Rockwell Automation

100BASE-T1L for Motor Feedback Communication

Dayin XU • Rockwell Automation • May 25,2022

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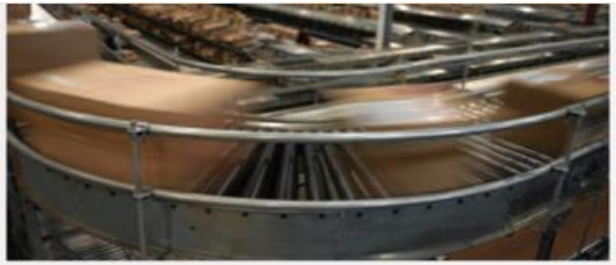
Purpose of this presentation

- Introduce servo control use case
- Introduce motor feedback communication
- Explain advantages of 100BASE-T1L for motor feedback
- Explore market potential of 100BASE-T1L for motor feedback
- Discuss requirements for 100BASE-T1L for motor feedback
- Assess technical feasibility of requirements
- Propose actions

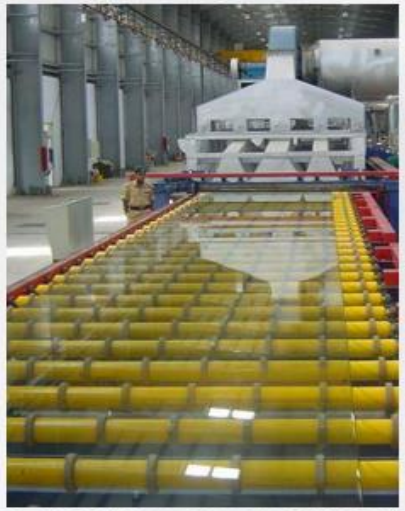
Motion Control Applications






Motion Control:

- Is the process of controlling a change in position of machinery or equipment
- Provides machine movement that is accurate (exact) and precise (repeatable)



