ANALOG DEVICES

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Channel Resistance Breakdown

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Introduction

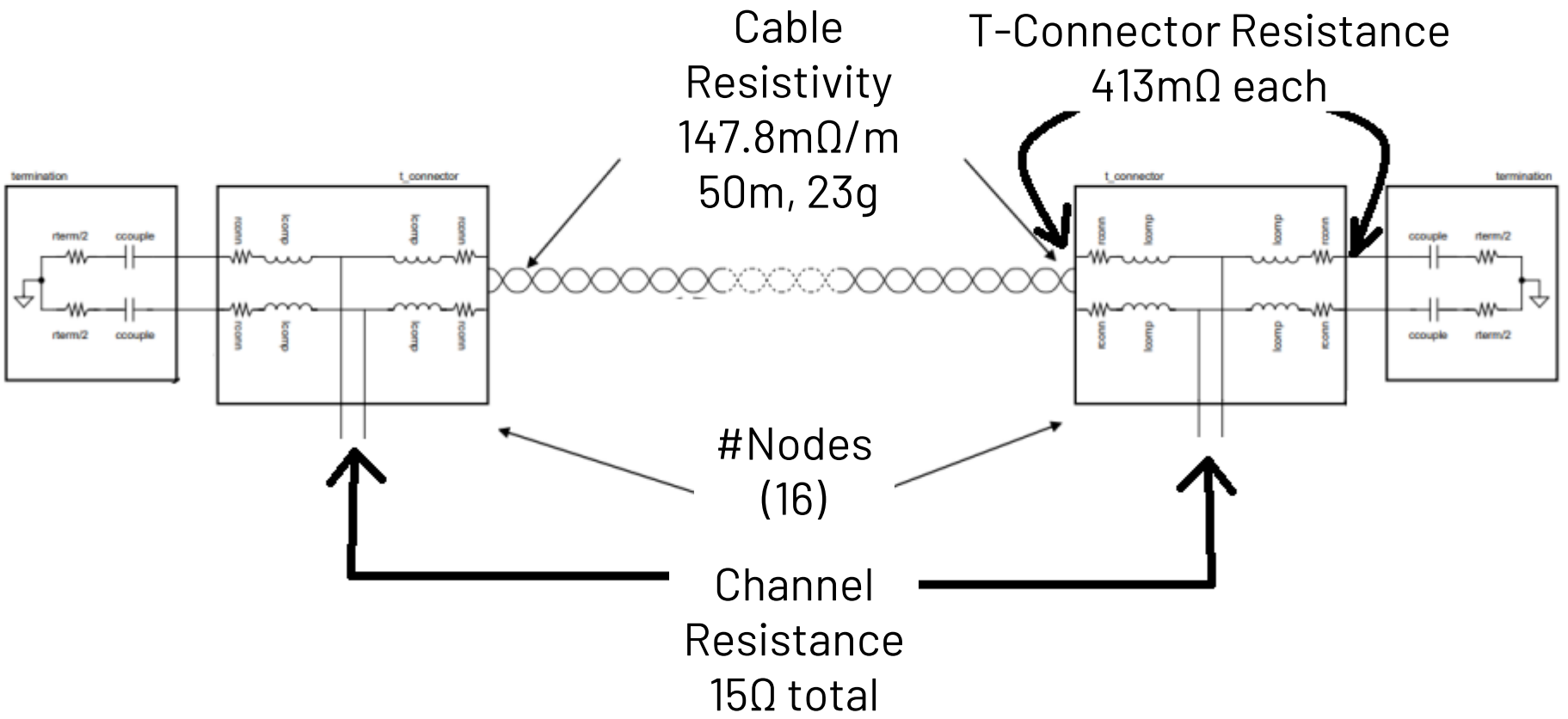
- My goal is to write MPD inrush baseline text
  - Several critical parameter remain undefined and must be addressed
- This presentation is broken into 3 parts
  1. Channel Resistance Breakdown (this presentation)
  2. Voltage Stack-up (https://www.ieee802.org/3/da/public/0827/Paul_da_02_20230830.pdf)
  3. MPD Inrush / Power-On Baseline Text (https://www.ieee802.org/3/da/public/0827/Paul_da_03_20230830.pdf)

