Length vs. IL-Bandwidth vs. Wire Gauge

IEEE P802.3cg 10 Mbps Single Pair Ethernet Task Force

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Overview

- Use of different wire gauges for different 802.3cg use-cases make choosing the bandwidth of the PHY difficult
- This contribution presents curves to aid 802.3cg members in choosing appropriate PHY bandwidths for given reaches at given wire gauge sizes

How much IL is too Much

- Applications vary how much IL they can tolerate based on:
  - Noise environment
  - Implementation margin
  - PHY design complexity and coding
- Analysis based on AWGN background noise and Ethernet PHY experience may be useful in determining relevant 802.3cg bandwidths
- Use Cat 5e 22 dB/100m at 100MHz as a reference point

Some PHY Benchmarks

PHY Technology	Bits / Sec / Hz /pair	Nyquist Frequency	Insertion Loss at Nyquist	Primary Impairments
100BASE-TX (dual-simplex)	2	62.5 MHz	18.5 dB	Near-End Crosstalk & Intersymbol Interference
Proposed 4B3T 10MSPE	**2.67**	**3.75 MHz**	**25.6 dB (proposed)**	**Environmental Noise Sources**
1000BASE-T (echo-cancelled)	4.1 (6 dB trellis code)	62.5 MHz	18.5 dB	Far-End & (residual) Near-End Crosstalk
40GBASE-CR4 (simplex)	2	5.15625 GHz	20.9 dB	Timing Jitter, Near & Far-End Crosstalk
2.5GBASE-T (echo-cancelled)	6.25 (LDPC code)	100 MHz	24.0 dB	Alien Crosstalk
5GBASE-T (echo-cancelled)	6.25 (LDPC code)	200 MHz	35.3 dB	Alien Crosstalk
10GBASE-T (echo-cancelled)	6.35 (LDPC code)	400 MHz	46.9 dB	Alien Crosstalk & Receiver Noise/Residual Echo

IL verses AWG

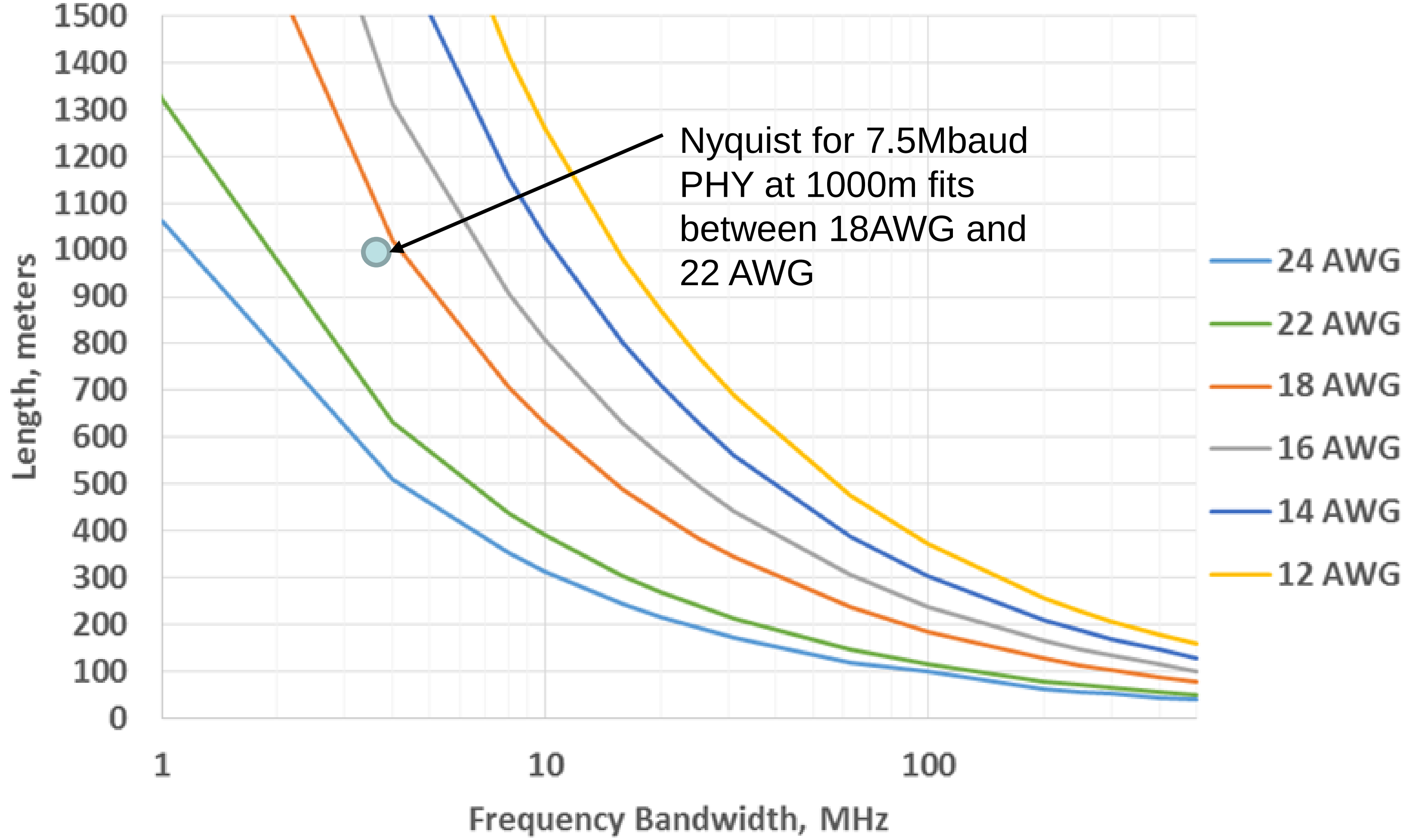
- The basic rule of thumb is that for a 6 wire gauge reduction (24 AWG to 18 AWG) the insertion loss in dB is divided in half.

