100BASE-T1L for Motor Feedback Communication Update

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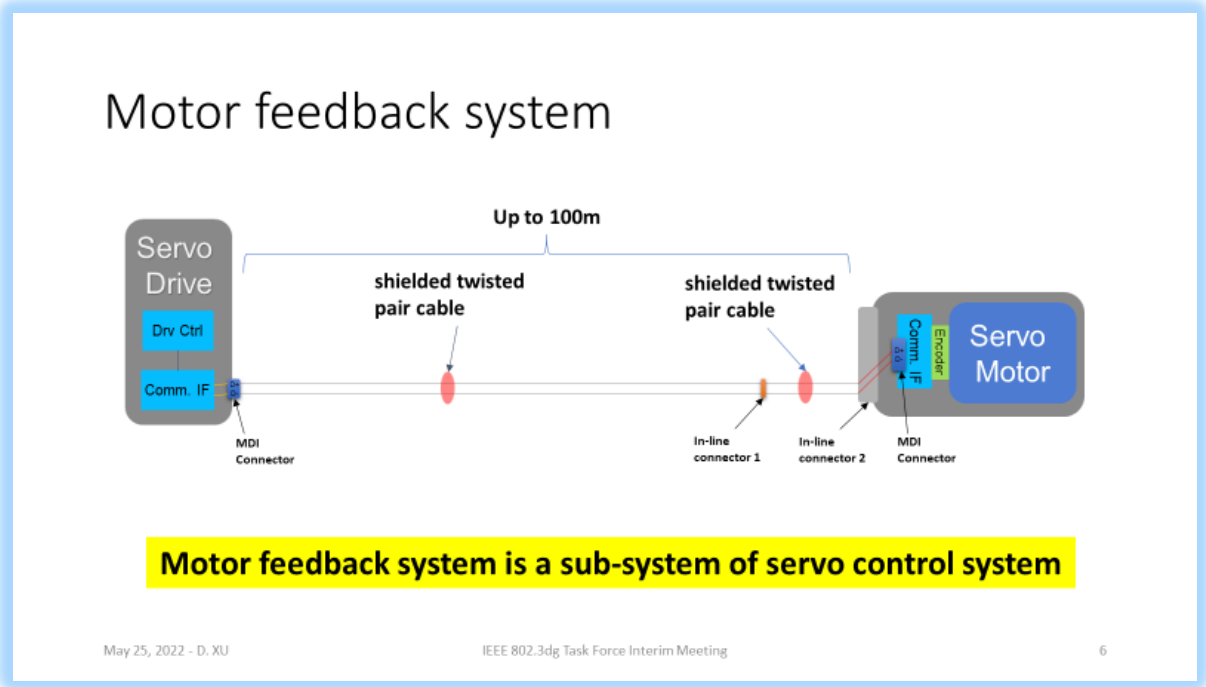
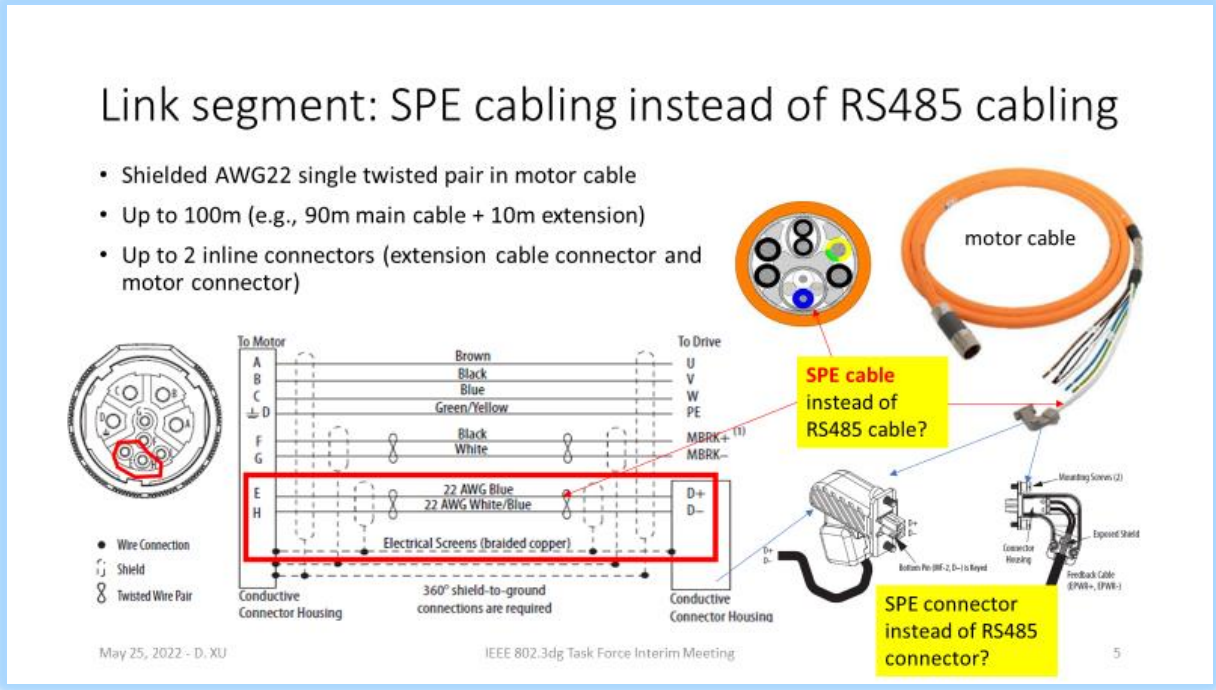
Purpose

