Link Segment Considerations Industrial Applications IEEE 802.3 10 Mb/s Single Twisted Pair Ethernet Study Group

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- Mike Klempa – UNH-IOL

Purpose

- **Scope**
  - **Link Segment Considerations for Industrial Applications**

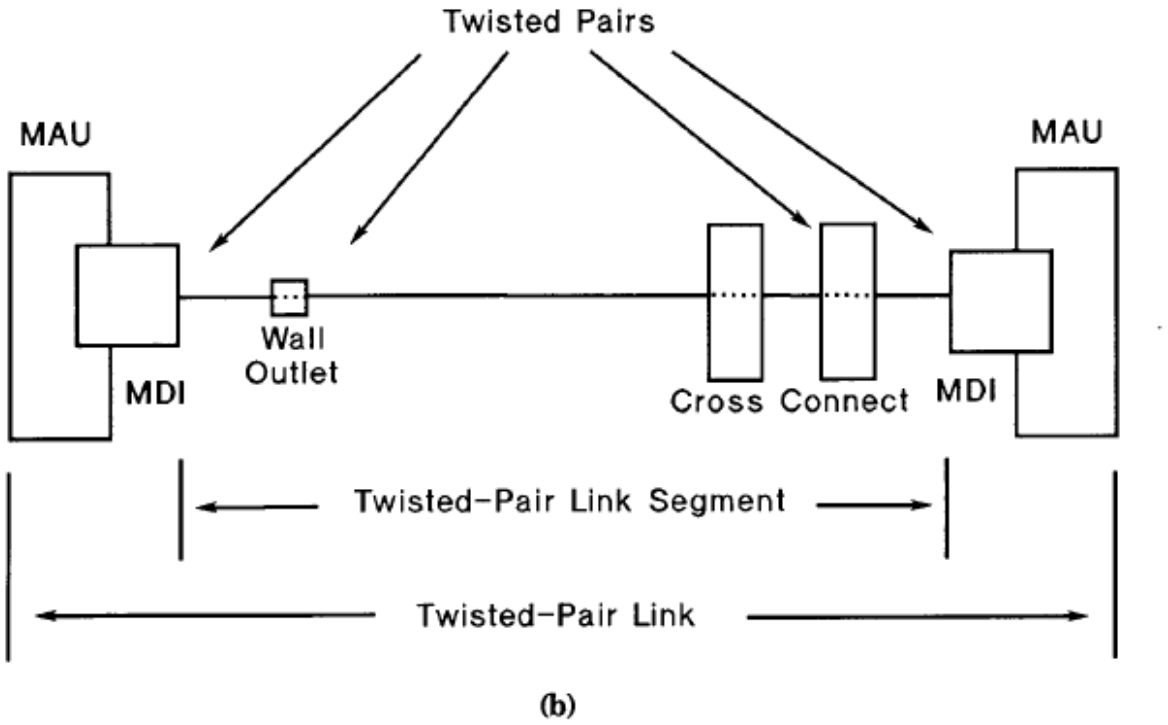
- **Rationale**
  - **Link segment characteristics enables considerations for PHY (e.g., signaling)**
  - **Required for baseline**

- **Link Segment**
  - **Developed in conjunction with the Industrial networking industries**

Link Segment

1.4.242 link segment: The point-to-point full-duplex medium connection between two and only two Medium Dependent Interfaces (MDIs).

- **10BASE-T**



(b)

Figure 14–2—Twisted-pair link

Cabling Measurements

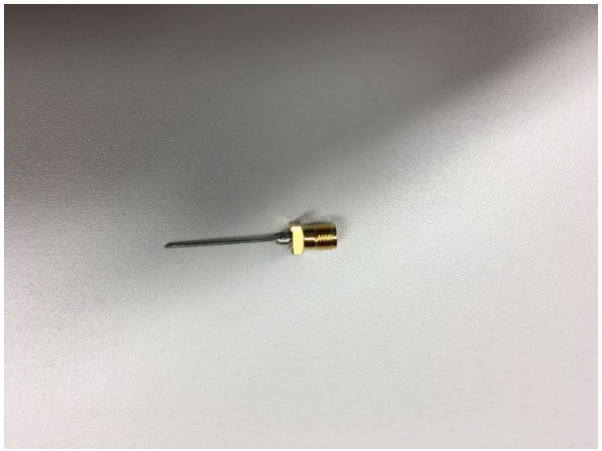
•Lab Measurements

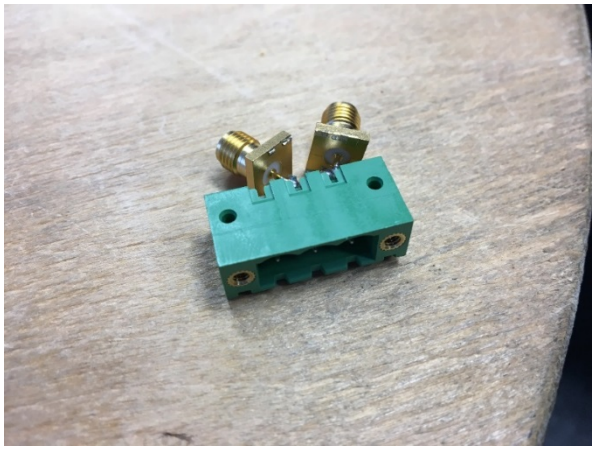
Cable Name	Cable Measurement	AWG	Length/m
Cable1	1000m Multicore 10x 100m AWG18_7 Spring Clamps	18/7	1000
Cable2	1032m Cable Reel *1x2x1_AWG18_solid	18/1	1032
Cable3	148m 1x2x1 AB	18(bell wire)	148
Cable4	198m AWG14_7 AB	14/7	198
Cable5	480m Cable Reel 4x 120m AWG18_1	18/1	480
Cable6	764m AWG16_7 ABCDEFG	16/7	764
Cable7	98m AWG16_7 A	16/7	98
Cable8	99m AWG16_7 B	16/7	99
Cable9	99m AWG16_7 C	16/7	99

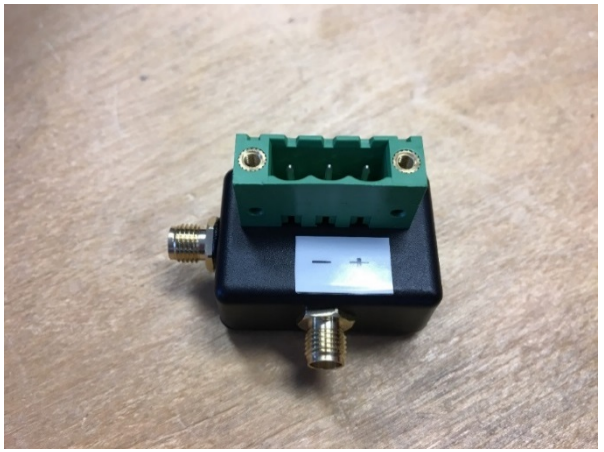
*1x2x1
1: Single Bus (not Multicore Cable)
2: 2 wires (red: plus; green: minus)
1: wire diameter of 1 mm (1,024 mm = AWG18)

