RTPGE
Cable and Channel Considerations

CommScope

March 2013

Orlando Plenary Meeting

Richard Mei

Trent Hayes

Bryan Moffitt

Todd Herman

connect+evolve

Agenda

- Insertion Loss in Cable
  - Solid vs. Stranded Cable
- Thermal De-rating of Insertion Loss in Cable
- Effects of Cable Flexing
- Channel Parameters Proposal

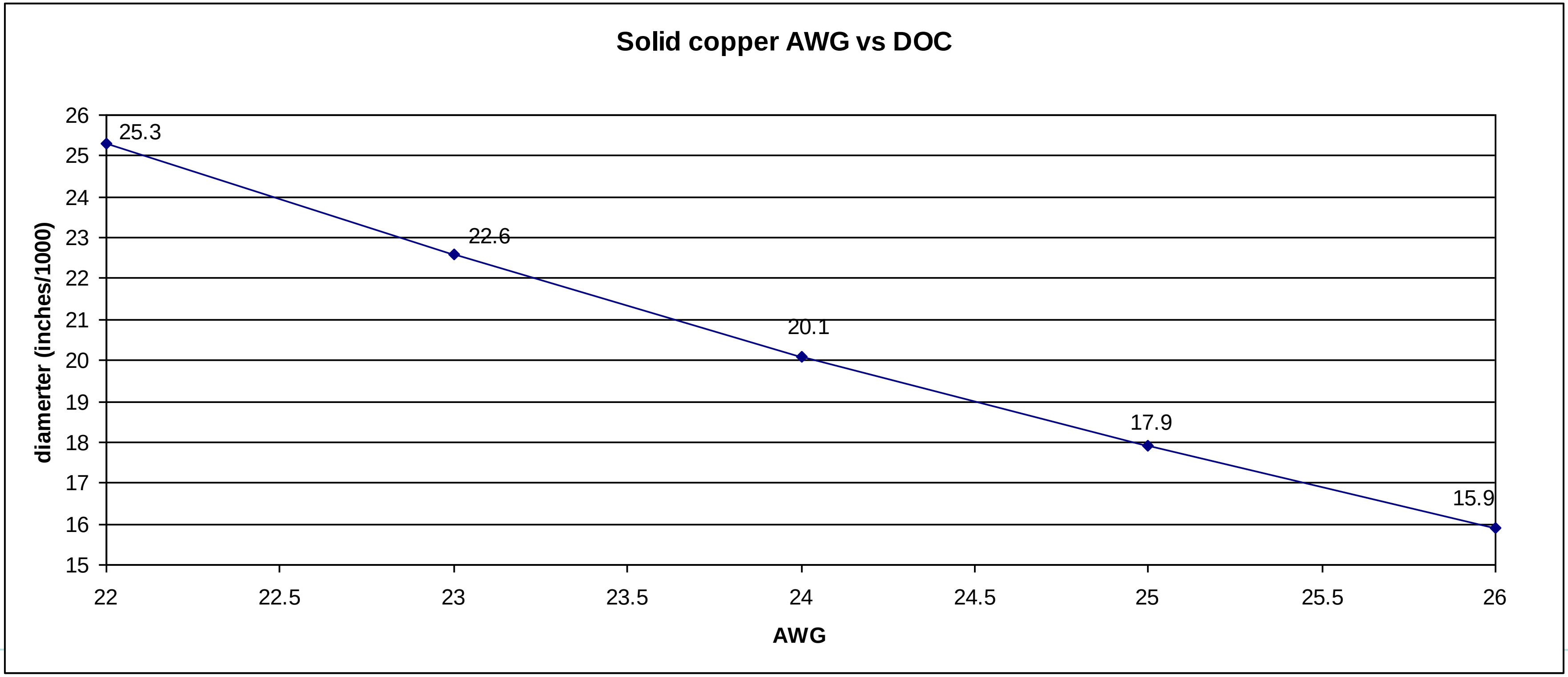
Cable IL Model

$$IL(f) \le k1 \cdot \sqrt{f} + k2 \cdot f + \frac{k3}{\sqrt{f}}$$

- Constants $k1$, $k2$, $k3$ proportional to copper loss, dielectric loss, and shield loss respectively
- Copper loss scales with copper diameter (approximately 12% per AWG)
- $k2$ is sensitive to insulation and jacket properties
- $k3$ is small for UTP cables
- Stranded conductors generally observed to have 20% greater IL than solid conductors for a given AWG

