Impedance balance requirements for 2.5G & 5GBASE-T link segments

IEEE P802.3bz 2.5G/5GBASE-T TASK FORCE

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Recent Fluke Comment (Atlanta)

ISO/IEC includes impedance balance requirements

TIA 568 does not

Both cabling standards are referenced for use in 802.3bz.

2.5G/5GBASE-T link segment should be explicate about impedance balance parameters so as to remove any ambiguity for equipment and system implementers.

ISO/IEC 11801:2002, Class D, Class E

Table 20 - Unbalance attenuation for channel

Class	Frequency MHz	Maximum unbalance attenuation dB
A	f = 0,1	30
B	f = 0,1and 1	45 @ 0,1 MHz; 20 @ 1 MHz
C	$1 \leq f \leq 16$	30 - 5log(f) f.f.s.
D	$1 \leq f \leq 100$	40 - 10log(f) f.f.s.
E	$1 \leq f \leq 250$	40 - 10log(f) f.f.s.
F	$1 \leq f \leq 600$	40 - 10log(f) f.f.s.

Note: The 2002 edition of 11801 has no regard for screened or unscreened cabling constructions.

ISO/IEC 11801 Class D, Ed. 2.2, 2011

Table 21 – TCL for channel for unscreened systems

Class	Frequency MHz	Minimum TCL [a] dB
A	$f = 0,1$	30
B	$f = 0,1$ $f = 1$	45 20
C	$1 \le f \le 16$	$30 - 5 \lg(f)$
D, E, E_A, F, F_A	$1 \le f < 30$ $30 \le f \le$ NOTE [b]	$53 - 15\lg(f)$ $60,3 - 20\lg(f)$
NOTE This equation for TCL applies to upper frequency of the class.		
[a] *TCL* at frequencies that correspond to calculated values of greater than 40,0 dB shall revert to a minimum requirement of 40,0 dB. [b] TCL at frequencies above 250 MHz are for information only.		

ISO/IEC 11801 Class D, Ed. 2.2, 2011

Table 22 – ELTCTL for channel for unscreened systems

Class	Frequency MHz	Minimum ELTCTL dB
D, E, E_A, F, F_A	$1 \leq f \leq 30$	$30 - 20\lg(f)$

Additional considerations

MDI has explicit impedance balance requirements (clause 126.8)

- Historically these are derived to provide margin against the CM output voltage being sufficient to exceed the Class A emission limits (see Cobb_0705).