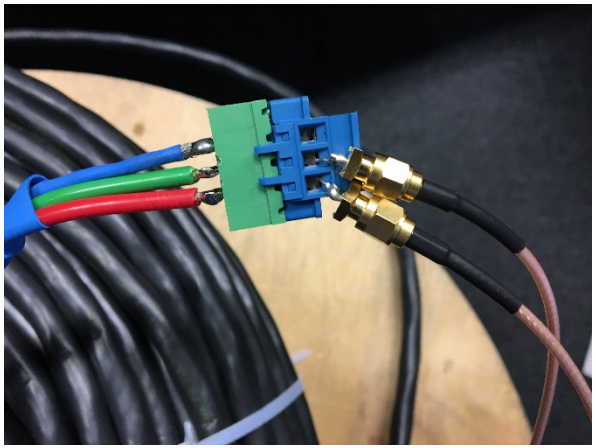
•Field Measurements – Chemical Plant

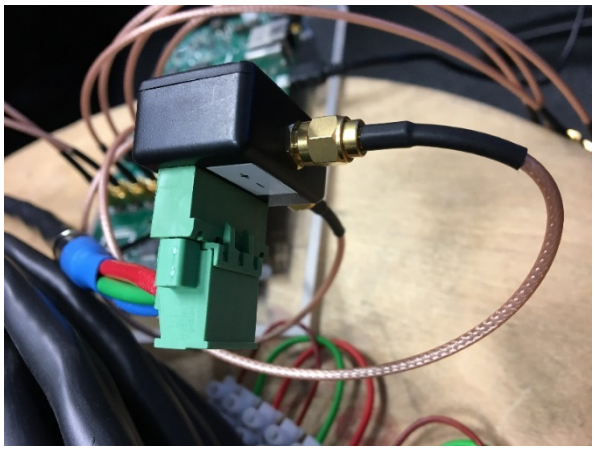
Cabling Connections

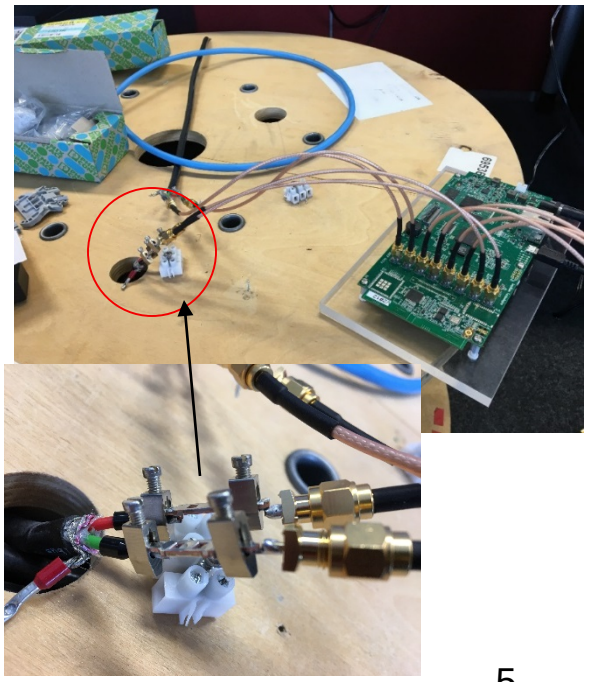




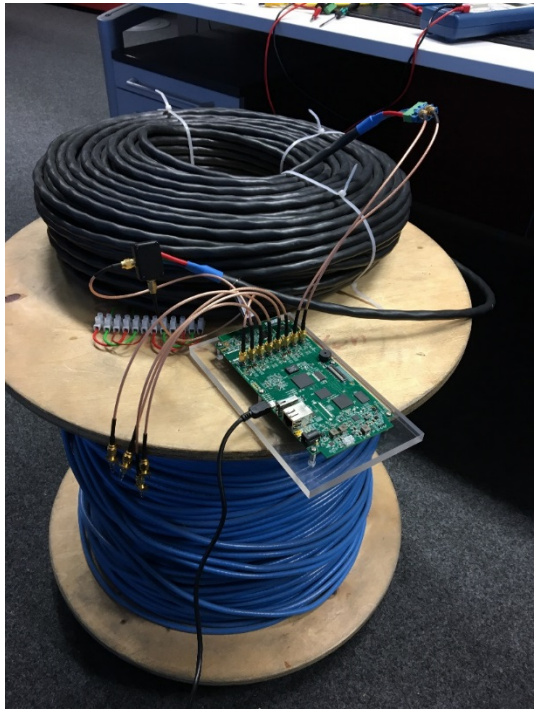