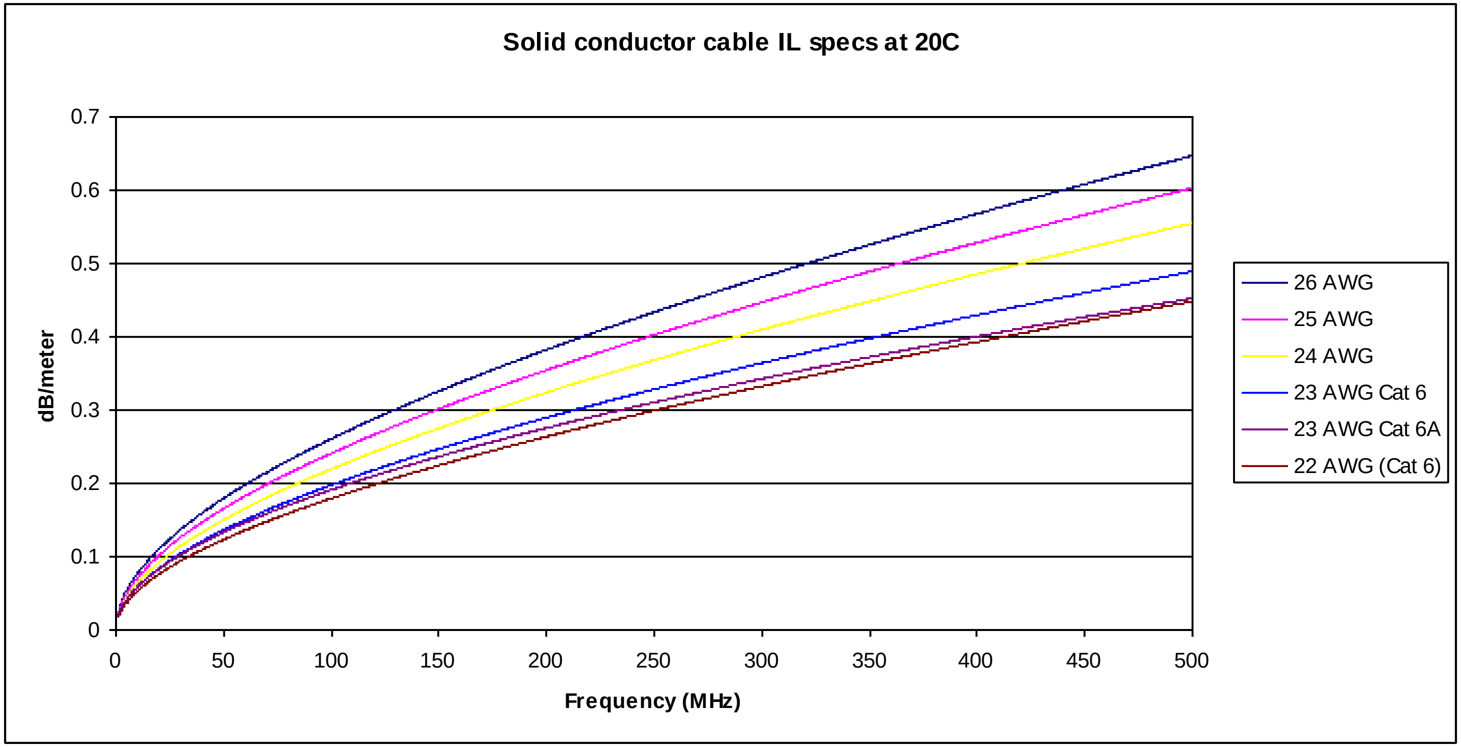
Solid Conductor Cable IL Coefficients (dB/100 meters) Commonly used Copper Size

	Cat 3	Cat 5e	Cat 6	Cat 6A
$k1$	2.32	1.967	1.808	1.82
$k2$	0.238	0.023	0.017	0.0091
$k3$	na	0.05	0.2	0.25
nominal Cu AWG	small 24	24	23	23