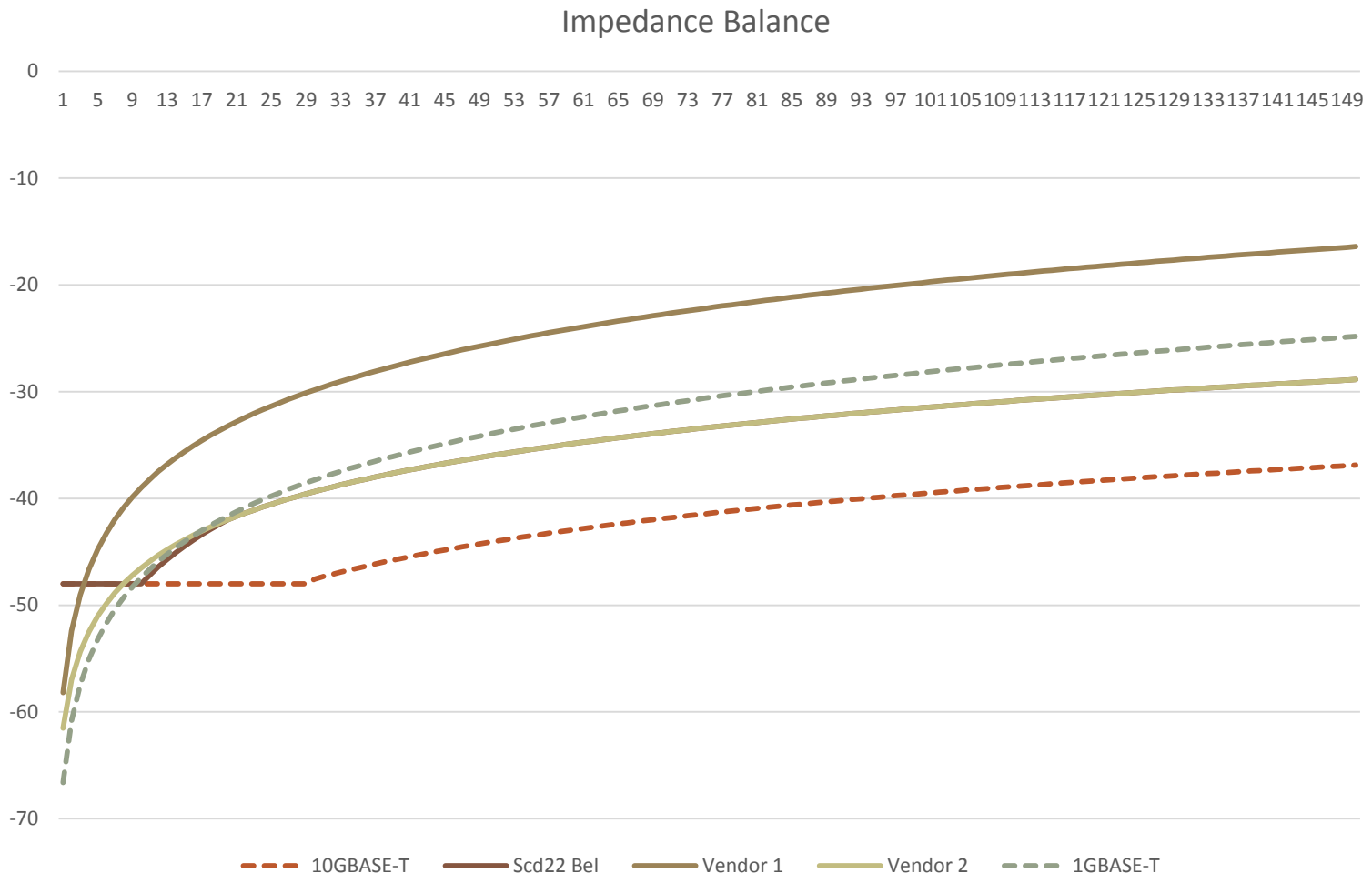
The CMRR test has *implied* minimum mode conversion requirements for the media used in the test setup (Annex 113A)

- The +6 dBm input voltage is similarly derived from immunity test limits (see Cobb_0505).

Poorly balanced cabling can contribute to failing EMC tests.

Prudent system design would seem to dictate that these minimums be compared to the link segment requirements.