- Recap link segment, noise environment, latency requirement
- Discuss reliability requirement
- Layout factors that contribute to latency and reliability
- Discuss potential link segment specification options

Link segment

- Specially-designed motor feedback cabling





Link segment

- RS485 cabling for existing installation
  - Whitepaper_Cable_and_connector

Number of wires:	2 (for encoder supply & communication)
Recomm. wire diameter:	0,34 mm² (e.g. AWG22); flex wires, copper typically 19 x 0,15 mm
Style:	shielded twisted pair
Shielding:	coverage >85 % Type of shielding (braided and foil) based on the cable rated utilization
Max poss. cable length:	up to 100 m (for HIPERFACE-DSL®)

The above listed wire cross section of 0,34 mm² is related to a max. possible communication distance of 100 m. As long as the other requirements for the communication are met it can be reduced for shorter distances (<25 m). Tests are recommended prior to final decision.

Based on today's knowledge recommendations for electrical performance are as followed:

DC-line resistance:	< 100 Ω/km (for each wire)
Line impedance:	110 ±10 Ω
Propagation delay:	≤ 4,8 ns/m
Velocity rate:	> 0,66 c
Line attenuation:	< 5 dB/100 m @ 10 MHz
Test voltage:	e.g. 600 V or 1000 V

The numbers shown below are some references based on initial tests and field application experiences with running DSL-utilizations. These values are neither fix design goal nor valid for all kinds of application. The purpose is to provide some basic information of currently running systems.

Capacitance:	<100 nF/km @ 1000 Hz (wire to shielding) <50 nF/km @ 1000 Hz (wire to wire)
Dielectric coefficient:	<2,3
Crosstalk attenuation:	<-50 dB (up to 100 MHz; power line to data line))
DC-shield resistance:	<65 m Ω/m (shielding motor cable)
DC-shield resistance:	<150 m Ω/m (shielding DSL cable)

- Standardized (IEC61156-12) single pair Ethernet cabling for new installation
  - Industrial Single Pair Ethernet Cable