Predicted Solid Cu Cable Loss vs AWG

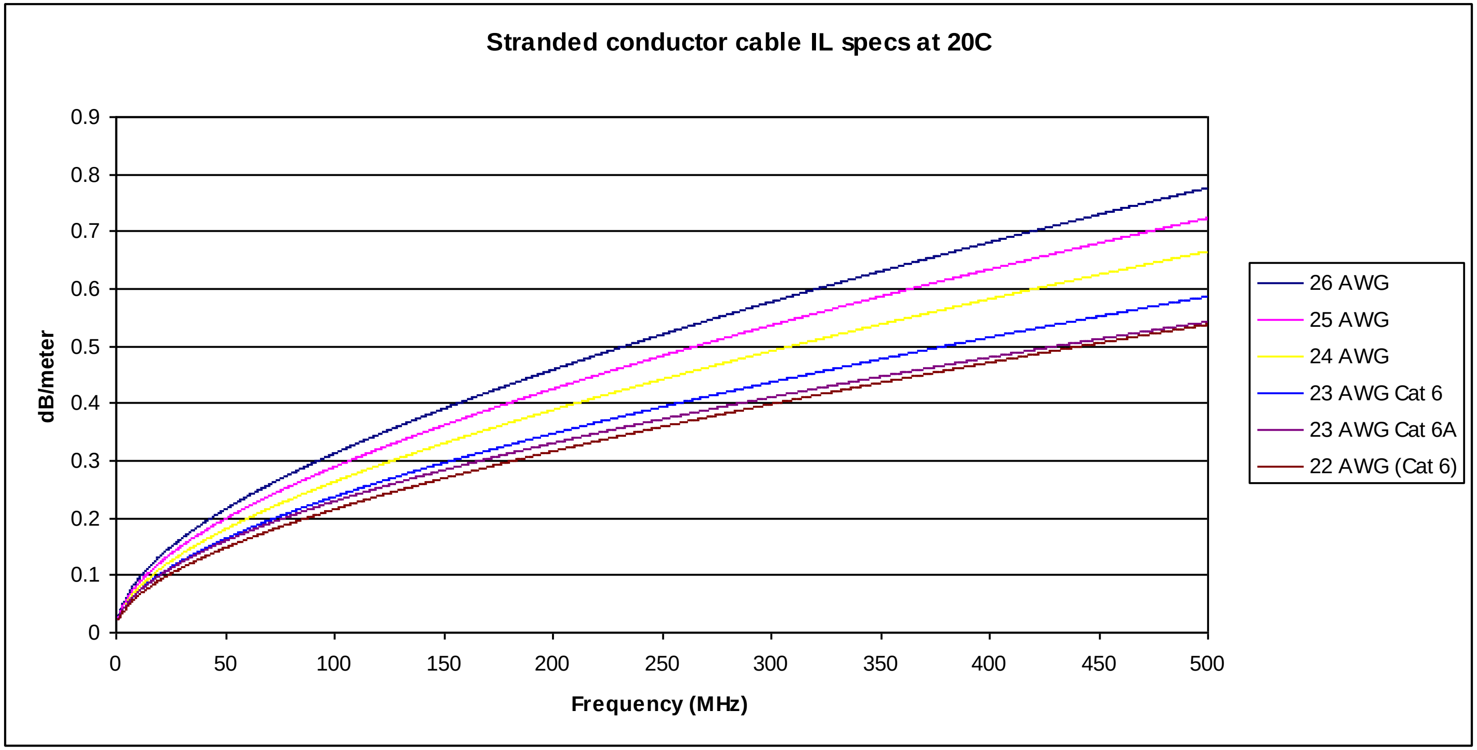
COMMSCOPE®



Solid conductor cable IL @ 20C (dB/meter)						
Frequency (MHz)	26 AWG	25 AWG	24 AWG Cat 5e	23 AWG Cat 6	23 AWG Cat 6A	22 AWG Cat 6
1	0.025	0.023	0.020	0.020	0.021	0.018
100	0.261	0.241	0.220	0.198	0.191	0.180
200	0.383	0.355	0.324	0.290	0.276	0.264
300	0.481	0.447	0.410	0.364	0.343	0.333
400	0.568	0.529	0.485	0.430	0.401	0.393
500	0.647	0.603	0.555	0.489	0.453	0.448