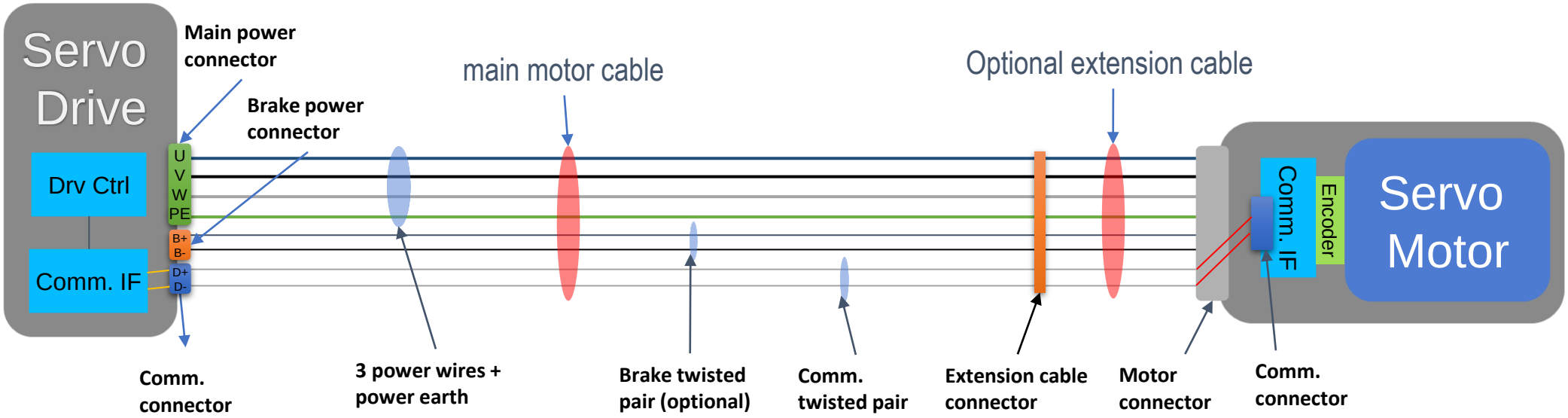



Servo control system

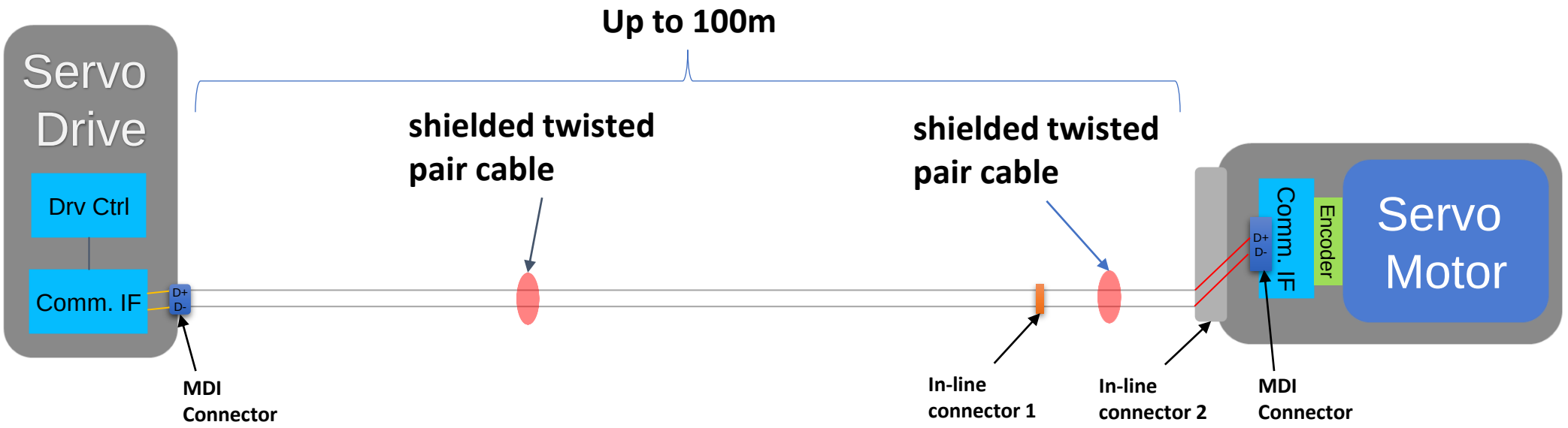
- **Servo Drive**
- **Servo Motor**
- **Motor Cable**

Servo control basic principle

- Encoder measures current motor position and sends the position data back to drive via **motor feedback communication**
- Drive calculates the next position and modulates main power output to move the motor to next position
- At stop state, drive can control the motor brake to hold the motor