MDI Impedance Balance proposals



CMR Test – mode conversions

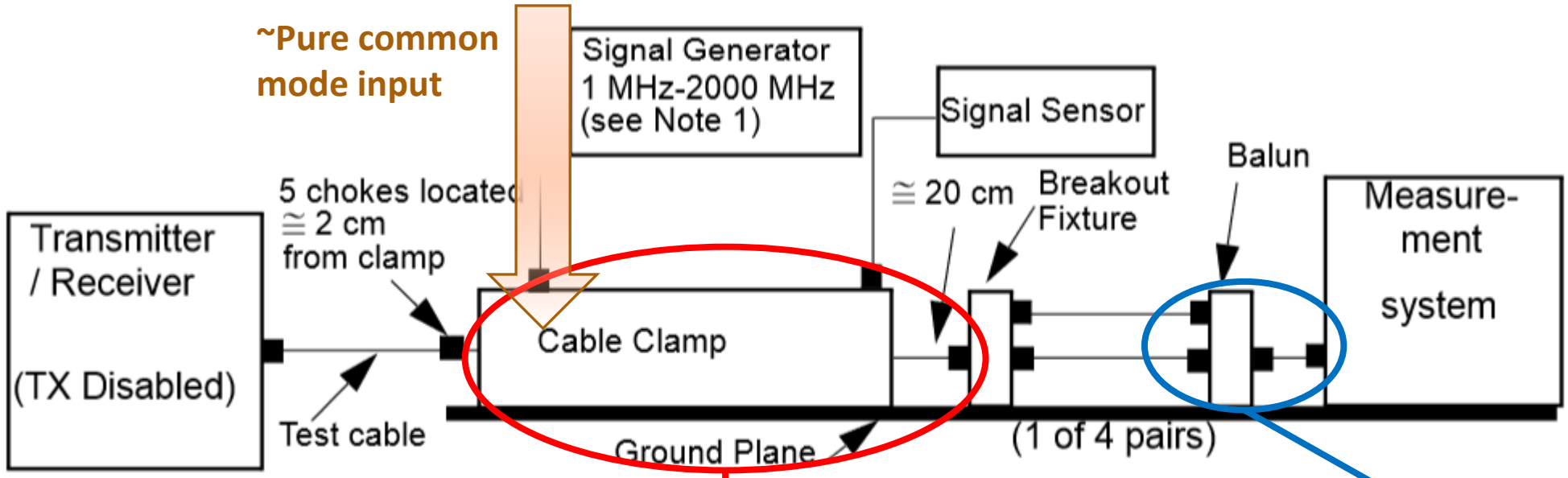


Figure 113A–3—Cable clamp validation test configuration

Some amount of mode conversion occurs here

Some amount of differential mode signal is allowed here

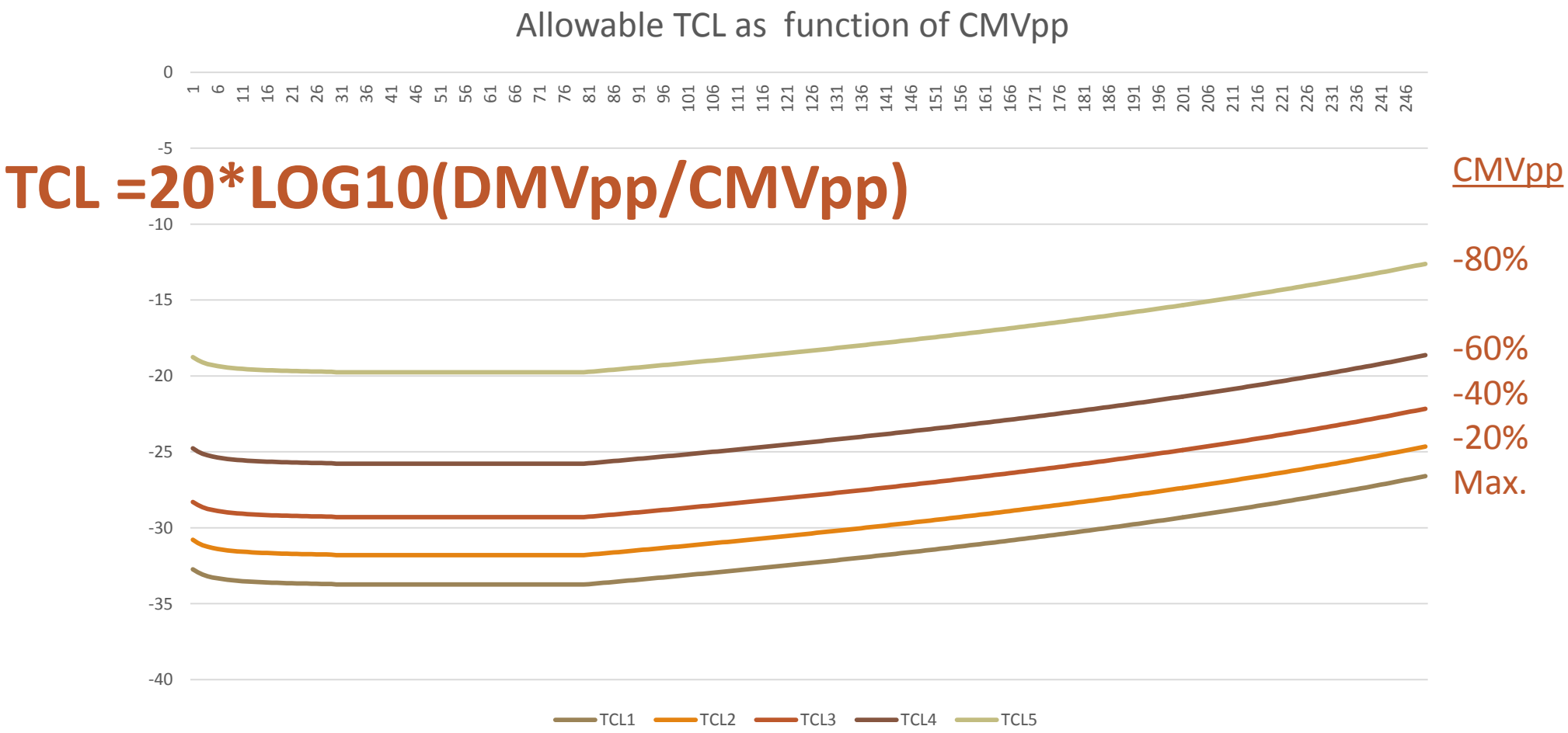
CMR Test – allowable CM/DM voltages

Table 113A–2—Common- and differential-mode output voltages