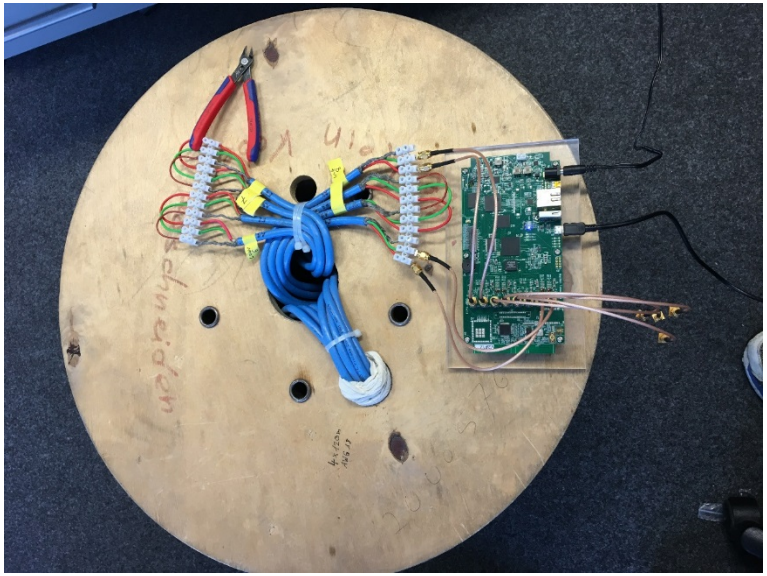


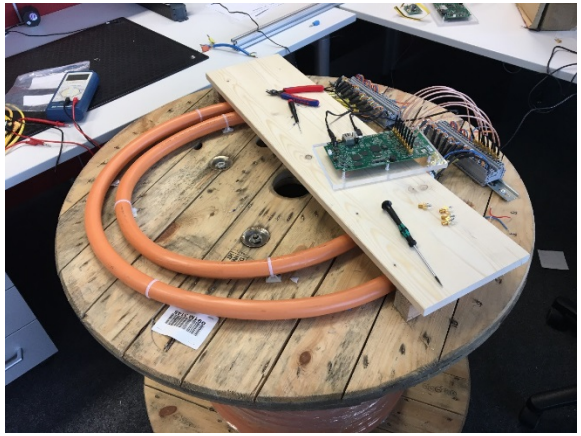


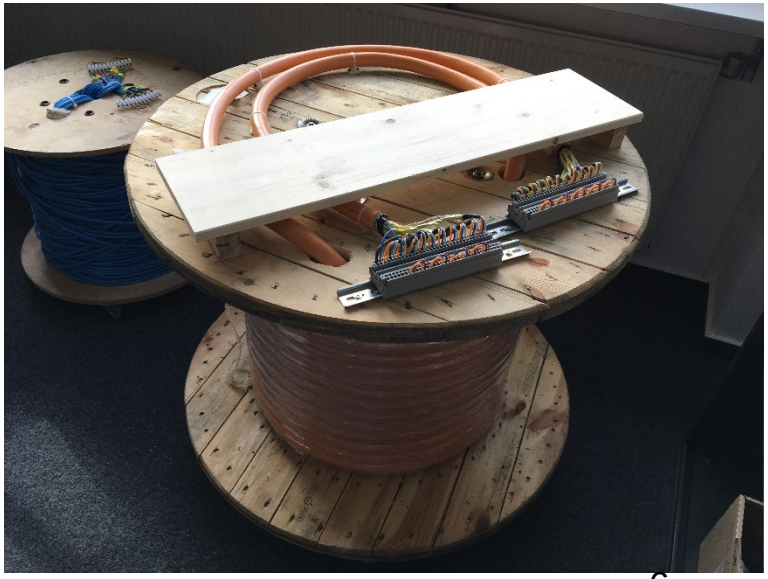


Cabling Configurations

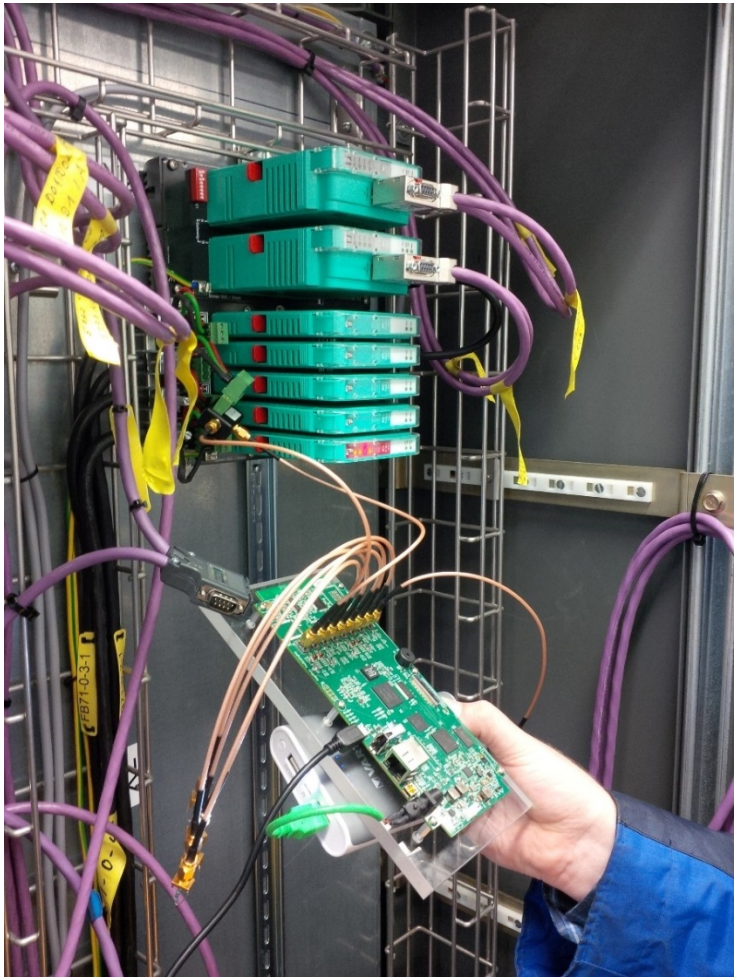








Field Measurements