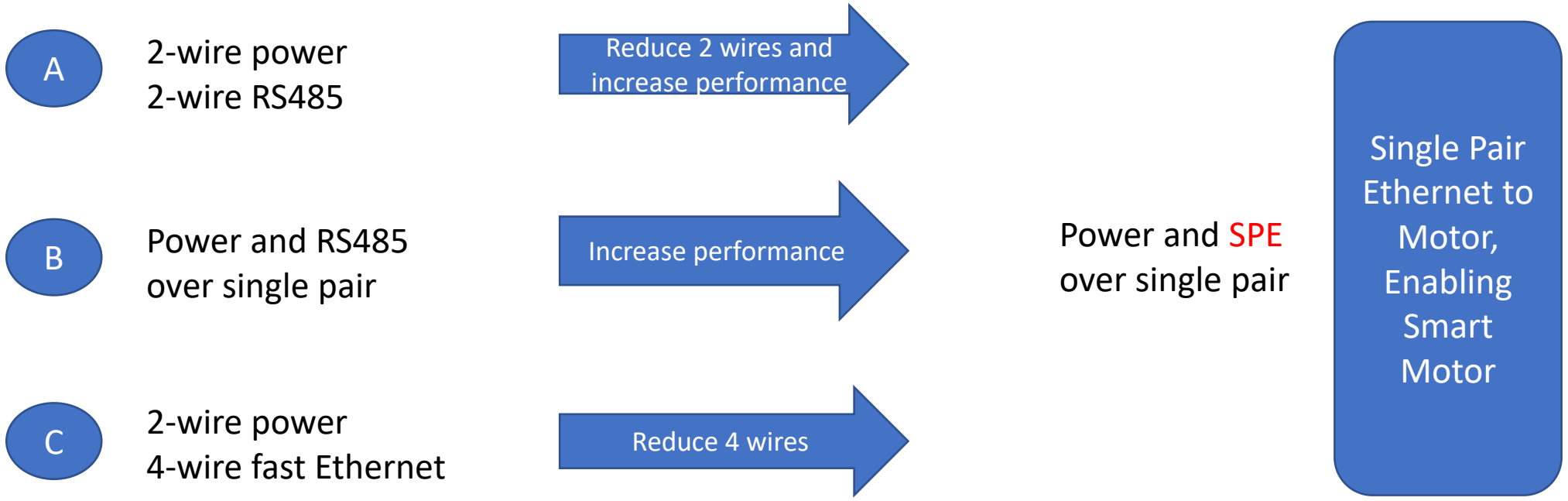


Motor feedback system



Motor feedback system is a sub-system of servo control system

100BASE-T1L for motor feedback communication



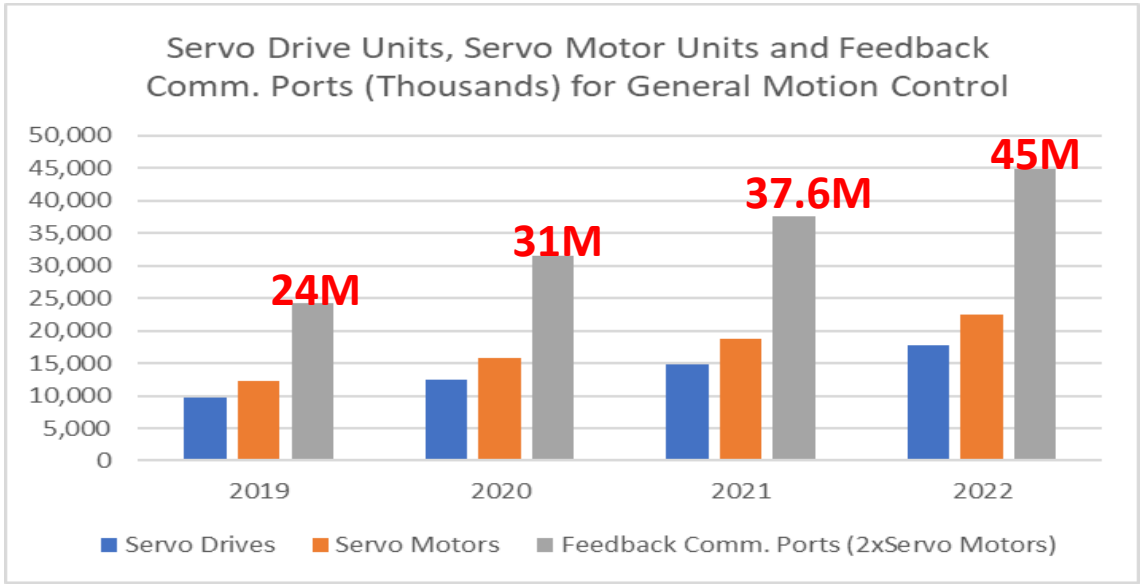
Today's technology variants

Potential technology trend

100BASE-T1L potentially enables motor feedback technology advancement

of motor feedback communication ports

- **31M** feedback comm. ports in 2020, **44%** of them (**13.6M**) require very low latency transceivers (<1.5us)
- **20%** annual growth



Data source: Omdia (former IHS), July 2021

Servo Control provides significant market potential for 100BASE-T1L

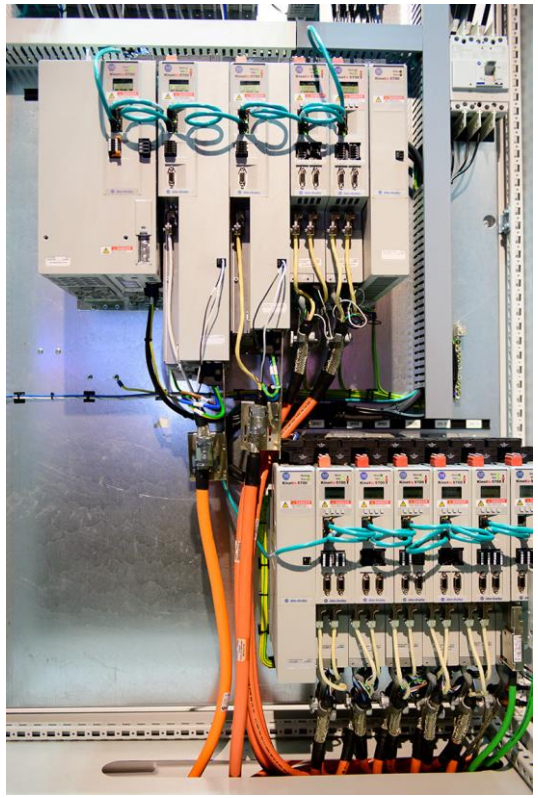
Requirements for motor feedback comm.