Predicted Stranded Cu Cable Loss vs AWG

COMMSCOPE®

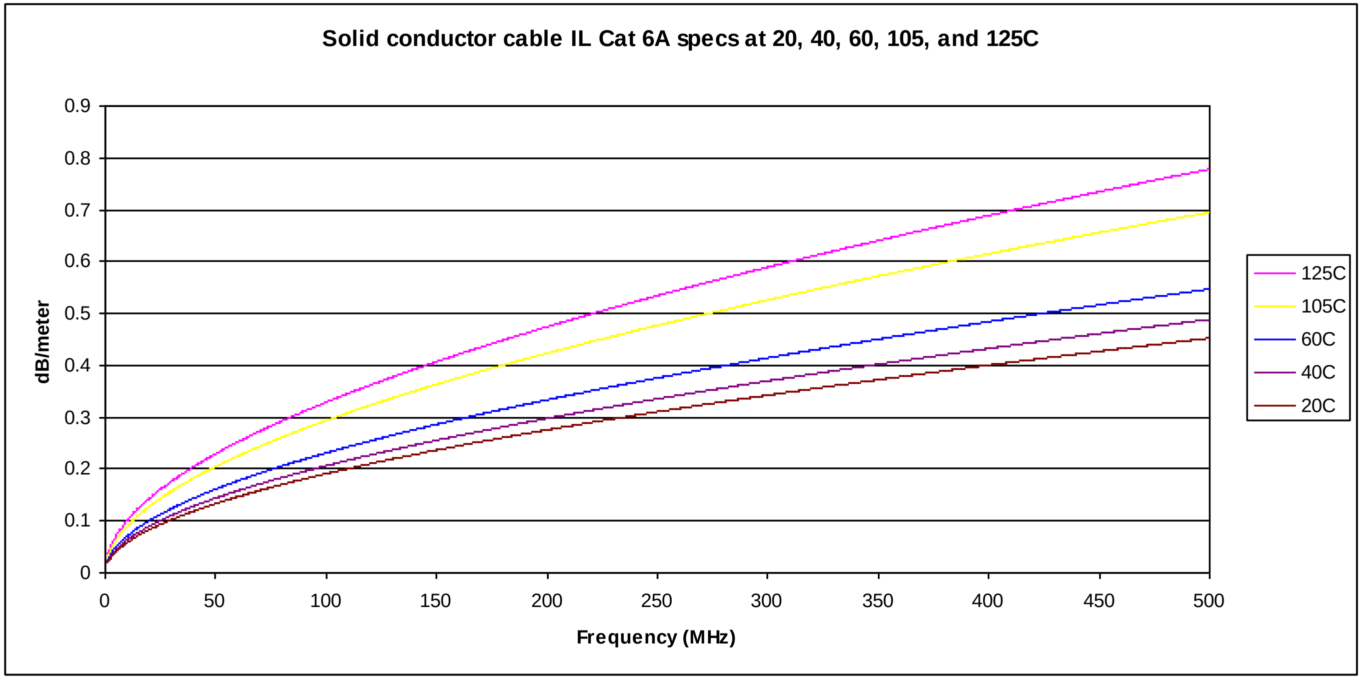


Stranded conductor cable IL @ 20C (dB/meter)						
Frequency (MHz)	26 AWG	25 AWG	24 AWG Cat 5e	23 AWG Cat 6	23 AWG Cat 6A	22 AWG Cat 6
1	0.029	0.027	0.024	0.024	0.025	0.022
100	0.313	0.290	0.264	0.238	0.230	0.216
200	0.459	0.426	0.389	0.348	0.331	0.317
300	0.578	0.537	0.492	0.437	0.411	0.399
400	0.682	0.634	0.583	0.516	0.481	0.472
500	0.777	0.724	0.666	0.587	0.543	0.538