AWG	AWG_{factor}
24	1.000
22	0.805
18	0.500
16	0.389
14	0.306
12	0.250

$$IL_{cable} = 10 * AWG_{factor}\left(1.967 * \sqrt{f} + 0.023 * f + \frac{0.05}{\sqrt{f}}\right)$$

Where 10 represents 10 times the cable insertion loss at 100 meters

Length vs. 22 dB IL-bandwidth for 12AWG to 24 AWG Cable



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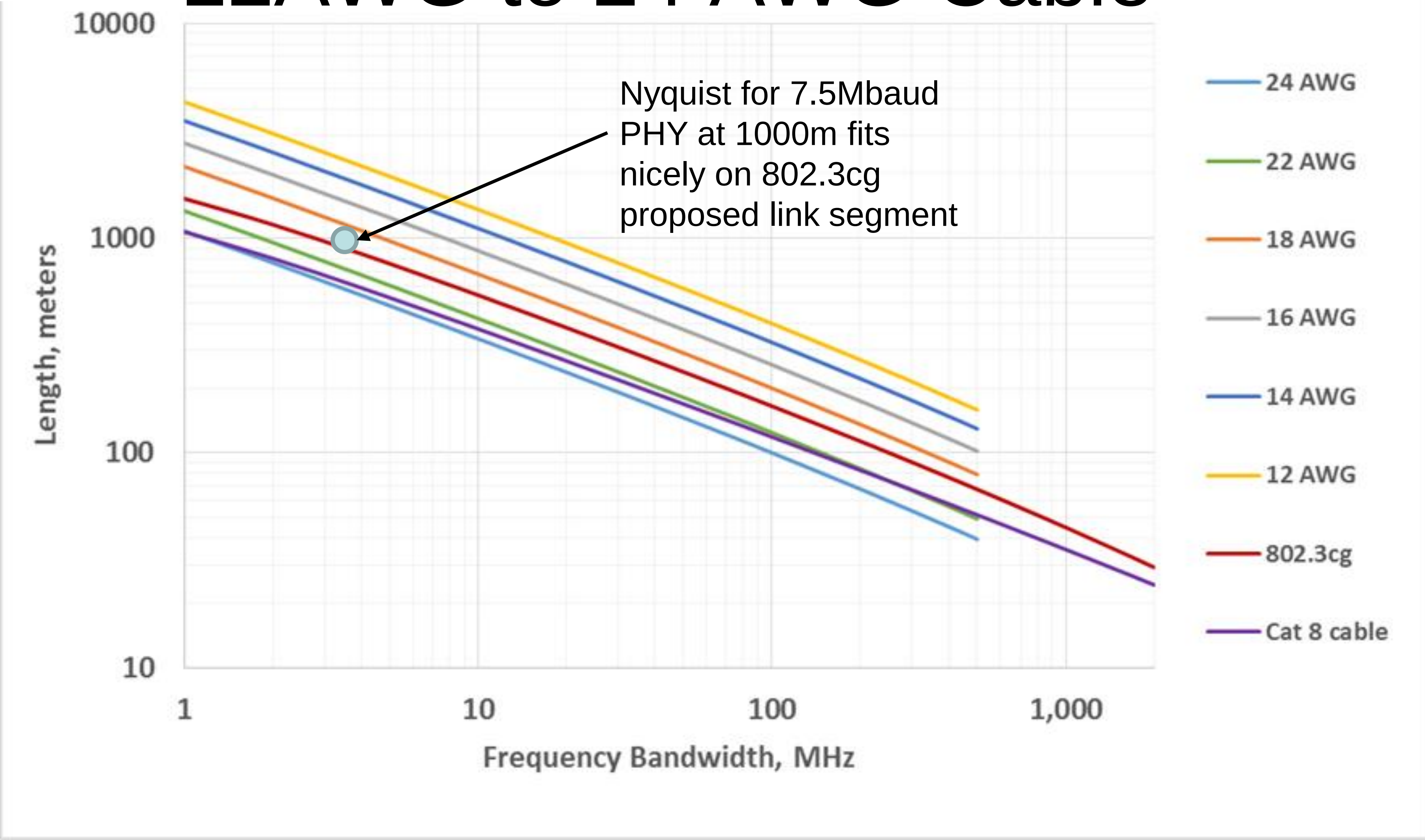
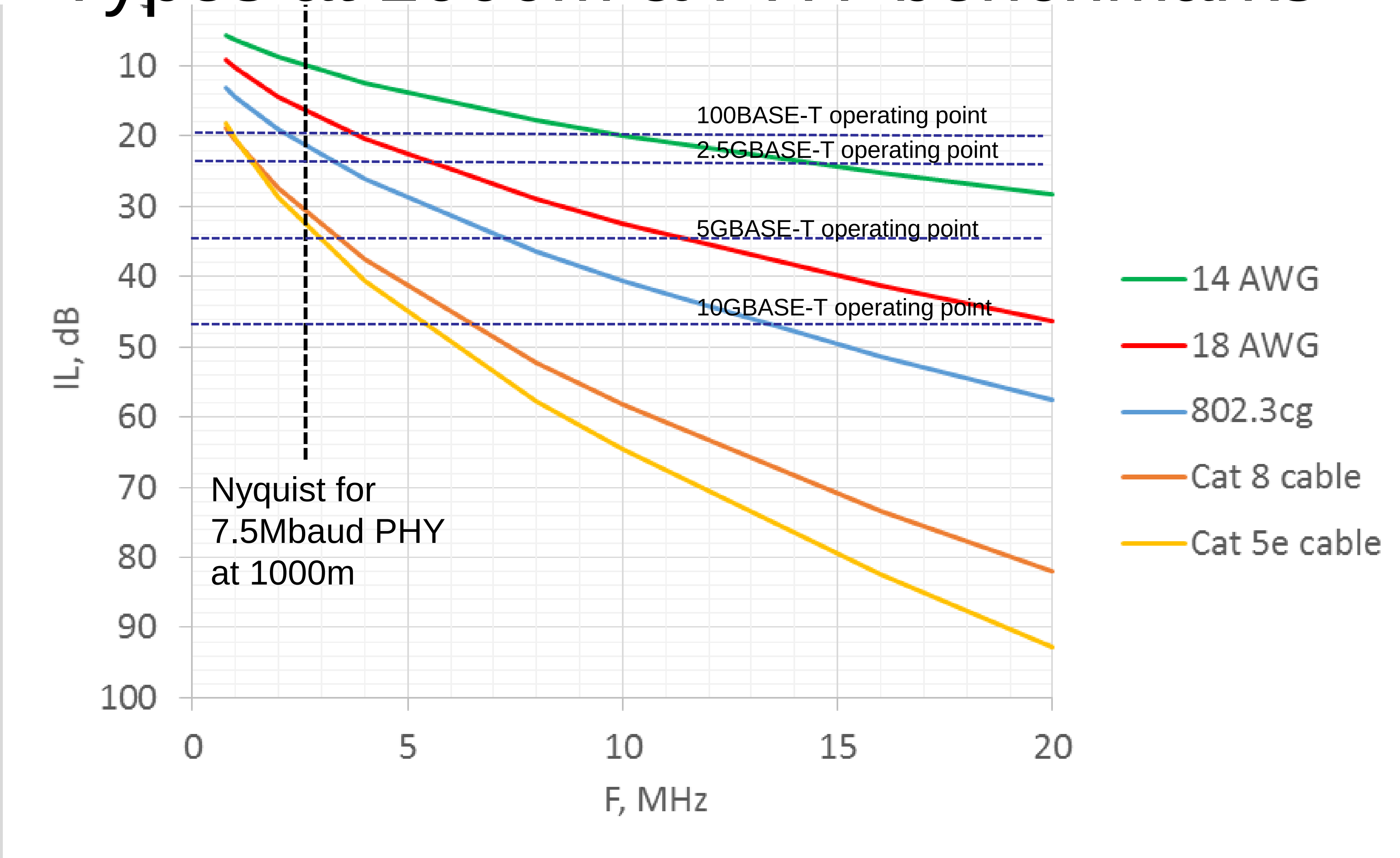


Bandwidths for 1000m Reach vs. Gauge

	~ 1000 meter bandwidth reach in meters					
Reach in meters	1 MHz	2 MHz	4 MHz	8 MHz	10 MHz	16 MHz
24 AWG Cat5e	1077					
Cat8	1070					
22 AWG Cat5e	1338	954				
802.3cg		1156				
18 AWG Cat5e			1085			
16 AWG Cat5e			1395	980		
14 AWG Cat5e					1111	
12 AWG Cat5e					1360	1066

Insertion Loss Comparison for 5 Cable Types at 1000m & PHY benchmarks



Conclusions

- Proposed 1000m link and 7.5Mbaud PHY are consistent with existing 802.3 PHYs of low complexity
  - Matches low complexity PHY types without coded modulation
- Good use of bandwidth under 5 MHz is important to long reach application
- Short link segment can use arbitrary bandwidth not limited by even narrow-gauge cabling

Thank You!