PHY
- 100Mb/s, Full Duplex
- BER: <= 10e-10
- PHY latency (TX+RX): <=1.5us

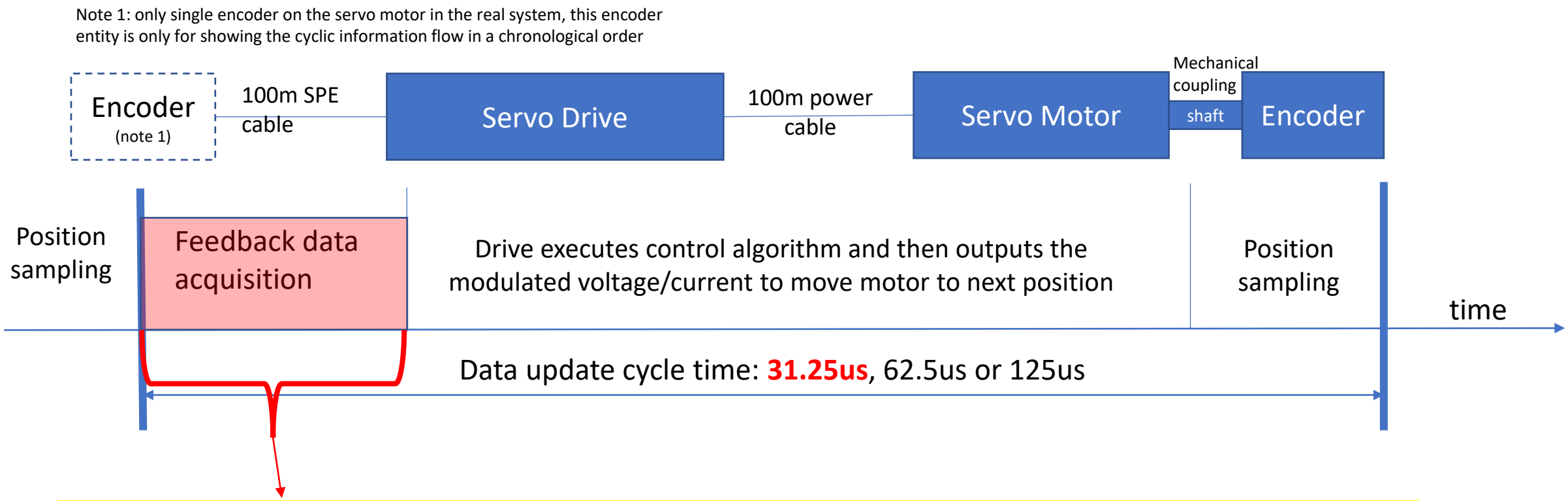
Link segment
- Length: up to 100m
- Shielded single twisted pair cable in motor cable
- Up to two inline connectors

Noise
- Operation under servo drive PWM noise

Power
- Power delivery over SPE pair
- 12VDC desirable, 24VDC acceptable
- Up to 500mA