Electrical Characteristics

ELECTRICALS

Max. Conductor DCR	Max. Capacitance Unbalance
59.4 Ohm/km	1,600 pF/km

DELAY

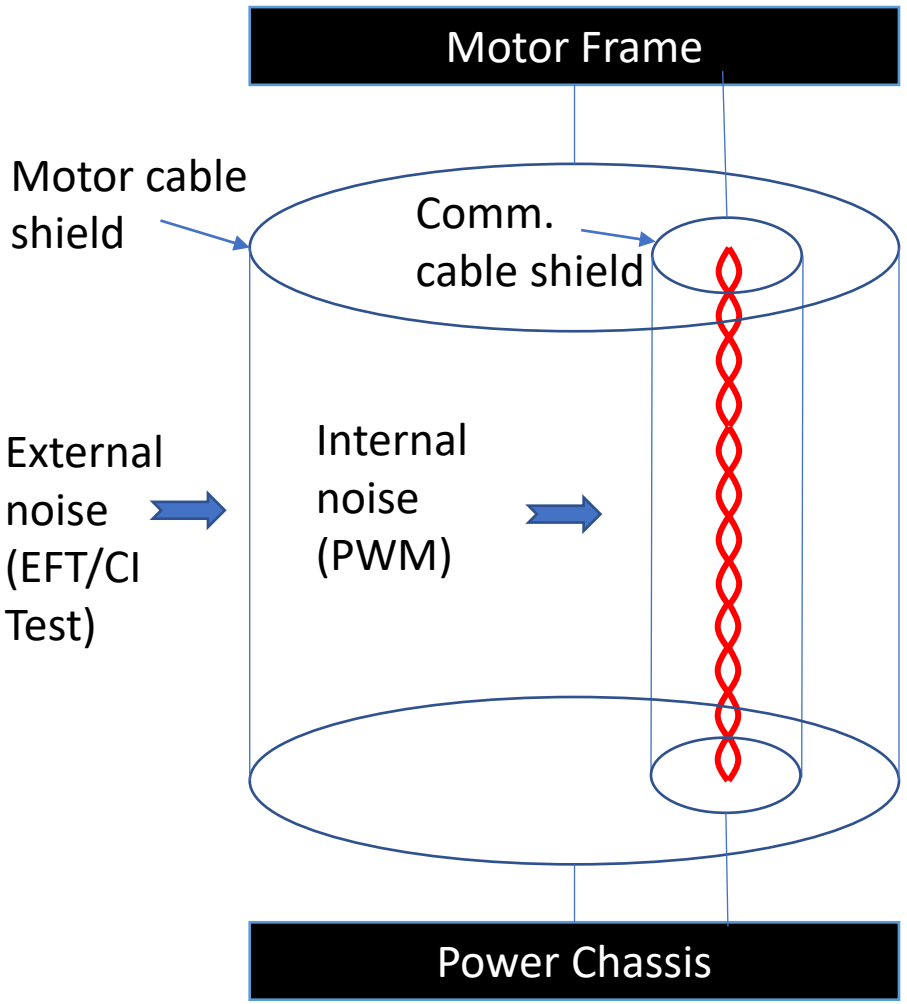
Frequency	Max. Delay	Max. Delay Skew
100 MHz	538 ns/100m	25 ns/100m

HIGH FREQUENCY

Frequency [MHz]	Max. Insertion Loss (Attenuation)	Min. RL (Return Loss) [dB]	Min. TCL [dB]	Min. ELTCTL [dB]	Max. Surface Transfer Impedance [mOhm/m]	Min. Coupling Attenuation [dB]
1	3.1 dB/100m	20	40	40	50	
4	5.6 dB/100m	23	40	28	76	
8	7.8 dB/100m	24.5	36.5	21.9	93	
10	8.7 dB/100m	25	35.0	20.0	100	
16	11 dB/100m	25	31.9	15.9	135	
20	12.3 dB/100m	25	30.5	14	155	
25	13.8 dB/100m	24.2	29	12	178	
30	15.1 dB/100m	23.5	27.8	10.5	200	85
60	21.4 dB/100m	20.9	23.3	5		85
100	27.8 dB/100m	19	20	5		84