Clause 169 Development

- Characteristics that drive forward-looking concepts and details:
  - Number of nodes (16)
  - **Mixing Segment Loop Resistance (15Ω)**
    - Cable Gauge (23g)
    - Channel length (50m)
    - Connector resistance (58mΩ)
    - Compensation component resistance (355mΩ)

- Then choose:
  - MPSE minimum power on voltage
- Which determines:
  - Available power per node
- To Enable Specification of:
  - Voltage Stack-Up / Operating thresholds
    - Reset, Discovery, Type 0, Type 1
  - And enable Objective 11
    - Addition / Removal from powered mixing segment
- Author Clause 169:
  - Inrush attributes
  - Power on attributes
  - Discovery time, voltage, current attributes
  - Maintain Power Signature (MPS) attributes

Diagram of Channel Resistance Components



23g Cable Resistivity

- 23g cable measurements (IEEE802.3 Appendix 145C)
  - 74.4mΩ/m (2-pair resistance, cat cable, loop)
  - 148.8mΩ/m (Single twisted-pair, loop)
  - **50 meters * 148.8mΩ/m = 8.78Ω**

Temp. (°C)	23g Cable Resistivity (mΩ / m)
20	148.8
65	**175.6**

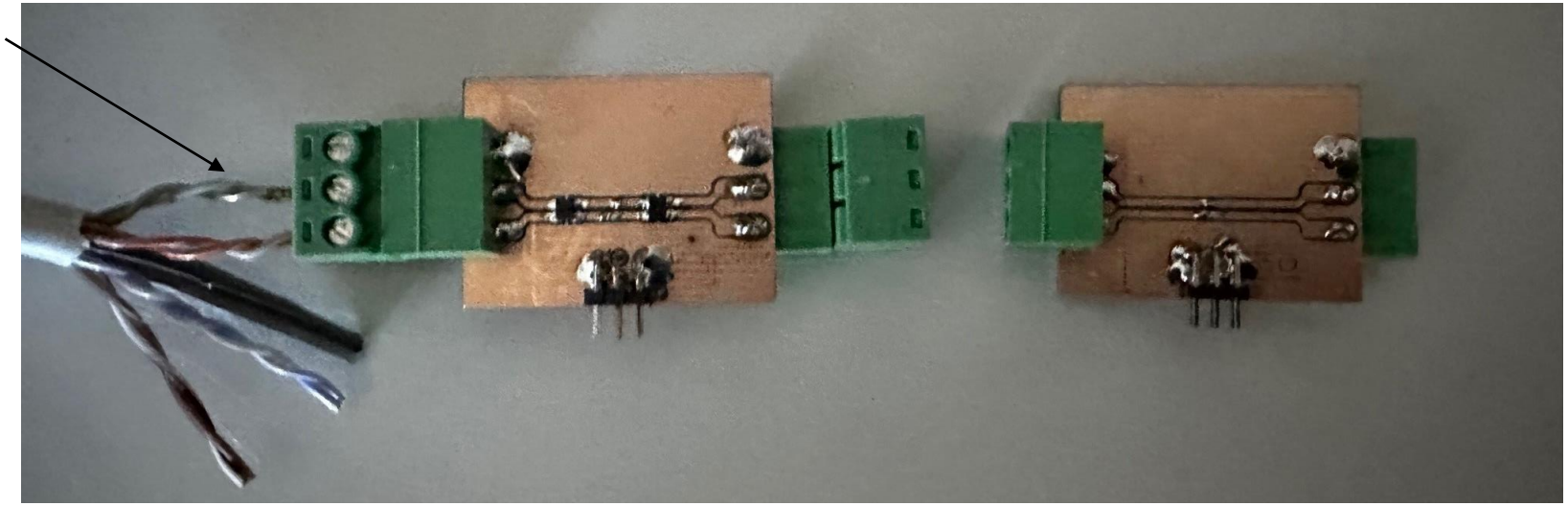
T-Connectors Resistance Measurement Setup