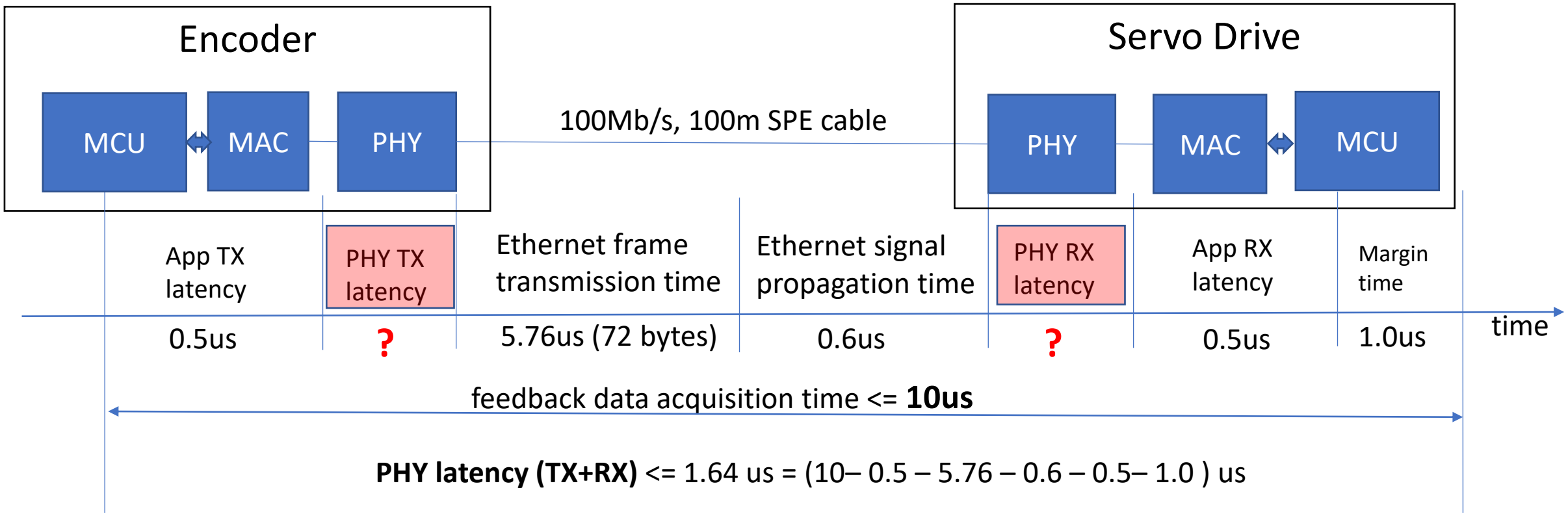


Maximum feedback data acquisition time



Feedback data acquisition time shall be less than or equal to 10us

Maximum PHY latency (TX+RX)



PHY latency (TX + RX) shall be less than or equal to 1.5us

Disabling FEC to achieve 1.5us PHY latency

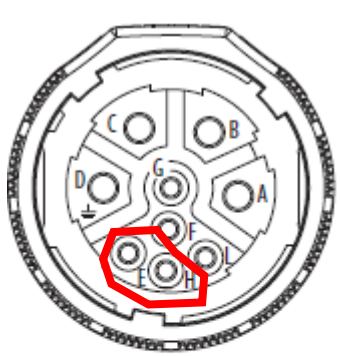
- Most likely FEC is required for the 100BASE-T1L PHY to achieve the link segment objective of “supporting up to 5 inline connectors for up to at least 500m reach” for process automation use cases, refer to 100BASE-T1L Reach and Connectors for more details
- FEC would possibly add at least 3-5us latency for 100BASE-T1L PHY, as a result, exceeding the maximum 1.5us PHY latency threshold for servo control

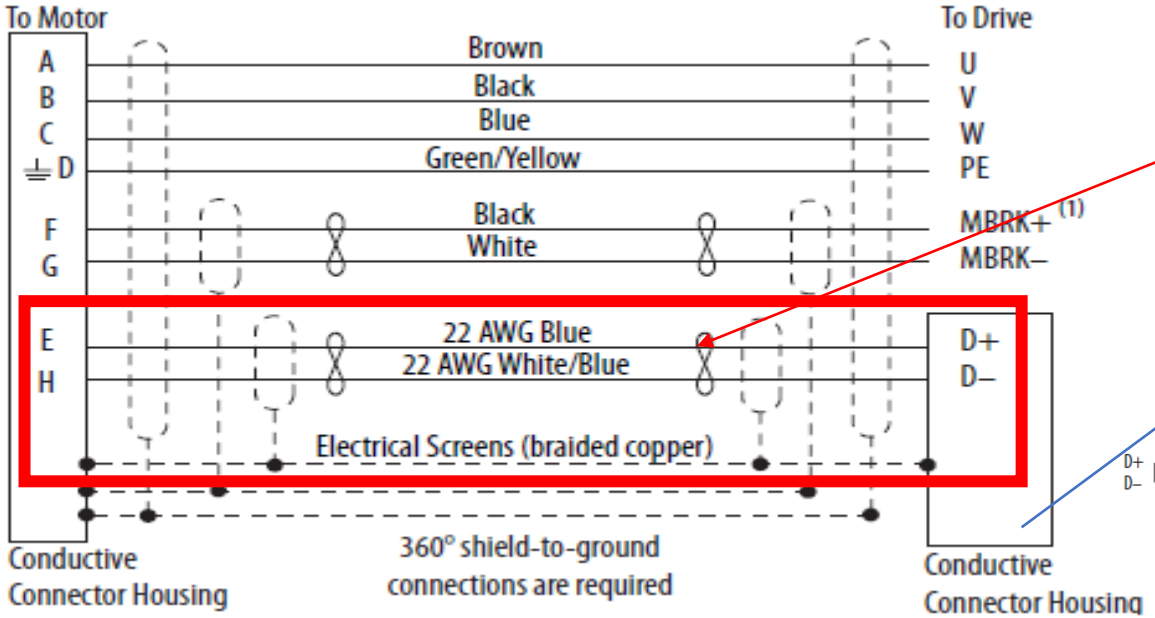
- Providing the capability to disable the FEC function is mandatory to achieve low latency operation if 100BASE-T1L PHY requires the FEC function
  - This technique has been proven in available PHY chips (e.g., 1000BASE-T1 PHY chip)