TEMPERATURE ANALYSIS
INSERTION LOSS

Predicted Cat 6A Solid Cu Cable Loss vs Temperature

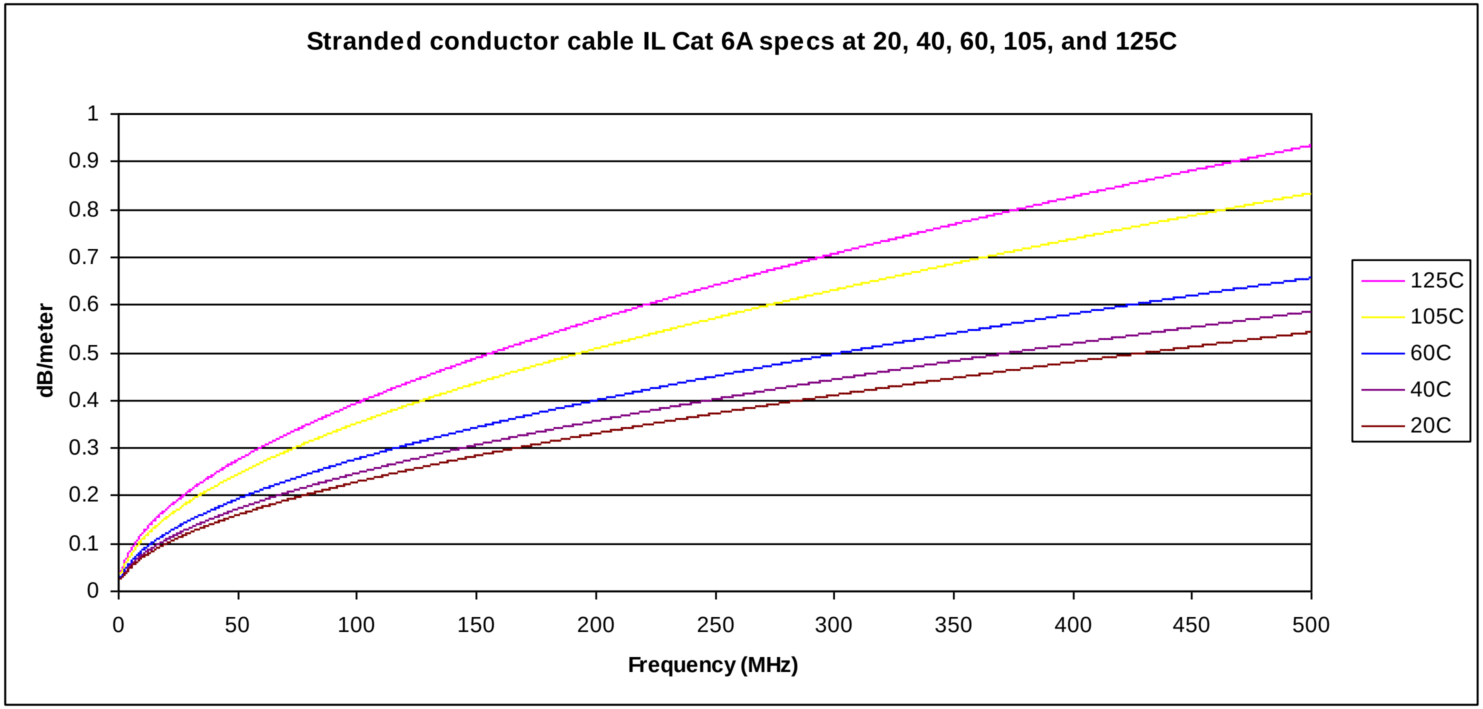
COMMSCOPE®



Solid conductor Cat 6A cable IL @ 20, 40, 60, 105 and 125C (dB/meter)					
Frequency (MHz)	20C	40C	60C	105C	125C
1	0.021	0.022	0.025	0.032	0.036
100	0.191	0.207	0.231	0.294	0.329
200	0.276	0.298	0.334	0.424	0.474
300	0.343	0.370	0.415	0.526	0.590
400	0.401	0.433	0.484	0.615	0.689
500	0.453	0.489	0.547	0.695	0.779