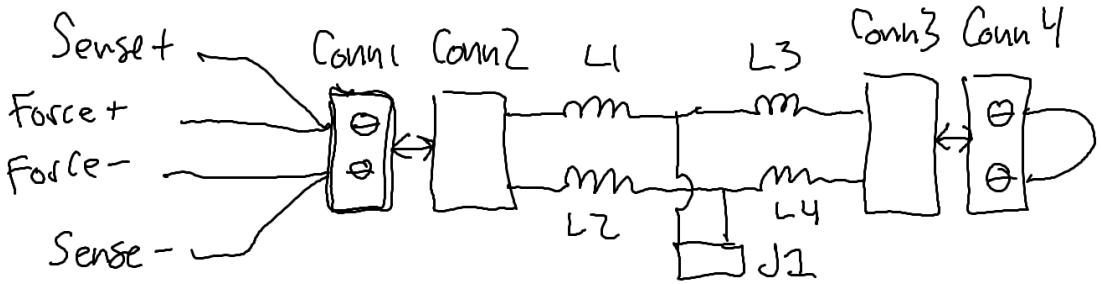
Compensated

Uncompensated

(Coilcraft 8085-LS78N)

4-wire Resistance Measurement

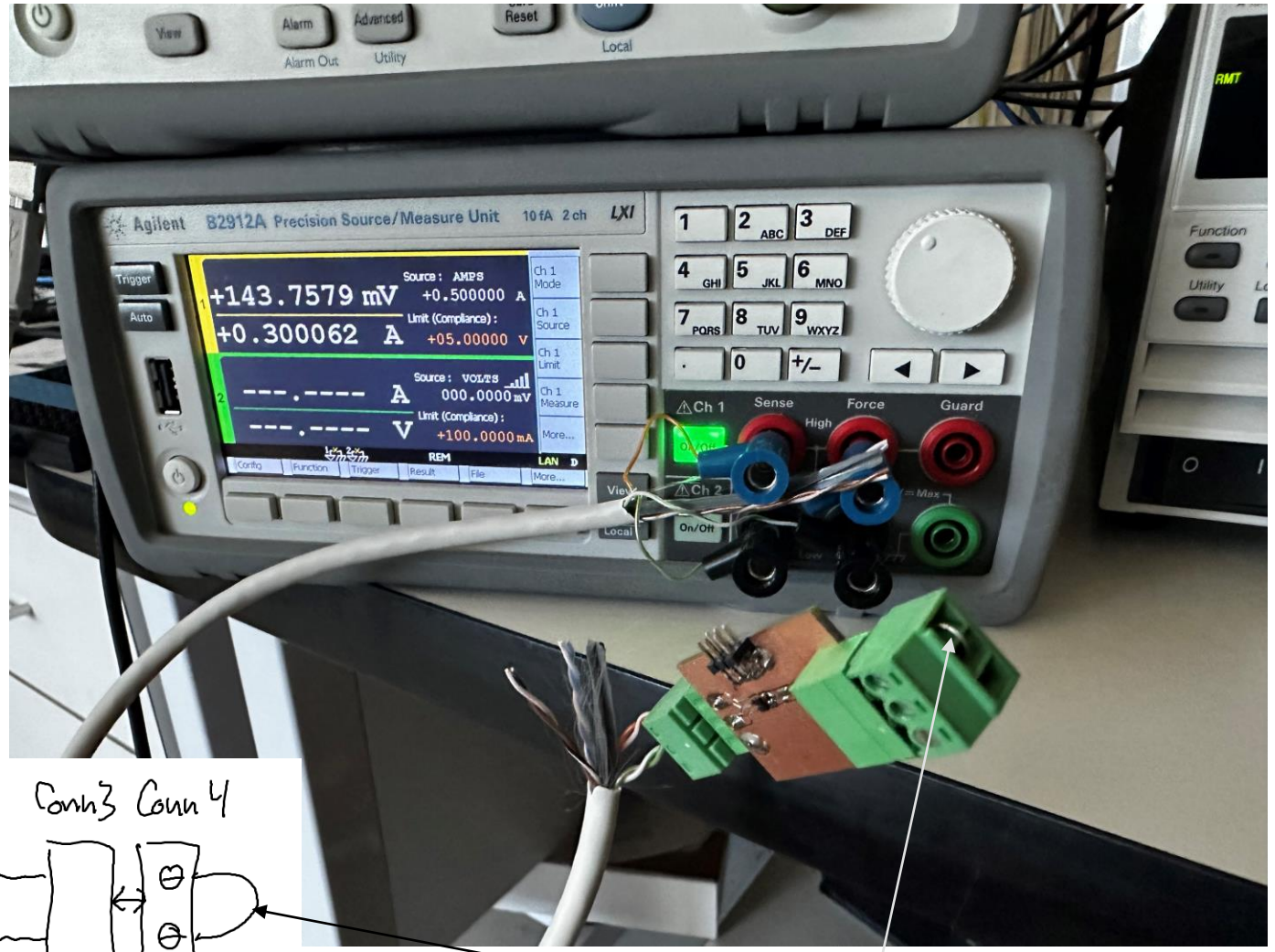


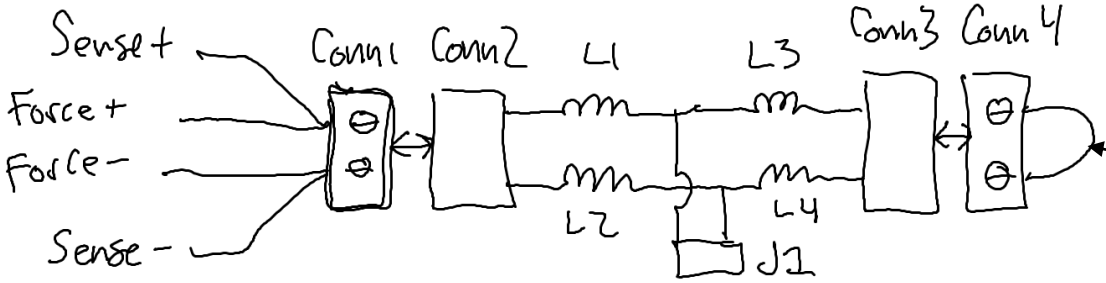


Same T-Connectors used for AC Correlation in this presentation:
https://www.ieee802.org/3/da/public/0523/Paul_da_01_05152023_v0.pdf

4-Wire Resistance Measurement Setup

- Measurement Procedure
  - Force Current
    - Terminals:
      - Force+, Force-
