- 470µH coupled inductor, shielded toroidal core, potentially suitable for center-tapped autotransformer approach
  - Package dimensions: 7.5mm by 5.6mm by 4.9mm
  - DC per winding (max): 0.21Ω
  - Summed current in both windings that causes 20C rise from 25C ambient: 1A
  - Saturation current not specified
- The increase in ampacity for the power coupling magnetics is dramatic when the inductor core material does not have to support the full flux developed by the load current!

EMI and Data Integrity Considerations

- When power and data are diplexed onto one twisted-pair, power supply ripple and transients must be filtered in order to preserve data integrity
- When power is common mode to data, power supply ripple and transients theoretically do not interfere with data integrity, but…
  - …AC voltage drops developed across shield resistance by power supply current can result in electric field with respect to external potentials
- Substantial low-pass filtering of power-supply current will be required with either approach

Conclusions

- A substantial reduction in cable resistance can be realized when the load current is returned on the shield of Fieldbus Type A Cable
- A substantial increase in ampacity for the power coupling magnetics can be realized when the load current is common mode to the data
- Substantial low pass filtering of the load current ripple and transients is required for either approach