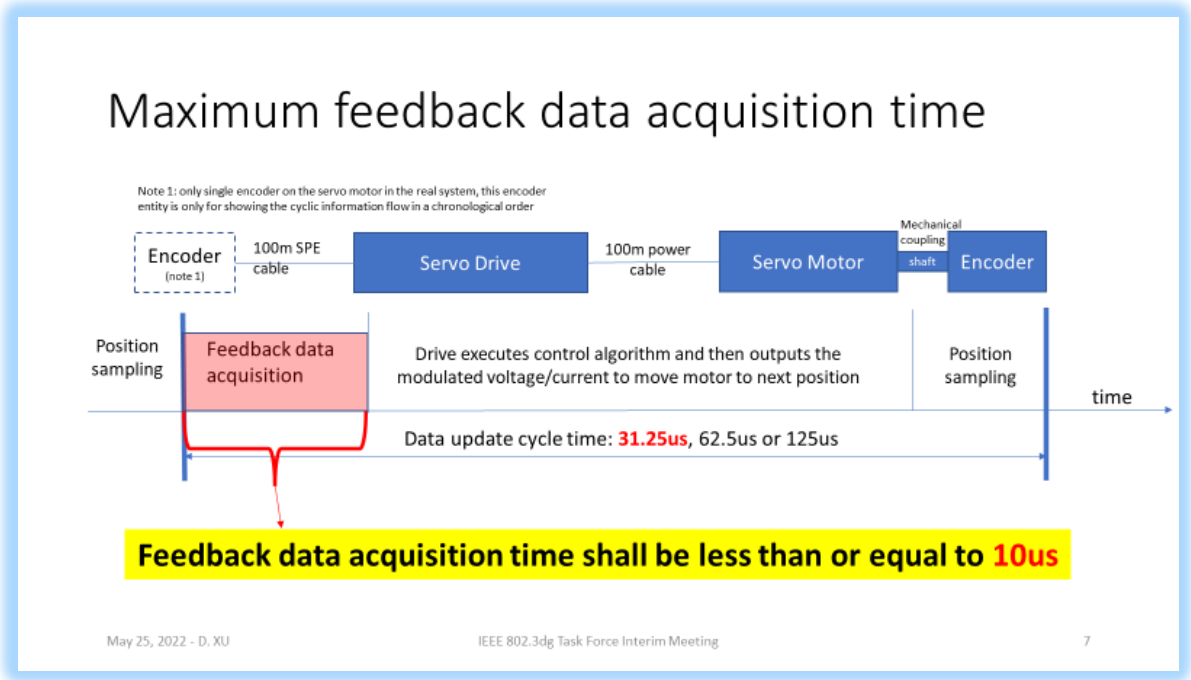
Noise environment

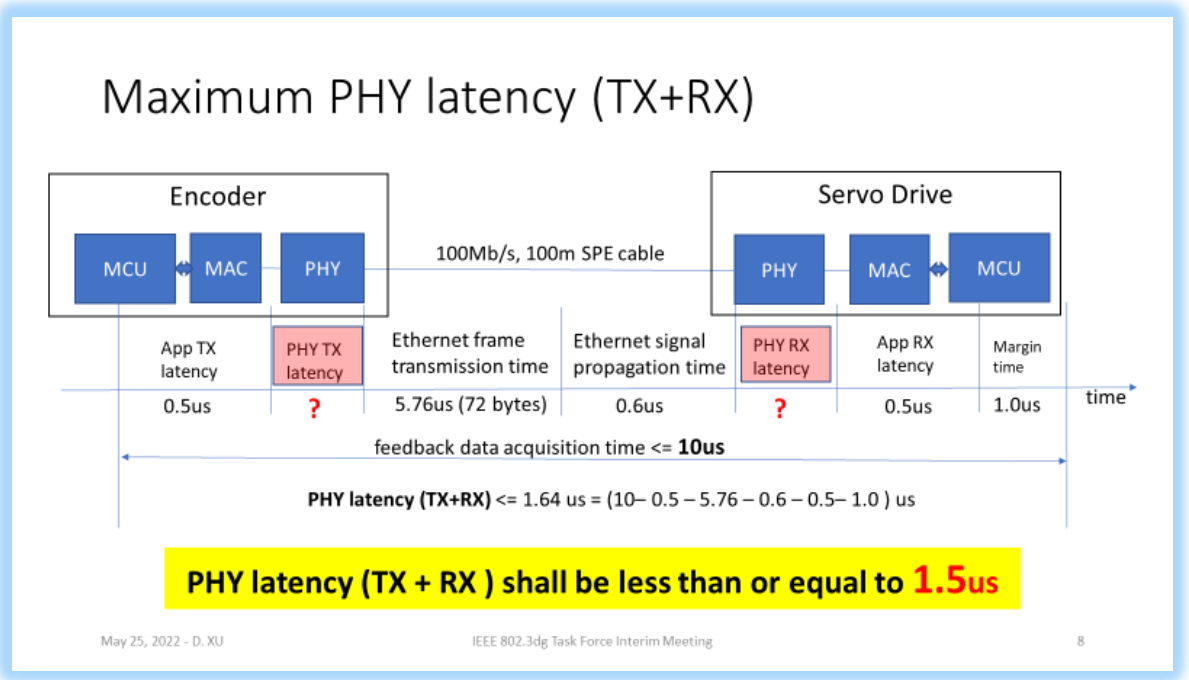
- External noise
  - EFT/CI test method
- Internal noise
  - PWM noise
- Very low or no alien cross-talk noise



PHY latency requirement

- Is “<=1.5us” feasible for 100BASE-T1L PHY?