    - 100mA to 1A
      - 100mA steps
  - Measure Voltage
    - Terminals:
      - Sense+, Sense-
  - Curve fit slope
    - Extract Resistance





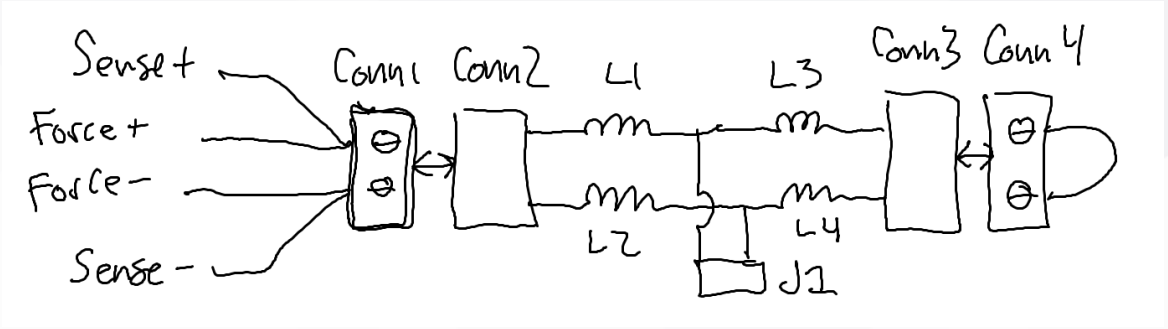
Measured Resistance

Temperature	Compensated	Uncompensated
Room (22C)	330mΩ	47mΩ
85C*	413mΩ	58mΩ

*calculated, assuming all resistance is from copper

(tempco = 0.4%/degC)

Temperature	Connectors sum(R_{Conn1}:R_{Conn4})	Compensators Sum(R_{L1}:R_{L4})
85C*	58mΩ	355mΩ