100BASE-T1L standard shall specify a standard way to enable low latency operation mode (e.g., disable FEC function)

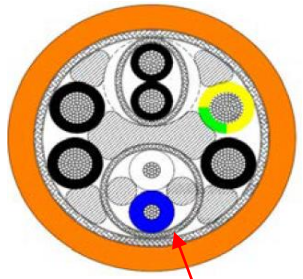
Link segment: SPE cabling instead of RS485 cabling

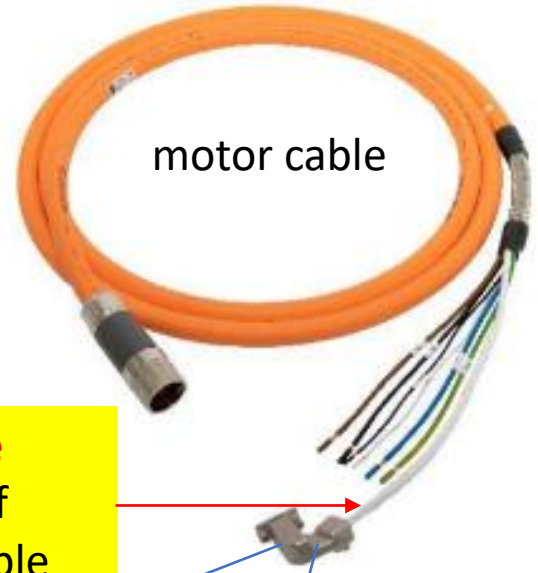
- Shielded AWG22 single twisted pair in motor cable
- Up to 100m (e.g., 90m main cable + 10m extension)
- Up to 2 inline connectors (extension cable connector and motor connector)



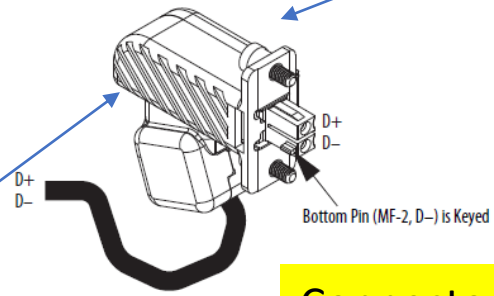


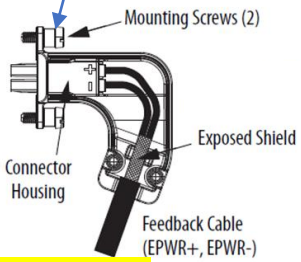
Wire Connection
Shield
Twisted Wire Pair