PER and PHY BER Requirement

- 1000 axis, 1 fault per 1 year
- 31.25us, 64 bytes Ethernet frame
- **3 packet loss/error in a row at default**

- 3 packets lost in a row
  - PER 4.62751E-06
  - BER 8.03388E-09

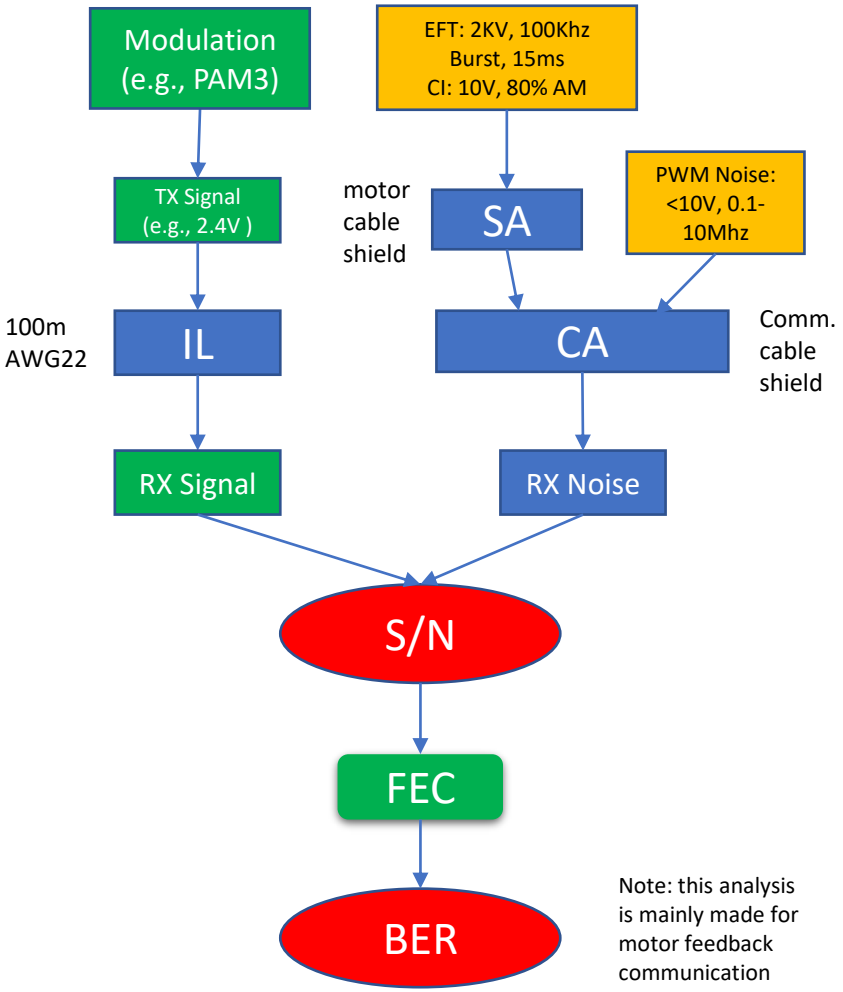
- 2 packets lost in a row
  - PER 9.95455E-09
  - BER 1.72822E-11