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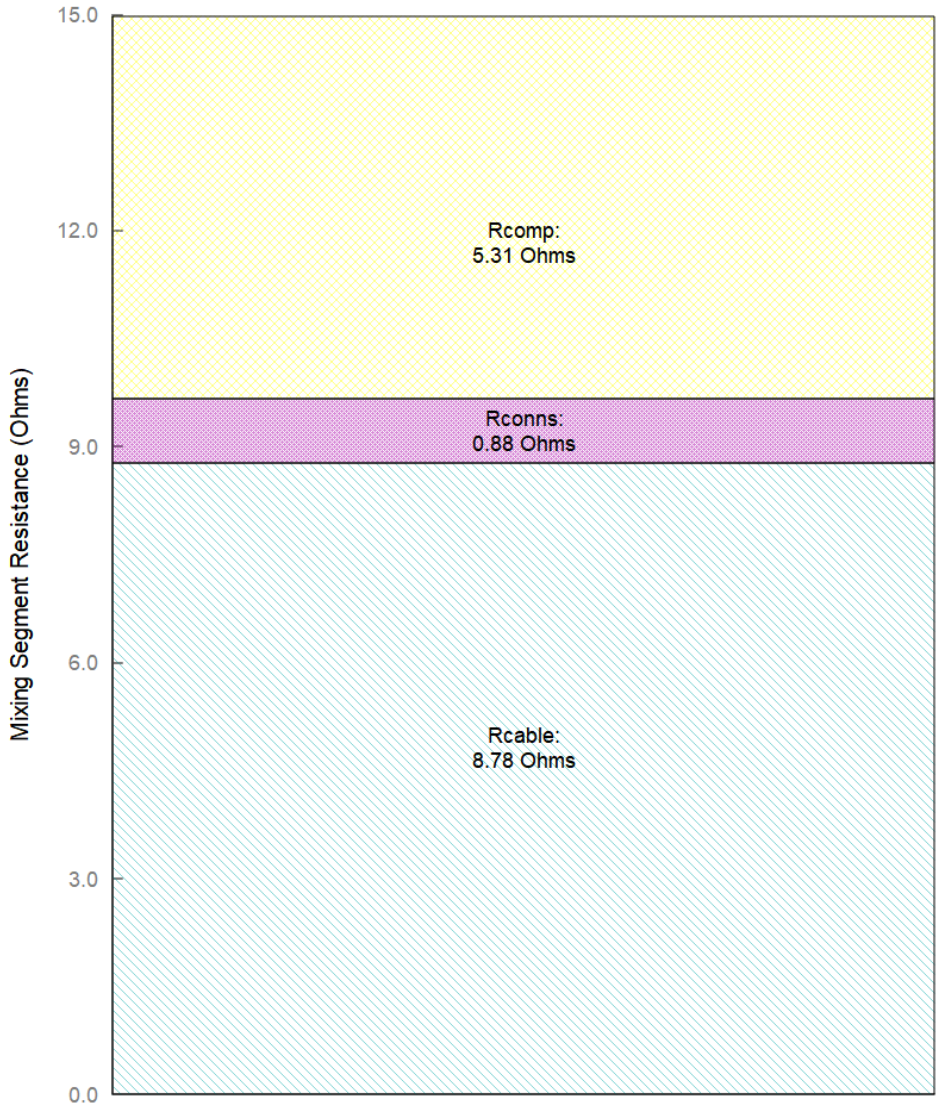
Channel Resistance Stack-Up

Channel Resistance Stack-Up

- **16 nodes, 50 meters total**
  - **23g cable**
  - **65C cable temperature**
  - **85C node (connector) temperature**
- 15 Cable sections (23g @ 65C)
  - Rcable = 50meters * 175.6mΩ = 8.78Ω
- 15 T-Connectors worth of resistance (@ 85C)
  - TC1 of connector 1 carries no current
  - TC2 of connector 16 carries no current
  - Rconns = 15 * 58mΩ = 880mΩ
  - Rcomp = 15 * 335mΩ = 5.31Ω
- Rchan,max = 15Ω
  - Rcable + Rconns + Rcomp = 14.98Ω