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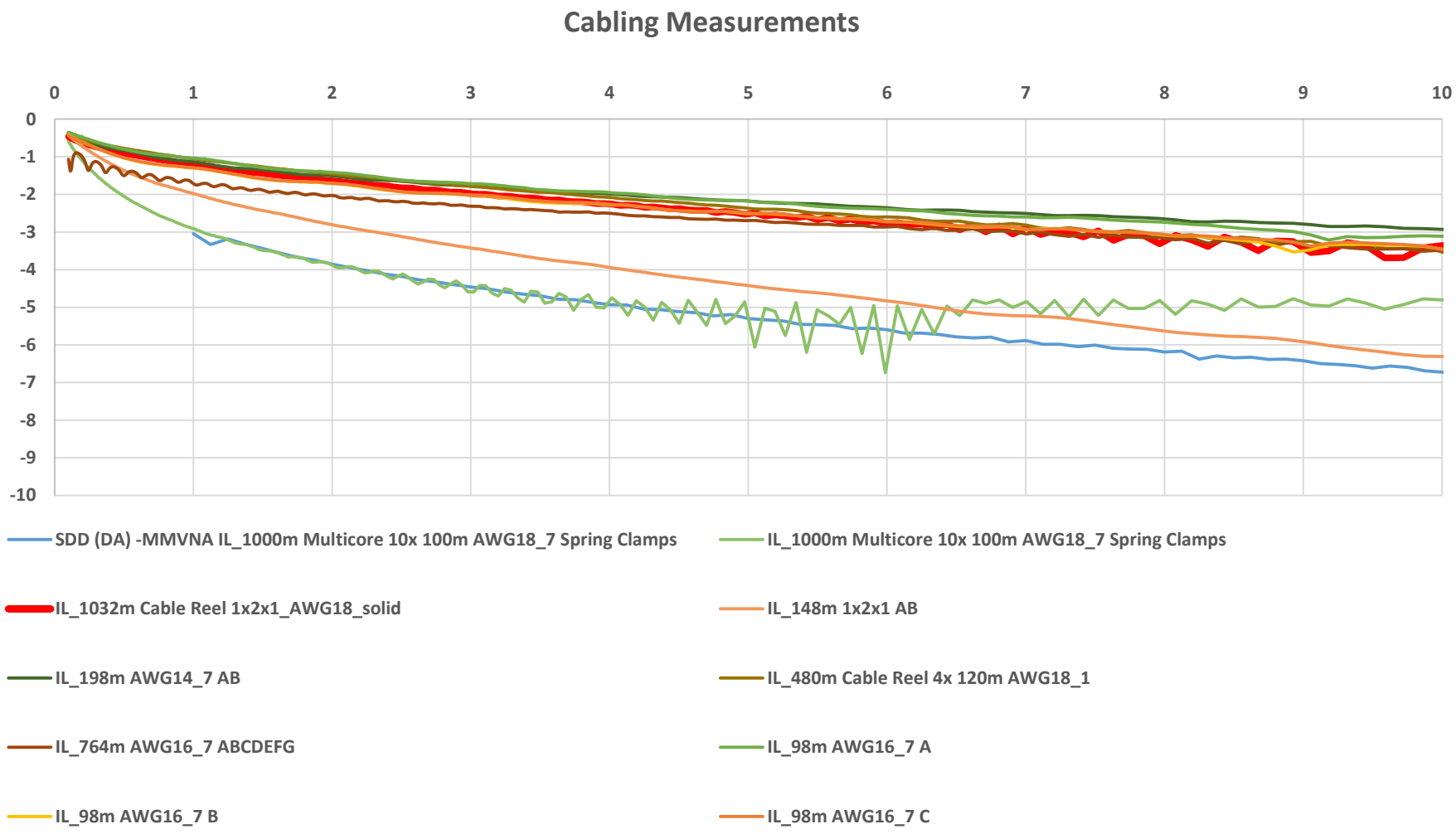
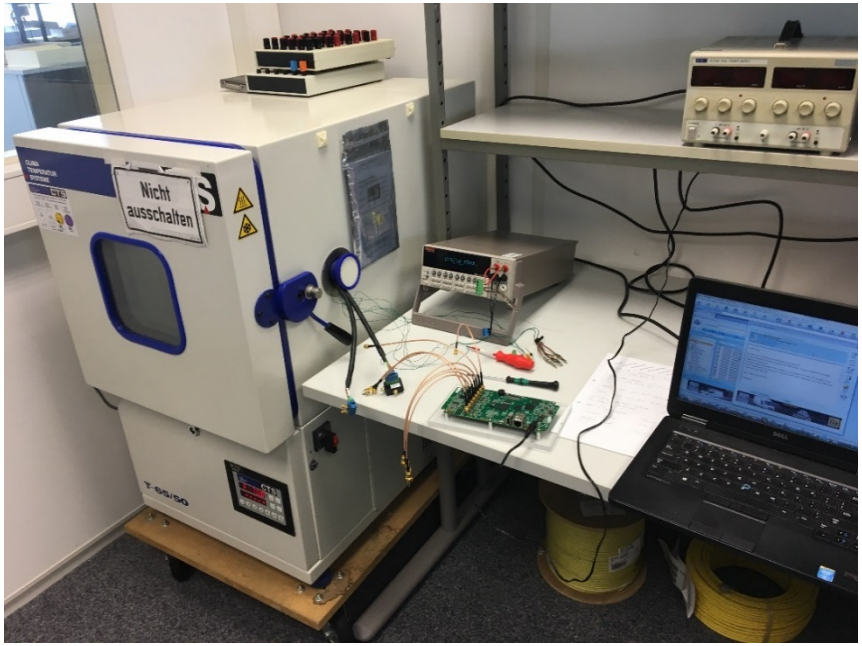
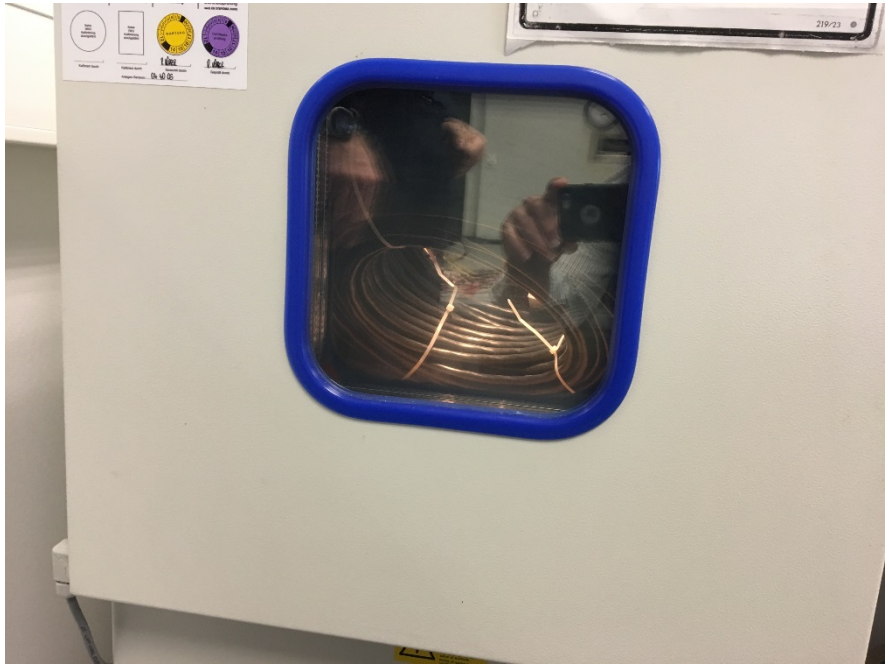
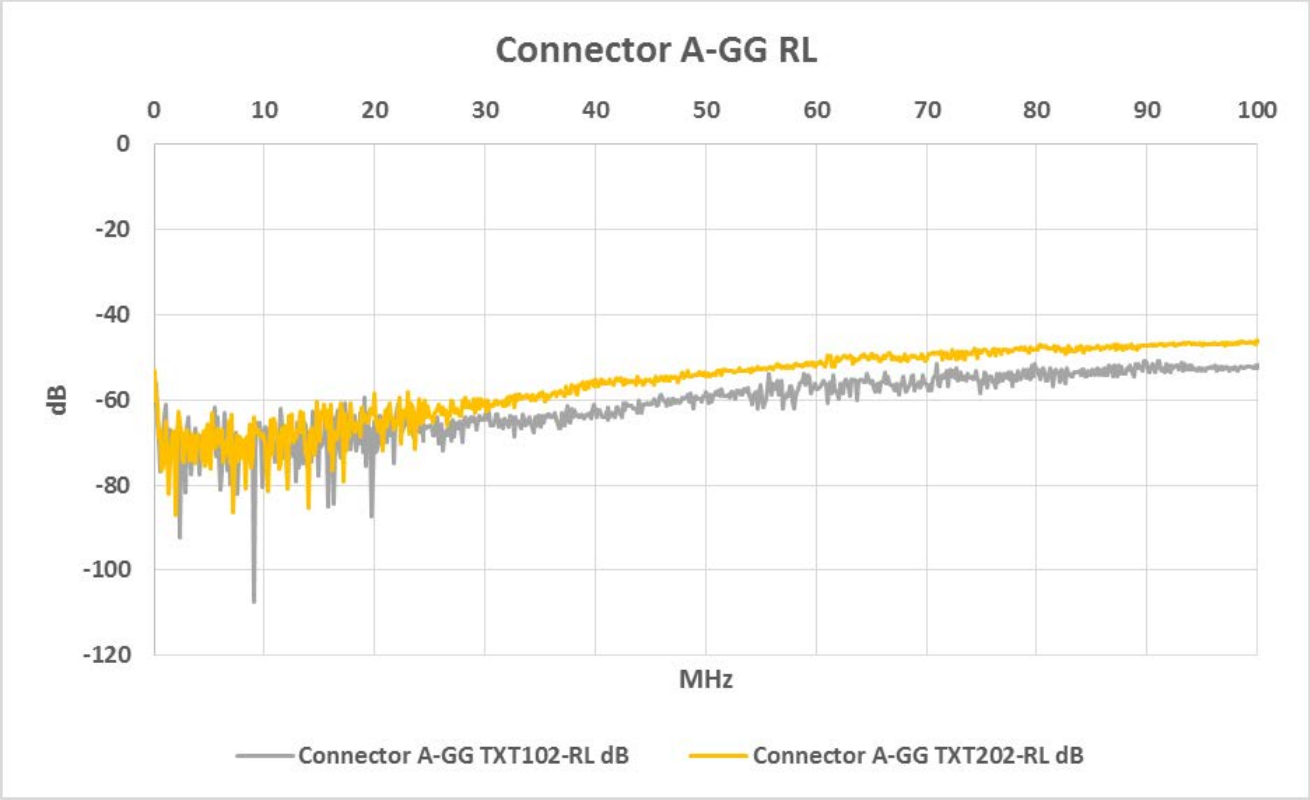