Predicted Cat 6A Stranded Cu Cable Loss vs Temperature

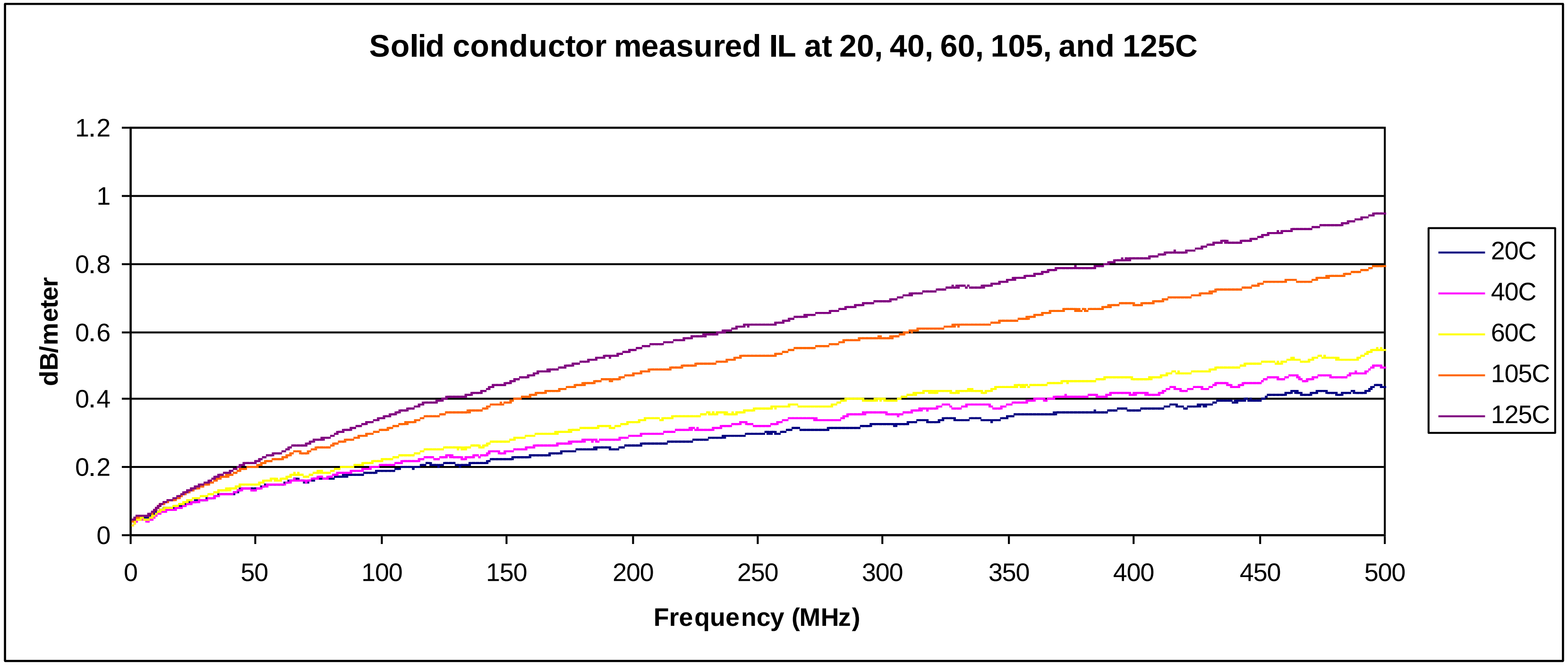
COMMSCOPE®



Stranded conductor Cat 6A cable IL @ 20, 40, 60, 105 and 125C (dB/meter)					
Frequency (MHz)	20C	40C	60C	105C	125C
1	0.025	0.027	0.030	0.038	0.043
100	0.230	0.248	0.278	0.353	0.395
200	0.331	0.357	0.400	0.508	0.569
300	0.411	0.444	0.497	0.632	0.708
400	0.481	0.519	0.581	0.738	0.827
500	0.543	0.587	0.657	0.834	0.934