PER: Packet error rate
BER: Bit error rate

Industrial Automation Bit Error Rate Calculation

Factors that contribute to S/N and BER

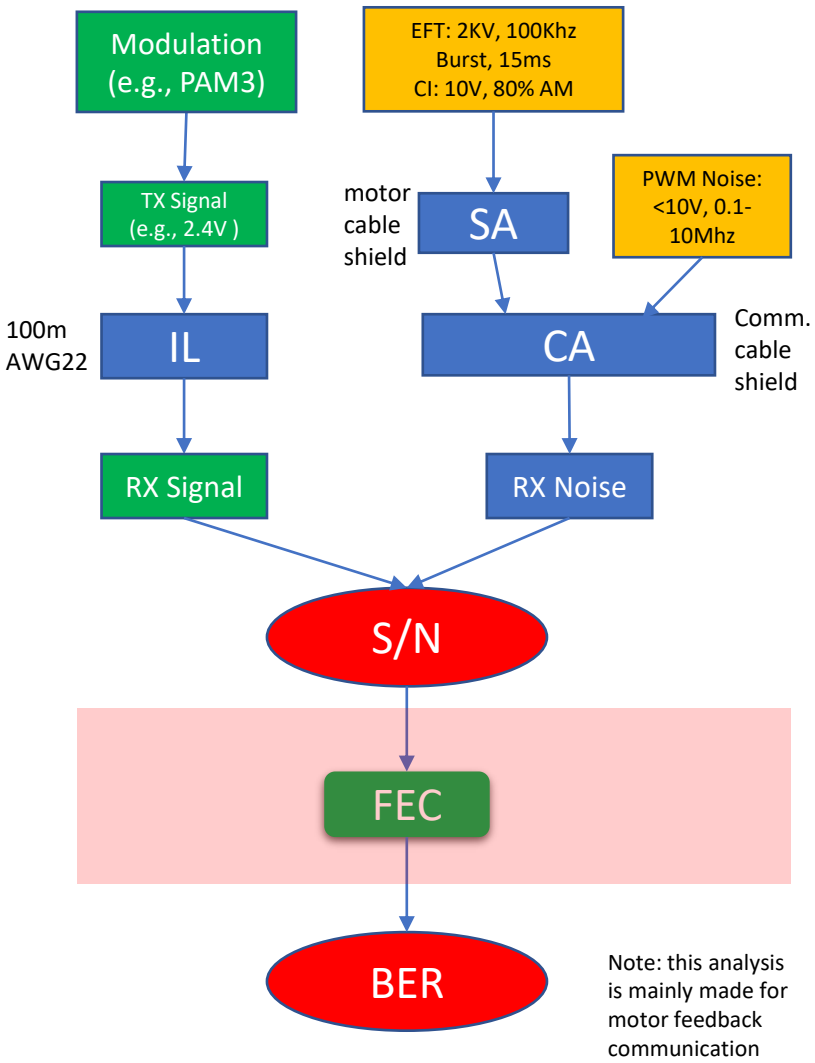
- Noise (environment)
  - External noise (EFT, CI))
  - Internal noise (PWM)
  - Alien cross talk noise (no/very small)
- Channel attenuation (link segment)
  - Insertion loss (IL)
  - Screen attenuation (SA)
  - Coupling attenuation (CA)
- Modulation and TX signal (PHY)
- FEC (PHY)