Temperature Dependencies

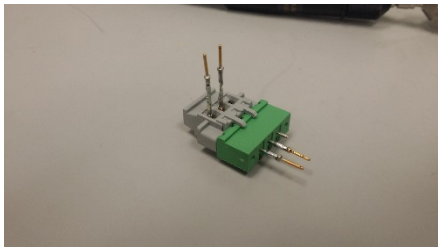




Connector Measurements



IL < 0.02 dB
100 KHz ≤ f ≤ 10 MHz



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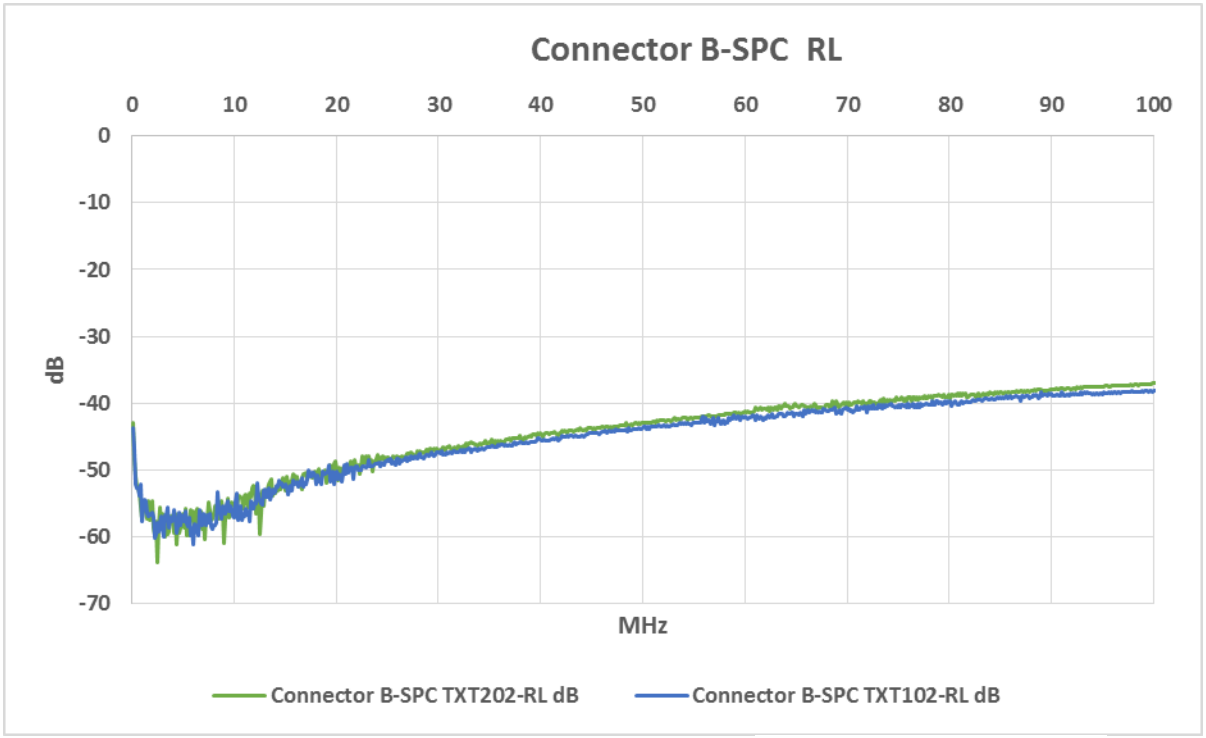

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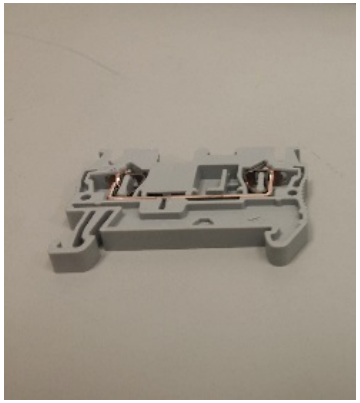

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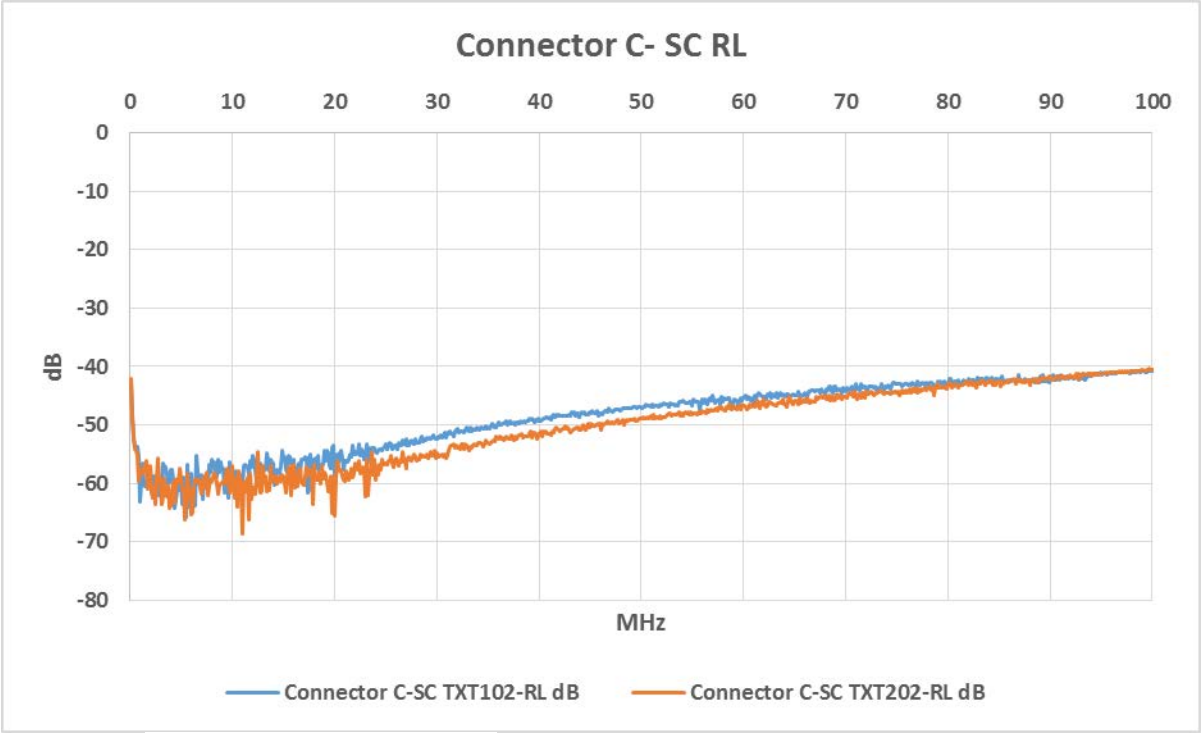