Measured Cat 6A Solid Cu Cable Loss vs Temperature

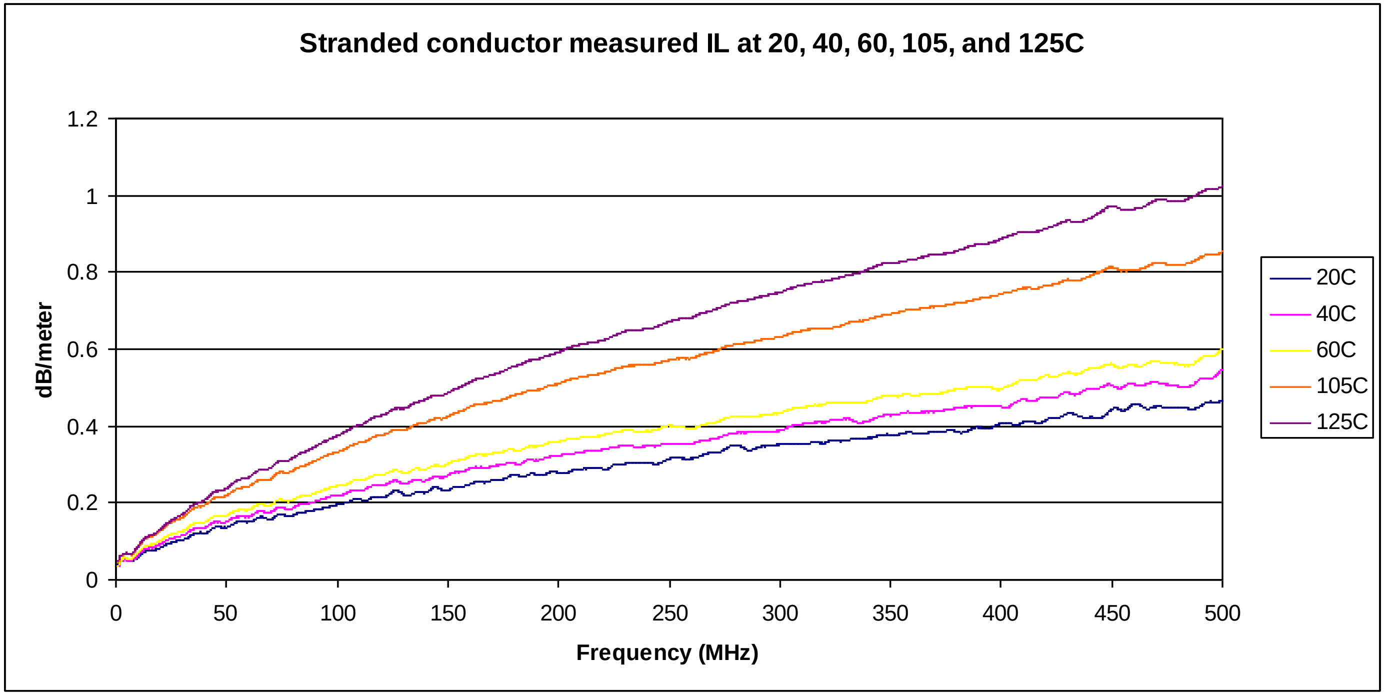
COMMSCOPE



Solid conductor Cat 6A cable IL @ 20, 40, 60, 105 and 125C (dB/meter)					
Frequency (MHz)	20C	40C	60C	105C	125C
1	0.045	0.029	0.031	0.041	0.044
100	0.190	0.206	0.221	0.309	0.345
200	0.264	0.291	0.332	0.473	0.544
300	0.326	0.360	0.399	0.582	0.689
400	0.368	0.416	0.460	0.679	0.813
500	0.434	0.492	0.546	0.794	0.948

Measured Cat 6A Stranded Cu Cable Loss vs Temperature

COMMSCOPE®



Stranded conductor Cat 6A cable IL @ 20, 40, 60, 105 and 125C (dB/meter)					
Frequency (MHz)	20C	40C	60C	105C	125C
1	0.040	0.034	0.037	0.046	0.050
100	0.196	0.221	0.244	0.333	0.375
200	0.279	0.323	0.360	0.510	0.592
300	0.352	0.388	0.435	0.632	0.749
400	0.408	0.449	0.496	0.744	0.887
500	0.468	0.548	0.602	0.854	1.025

Observed Temperature Dependence

- TIA 568-C.2 Cable IL adjustment factor
  - 0.4% increase per ˚C from 20˚C to 40˚C
  - 0.6% increase per ˚C from 40˚C to 60˚C
- The percent difference from 20C was computed for each frequency point
- The average percent difference was then measured
- There were observed differences from standard 4 pair cable and the 1 pair cable with automotive materials