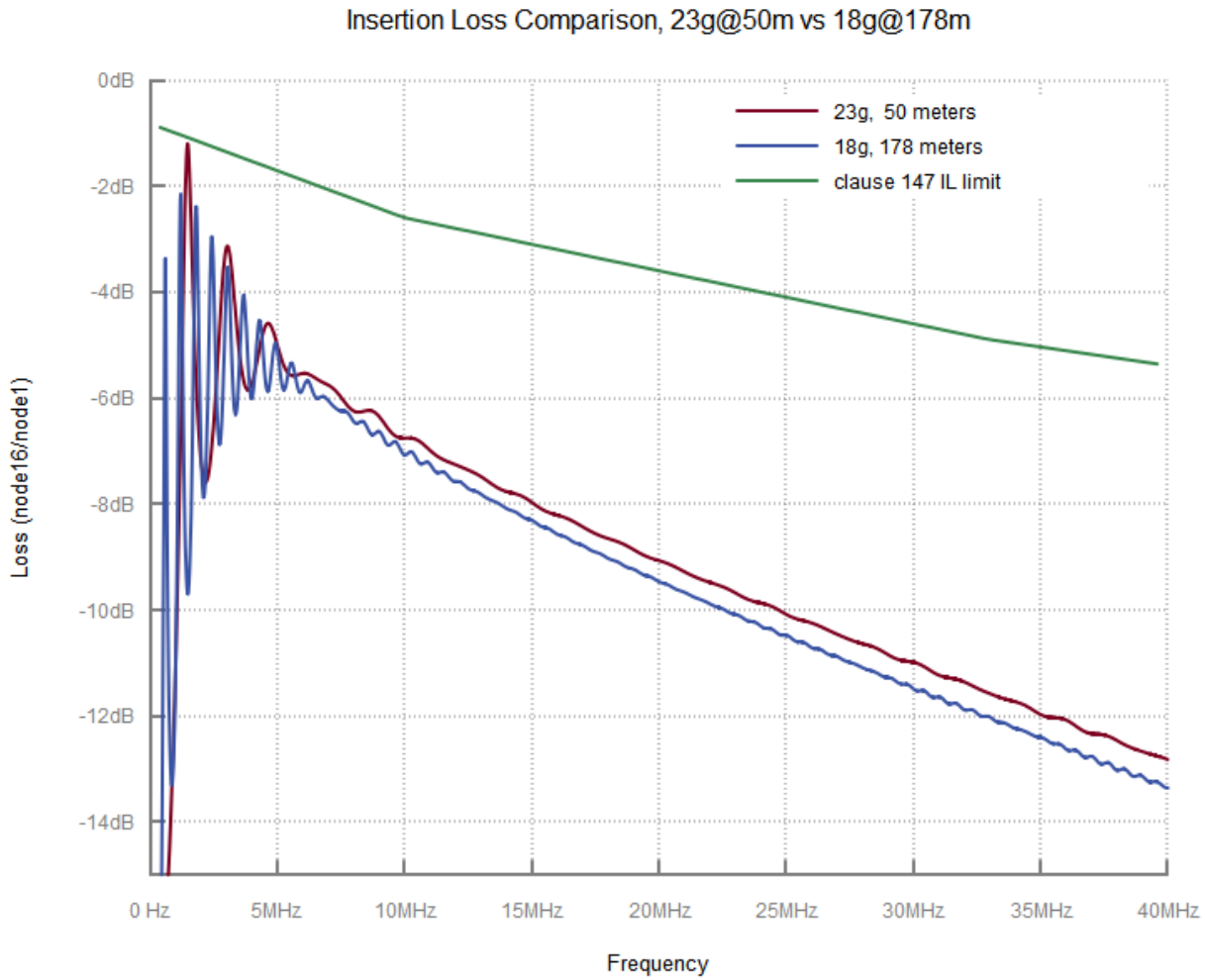


Mixing Segment, Gauge / Resistance / Length

Gauge	Resistivity @ 65C (mΩ / m)	Length (8.78Ω)
24	221.4	39.6
23	**175.6**	**50.0**
22	139.2	63.1
20	75.6	111
18	41.8	178

- If cable gauge changes, change system length
- Channel Resistance calculated for 16 nodes w/ cable and t-connectors
  - 8.78Ω allocated to total cable resistance (15-segments)
- Connector Resistance Remains Constant
  - Maximum 413mΩ / Node between TC1 and TC2
  - 6.2Ω total allocated to T-Connectors

Signal Attenuation vs. Gauge and Length



Gauge	Length	Node 16 RX Delay
23g	50m	340ns
18g	178m	829ns

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Thank You