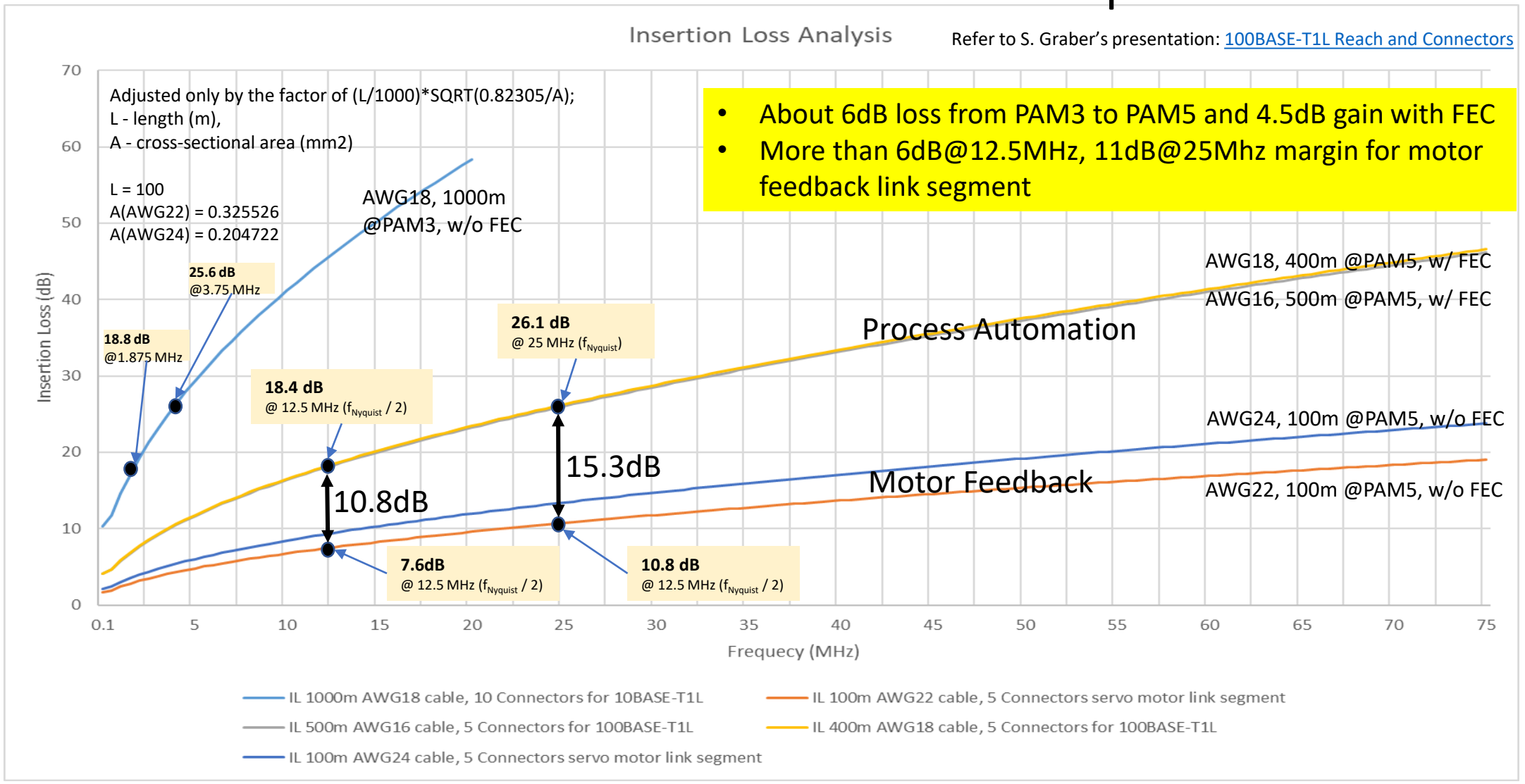
SPE cable instead of RS485 cable



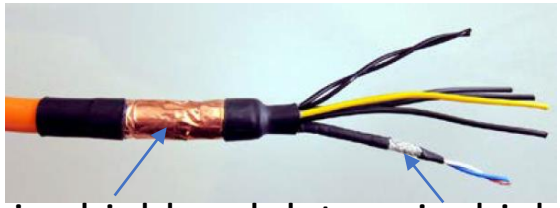


Connector might be reused?

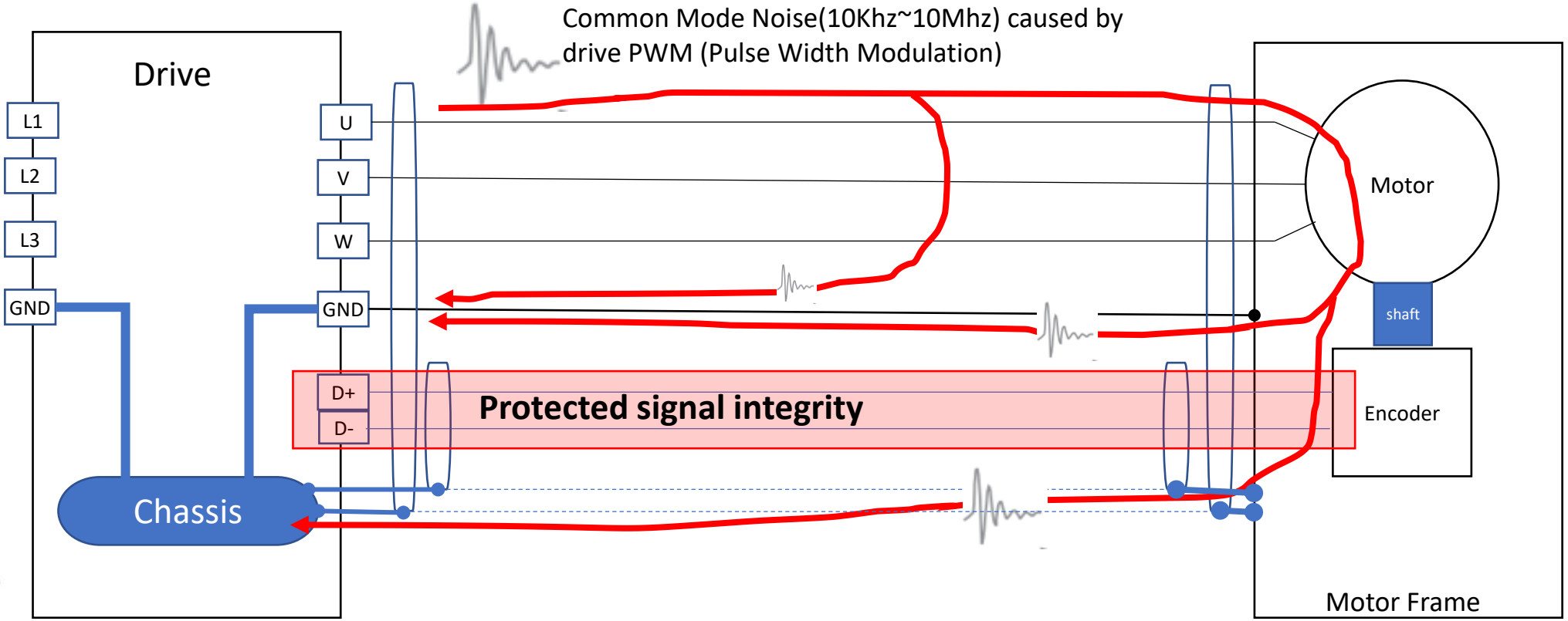
Process automation link segment specification would cover motor feedback link requirement