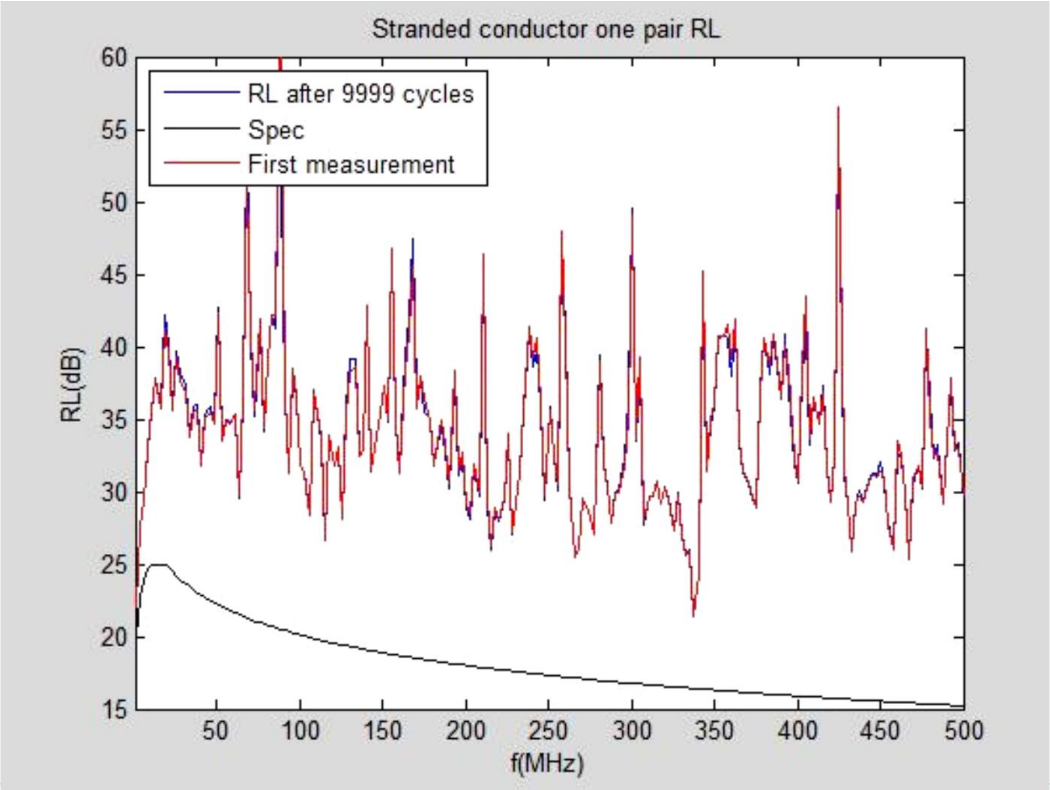
IL temperature adjustment factor (% per degree C)			
	predicted	observed	
temperature range C	TIA 568	solid Cu	stranded Cu
20 - 40	0.4	0.46	0.665
40 - 60	0.6	0.64	0.623
60 - 105	?	1.15	1.164
105 - 125	?	1.38	1.442

Recommendations

- Use 20% de-rated Cat 6A IL requirement for RTPGE cable with stranded conductors
- Assume temperature dependence shown on Slide 12
- More data is needed from other vendors with different cable constructions to finalize this cable performance calculation

Cable Flexing Effects on RL

- Cable Flexure Testing with a one pound load was conducted on 23 AWG stranded cable
- RL was measured continuously during the flexing cycles across the full frequency range



Channel Performance Proposal

COMMSCOPE®

- Adopt the ISO Class Ea Channel Specifications

Minimum return loss dB

$1 \le f < 10$	19,0
$10 \le f < 40$	$24 - 5\lg(f)$
$40 \le f < 398.1$	$32 - 10\lg(f)$
$398.1 \le f \le 500$	6,0

$$NEXT \quad -20\lg\left(10^{\frac{74,3-15\lg(f)}{-20}} + 2\times 10^{\frac{94-20\lg(f)}{-20}}\right)^{b,\,d}$$

$$PS\ NEXT \quad -20\lg\left(10^{\frac{72,3-15\lg(f)}{-20}} + 2\times 10^{\frac{90-20\lg(f)}{-20}}\right)$$

Whenever the Class E_A channel insertion loss at 450 MHz is less than 12 dB, subtract the term $1,4((f-450)/50)$ to the equation stated above for the range of 450 MHz to 500 MHz.

Whenever the Class E_A channel insertion loss at 450 MHz is less than 12 dB, subtract the term $1,4((f - 450)/50)$ from the equation stated above for the range of 450 MHz to 500 MHz.

Frequency MHz	**Minimum PS ANEXT** dB
$1 \le f < 100$	$80 - 10\lg(f)$
$100 \le f \le 500$	$90 - 15\lg(f)$

If the average insertion loss of all disturbed pairs at 100 MHz, $IL_{100MHz,avg}$, is less than 7 dB, then subtract the following for $f \ge 100$ MHz:

$$\text{minimum}\left\{7\cdot\frac{f-100}{400}\cdot\frac{7-IL_{100MHz,avg}}{IL_{100MHz,avg}},\ 6\cdot\frac{f-100}{400}\right\}$$

Several other parameter specifications should also be adopted, but may need scaling

Recommendation

COMMSCOPE®

- Cable, connecting hardware, link and channel performance (internal and external parameters) are well defined in ISO Class EA and TIA Cat-6A standards. It is the foundation for 10GBASE-T transmission
- Propose to adopt ISO Class EA specs for non-length dependent parameters such as RL, NEXT, PSNEXT, PSANEXT and PSAACR-F
- Length scaling is required for the following parameters: IL, ACR-F, PSACR-F, Delay and Skew.
- LCL, LCTL, TCL, TCTL should be specified based on EMC modeling study

Thank You