FEC effect

- Improve the PHY BER
- Cause the PHY latency
  - Additional bits for error correction and more algorithm processing time
- Add additional complexity and cost

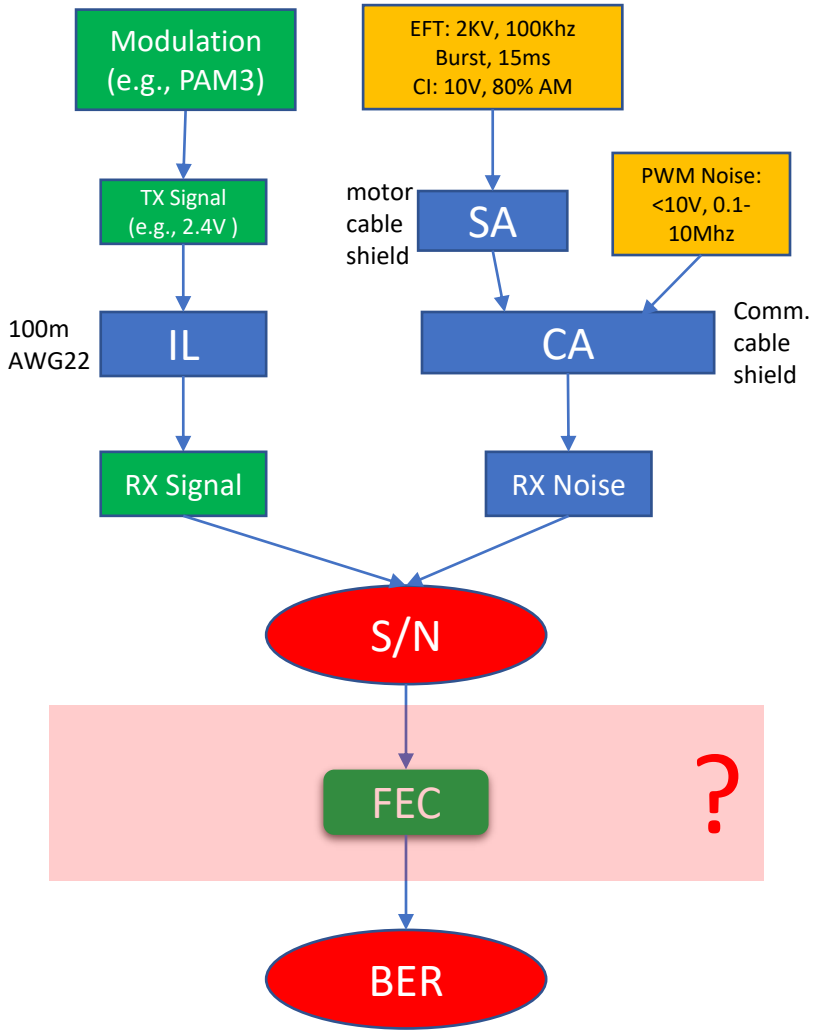
FEC is not required if S/N is good enough to achieve the BER objective



Is FEC required for 100BASE-T1L PHY?

- “No” for 100m motor feedback communication
- “YES” for 500m process automation trunk communication?

- If required for 500m use case, how to and how difficult to bypass FEC to reduce the PHY latency for motor feedback communication?



Link segment specification options

Potential Link segment specification options:

- Option1: specify one link segment for 500m process automation trunk communication
- Option2: specify two link segments: one for 500m process automation trunk communication; the other for 100m motor feedback communication
- …

Which option?

Summary and suggestion

- Recap link segment, noise environment, latency requirement
- Discuss reliability requirement
- Layout factors that contribute to latency and reliability

- PHY experts to evaluate the necessity of FEC
- Discuss and determine the link segment specification direction

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