Protected signal integrity w/ robust shield



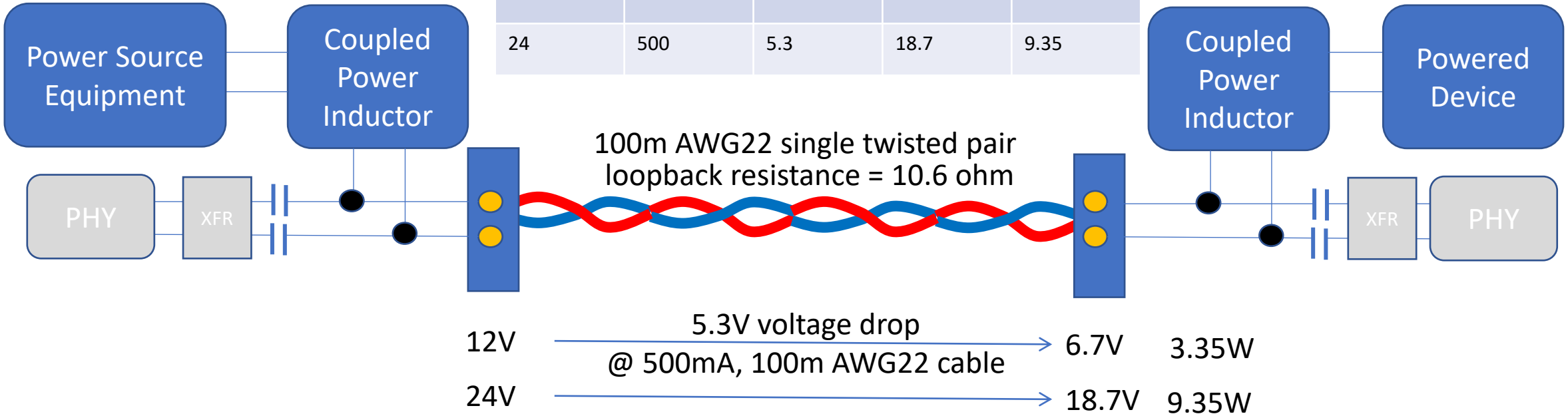
Main shield and data pair shield



Robust shielded cable(>85% braided shield + foil shield) and shielded connectors minimize the cross talk from power wires to data wires and protect signal integrity of digital feedback communication

Power over SPE pair

Power Source Voltage (V)	Current (mA)	Voltage Drop (V)	Powered Device Voltage (V)	Delivered Power (W)
12	500	5.3	6.7	3.35
24	500	5.3	18.7	9.35



It is feasible to power the encoder from a 100m AWG22 cable with a 12V power source according to the above calculation example

Summary

- Servo Control use case provides significant market potential for 100BASE-T1L while gaining technology advancement from 100BASE-T1L
- A list of requirements including latency, link segment, noise environment and power shall be considered and are assessed when 100BASE-T1L is applied for motor feedback communication
- <=1.5us PHY latency is the most critical requirement based upon the technical feasibility study on requirements
- Proposed action: **develop a standard method to enable low latency (<=1.5us) operation mode (e.g., disable FEC function) as part of 100BASE-T1L specification**

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