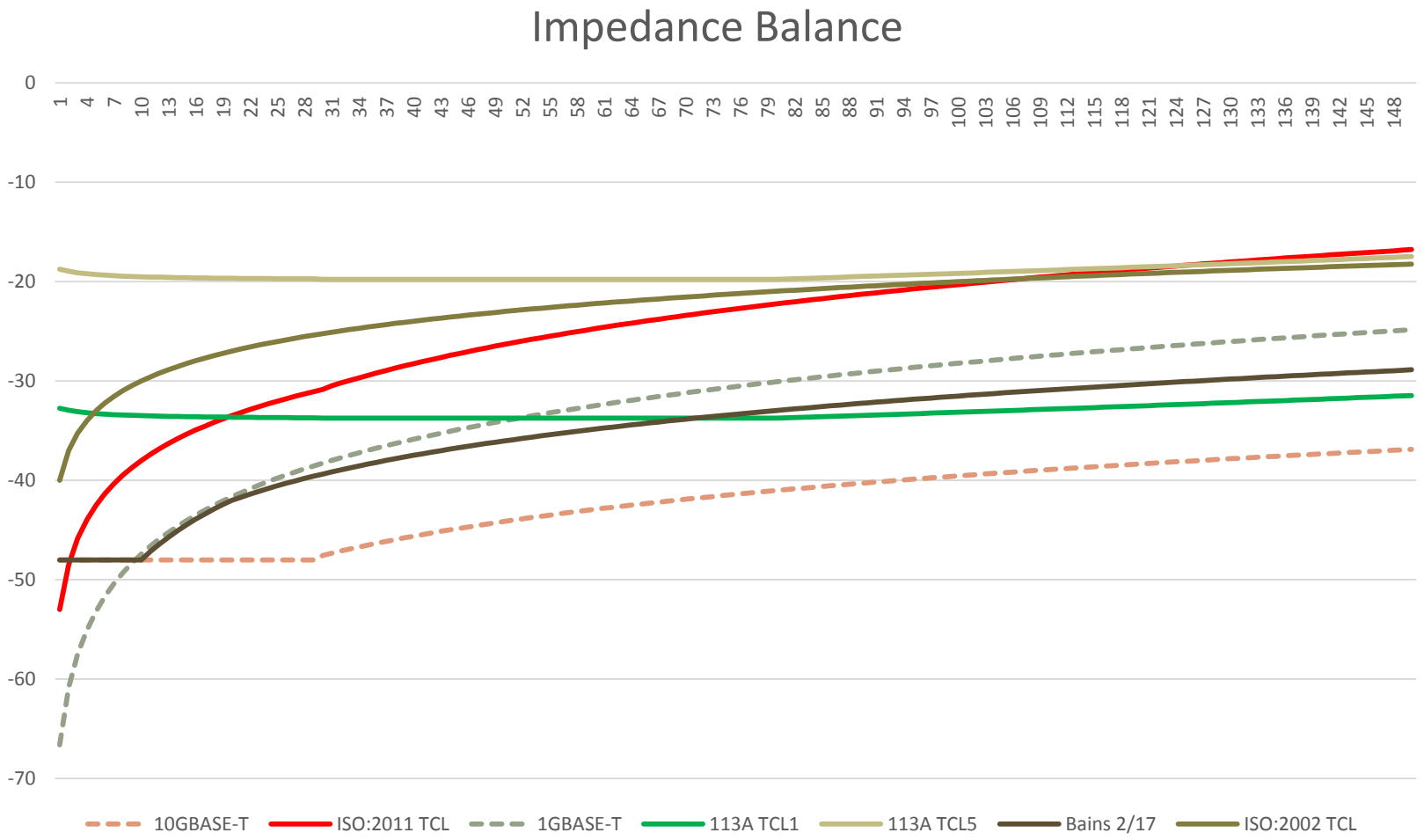
Frequency (f)	Common-mode voltage	Differential-mode voltage
1 MHz - 30 MHz	< 0.1 + 0.97 (f / 30) Vpp	< 2.4 + 19.68 (f / 30) mVpp
30 MHz - 80 MHz	< 1.07 Vpp	< 22 mVpp (-29 dBm)
80 MHz - 250 MHz	< 1.07 - 0.6 (f-80) / 170 Vpp	< 22 mVpp (-29 dBm)
250 MHz - 2000 MHz	< 470mVpp (-2.6 dBm)	< 22 mVpp (-29 dBm)