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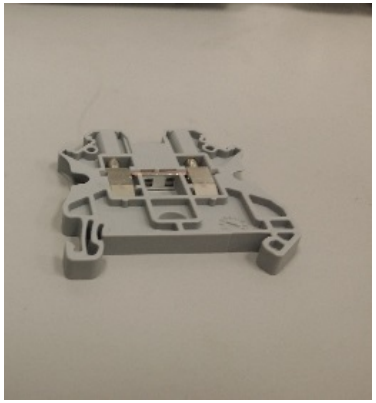
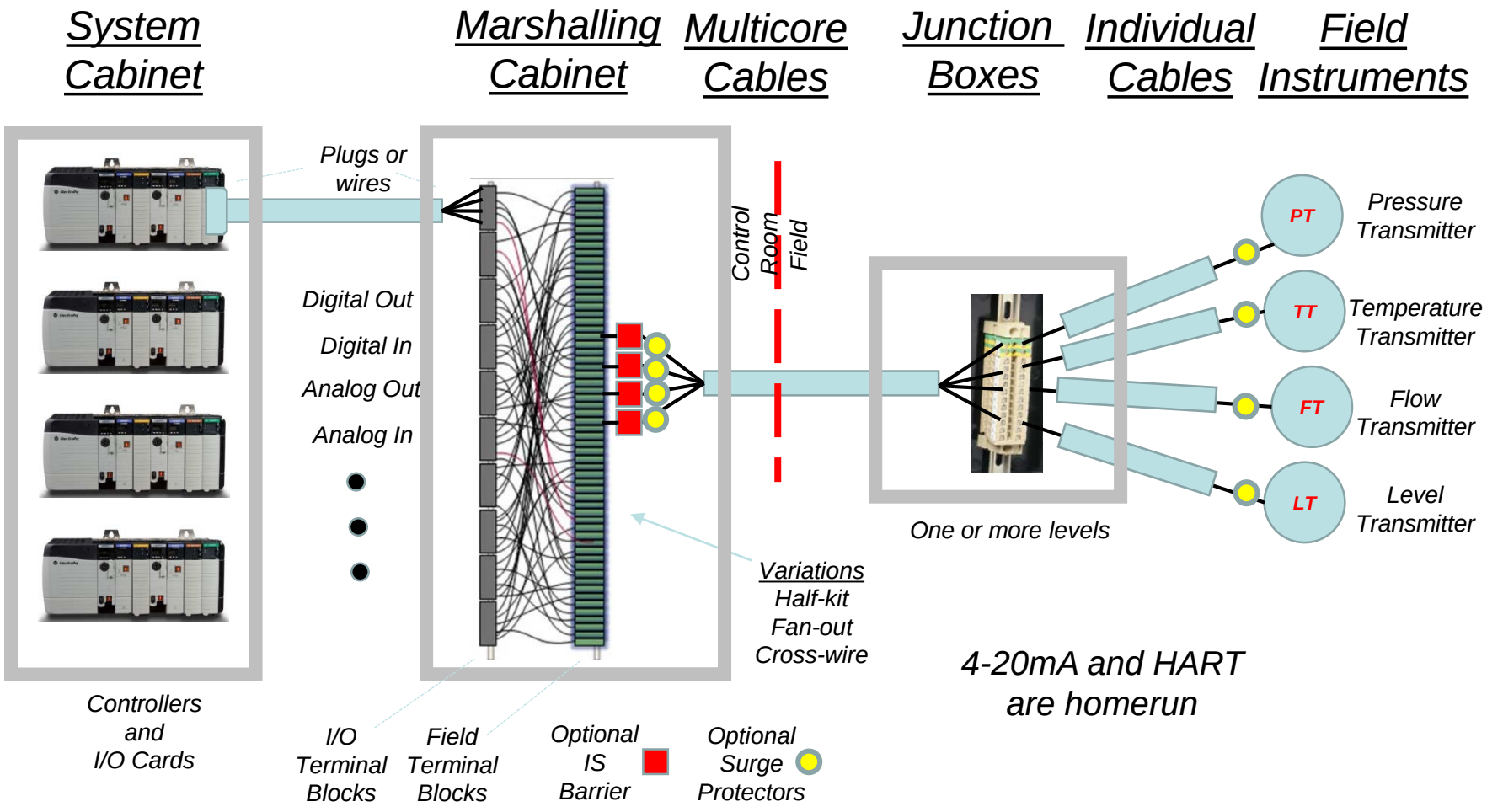