-20%, -40%, -60%, -80%

CMR Test – *Implied* link segment TCL



Compare Class D channel TCL



Conclusions

We have compared some impedance balance minimums to the link segment requirements for TCL.

There is no desire to throw out, or even challenge, the ISO limits. They are what they are.

It's up to the cabling standards to decide whether any specific guidance for these properties is needed for legacy cabling.

My personal experience: *poorly balanced cabling won't hold a 1Gb/s link, let alone 2.5G or 5G transmission.*

Impedance balance for the link segment should not be ambiguous.

Proposal

Recommended resolution to comment #209 (draft v2.0, 802.3bz):

Insert the following text as a new sub-clause in section 127.7.2 (after Return Loss).

Impedance balance at the near-end of a link segment, or TCL, is defined as the ratio of differential mode power to common mode power on a duplex channel within a link, which is exited with differential mode power only. TCL is also the S parameter measurement of Sdc11 expressed in dB, and measurement of Longitudinal Conversion Loss (LCL) will produce the same values for this application.

The TCL of all unshielded duplex channels shall meet the values determined using Equation (126–N)

$$TCL \geq \{ 53 - 15\log_{10}(f) \qquad 1 \leq f \leq 30 \}$$
$$TCL \geq \{ 60.3 - 20\log_{10}(f) \qquad 30 \leq f \leq 250 \}$$

where f is the frequency in MHz; 1 ≤ f ≤ 100 for 2.5GBASE-T; 1 ≤ f ≤ 250 for 5GBASE-T

Proposal (cont.)

Recommended resolution to comment #209 (draft v2.0, 802.3bz): cont.

Impedance balance at the far-end of a link segment, or TCTL, is defined as the ratio of differential mode power to common mode power on a duplex channel within a link, which is exited with differential mode power only. TCTL is also the S parameter measurement of Sdc12 expressed in dB, and measurement of Longitudinal Conversion Transfer Loss (LCTL) will produce the same values for this application. The ELTCTL value (Equal Level TCTL) is obtained by subtracting insertion loss from the TCTL values.

The ELTCTL of all unshielded duplex channels shall meet the values determined using Equation (126–N).

$$ELTCTL \geq \{ 30 - 20\log_{10}(f) \quad 1 \leq f \leq 30 \}$$

where f is the frequency in MHz; 1 ≤ f ≤ 100 for 2.5GBASE-T; 1 ≤ f ≤ 250 for 5GBASE-T