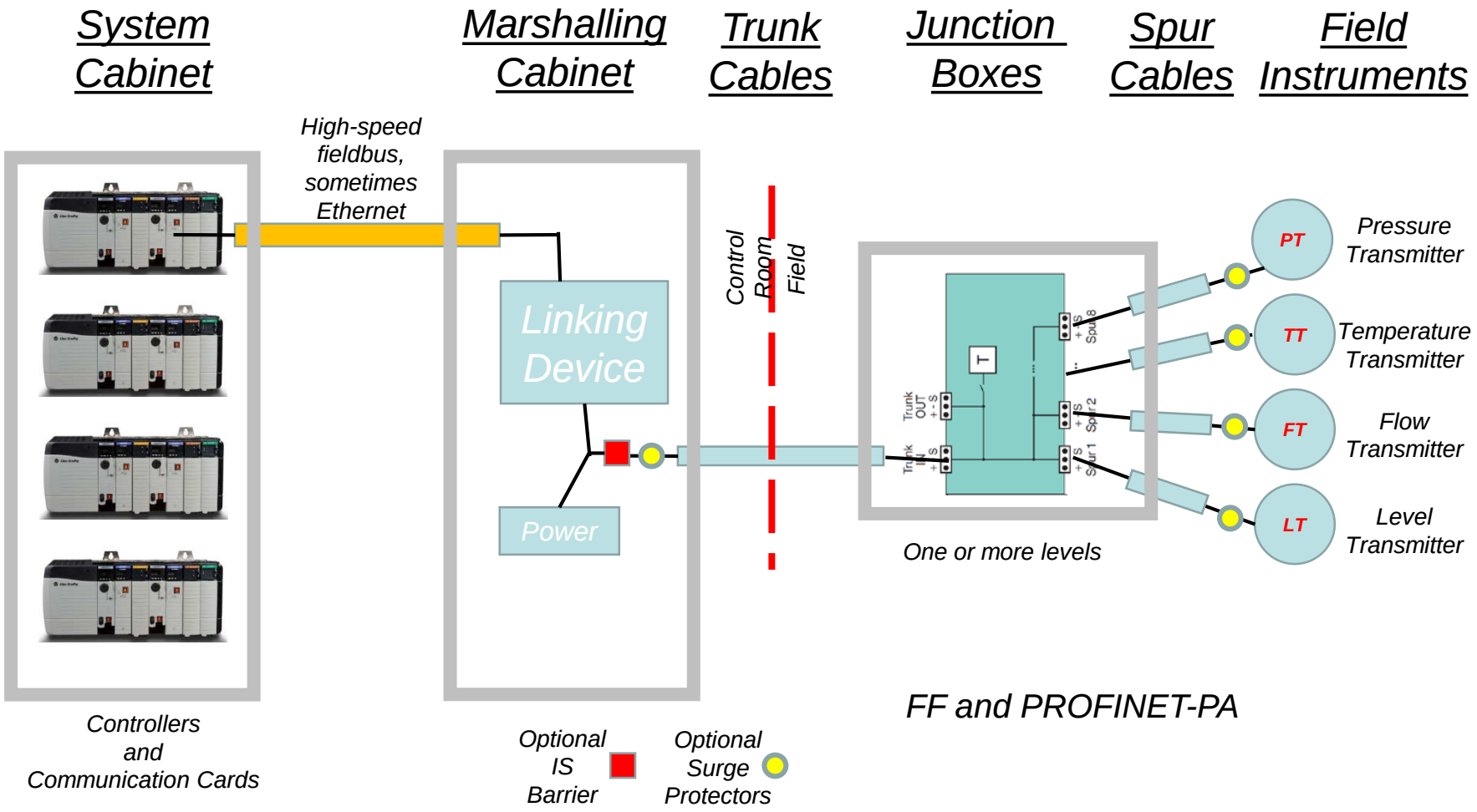
Process Automation wiring practice

- Two main styles
  - Homerun wiring
  - Fieldbus wiring
- Examples are shown on the following 2 diagrams, but there are MANY variations
- Much of the channel complexity will be removed by substitution of Ethernet switches
- Articles
  - http://ongengineering.blogspot.com/2013/03/typical-architecture-of-instrumentation.html
  - http://ongengineering.blogspot.com/2013/03/marshalling-cabinet-or-marshalling-panel.html
  - http://www.controleng.com/single-article/new-approaches-for-remote-io-installations/1d046b190ef45fa5aebce467f0017549.html

Process Automation “homerun” wiring practice



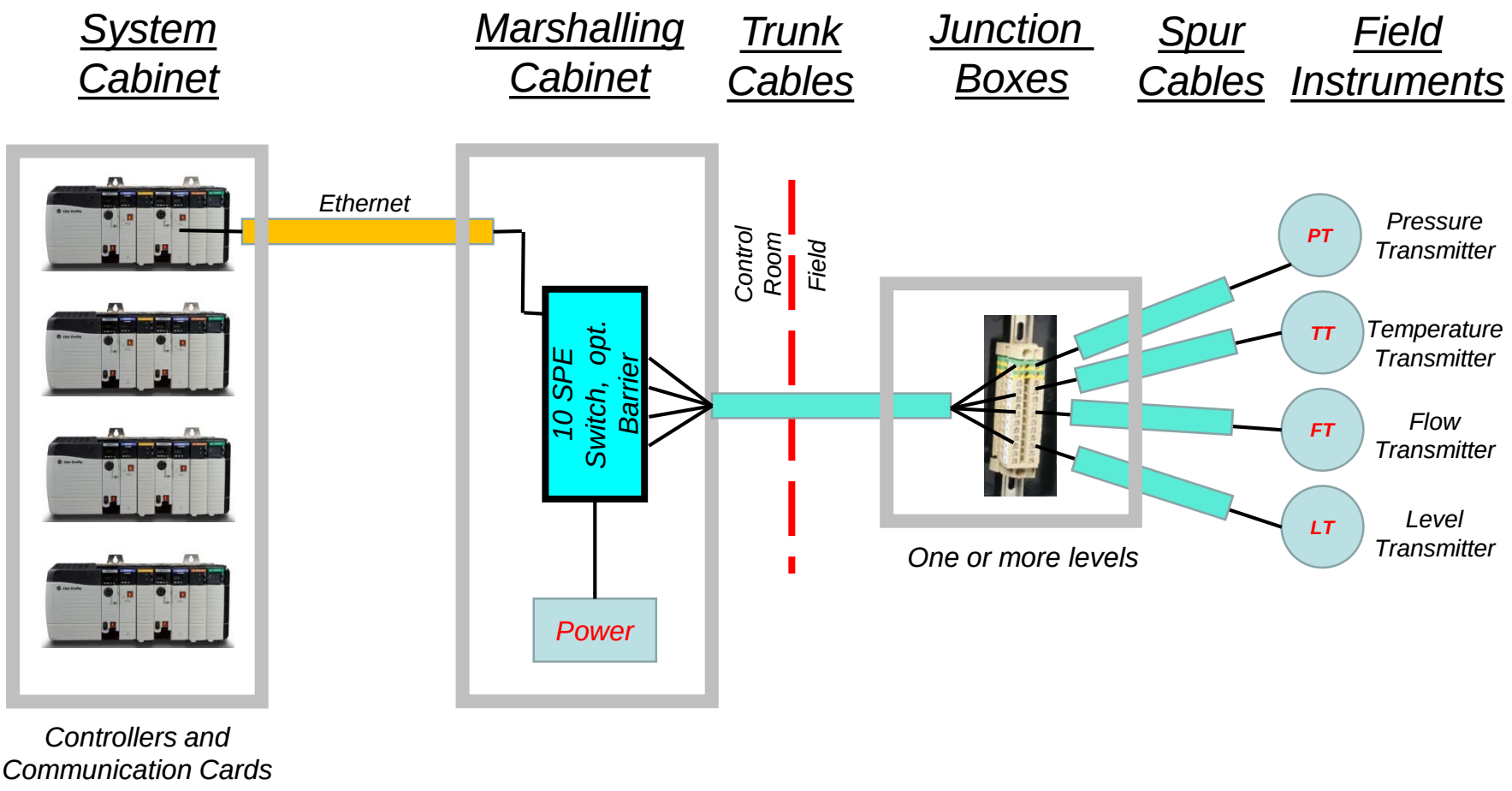
Process Automation “fieldbus” wiring practice



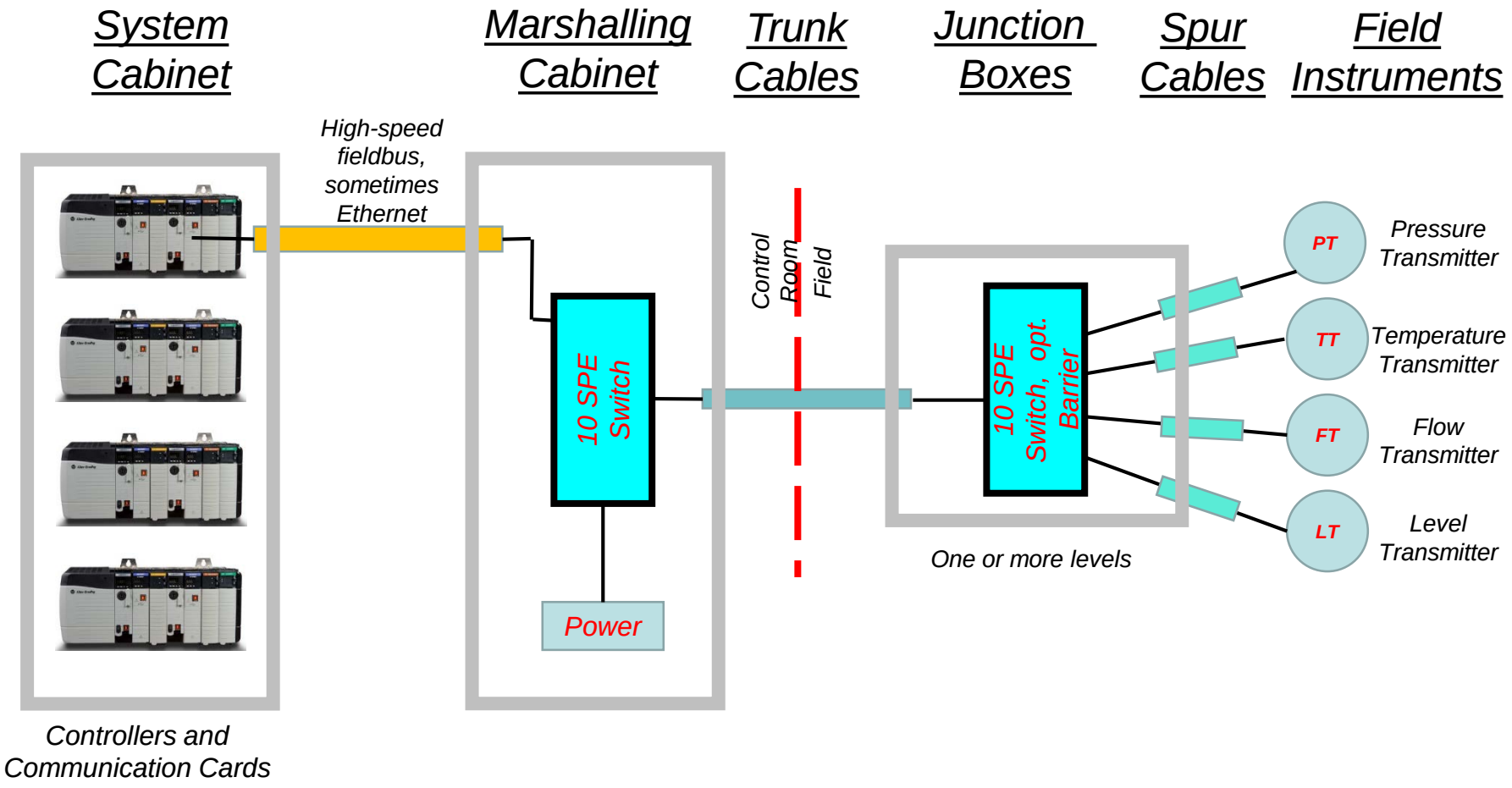
Expected simplifications with 10 SPE

- Surge protection
  - Legacy surge suppression will be removed
    - In-line connections may then be required (2 per link)
  - 10 SPE-compatible surge suppression will be substituted
    - IEC 61000-4-5 (surge immunity) or equivalent
- Barriers
  - Legacy communication barriers will be removed
  - 10 SPE switches (802.1 bridges) will provide intrinsic safety function
- Multi-drop
  - Multi-drop link segments (that form tree structures) will be replaced by multi-port switches that break the multi-drop into multiple shorter point-point link segments
- Marshalling cross-connections
  - 10 SPE will extend the fieldbus trend of replacing marshalling wiring complexity with switches and end node addressing

10 SPE “homerun” example

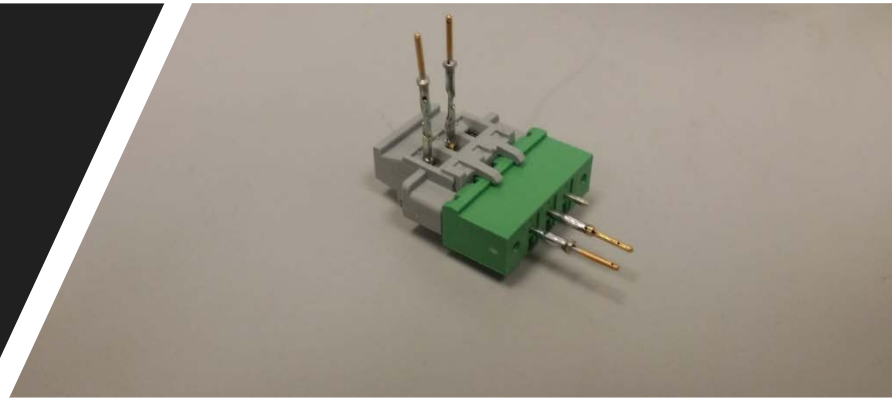


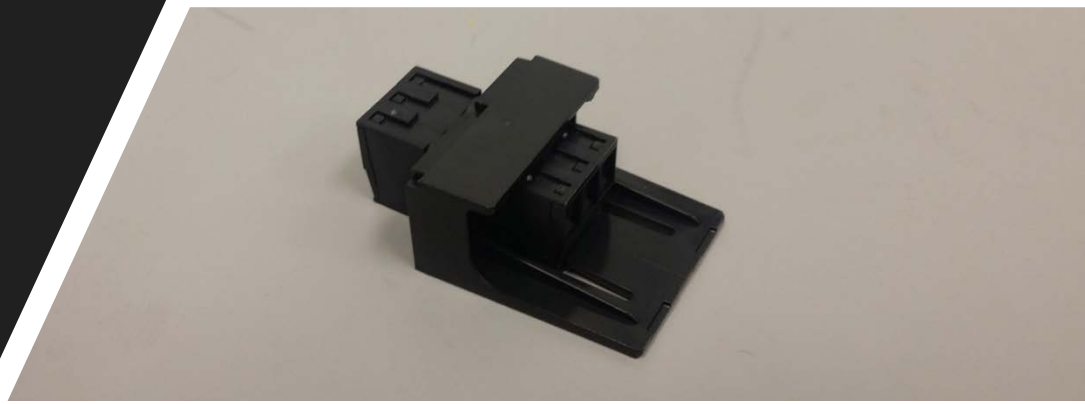
10 SPE “fieldbus” example



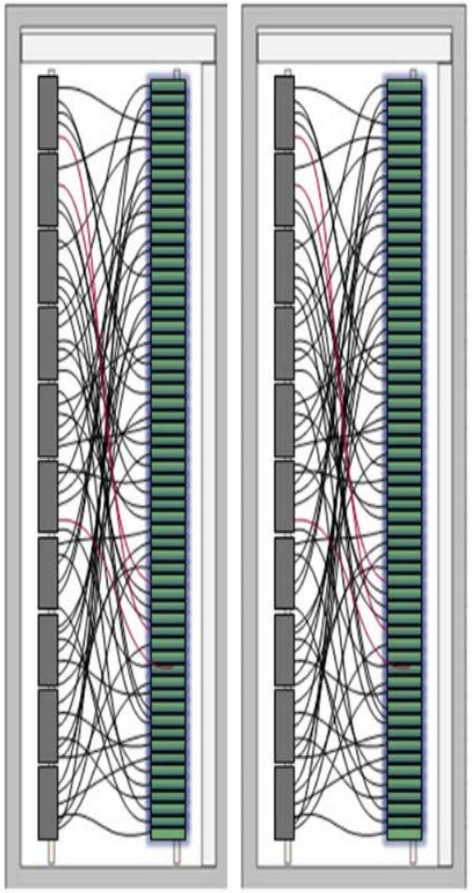
Controller Connection

- Connection is fieldbus wiring landed on controller and/or I/O blocks
- Commonly screw terminals with ferruled wire ends (see photos)
- Two types tested
  - P&F “green/grey”
  - PANDUIT CMBRS485BL



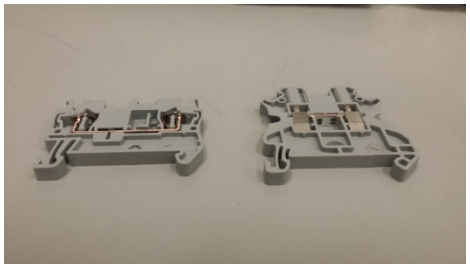


Marshalling Connection



Marshalling cabinet (typical)

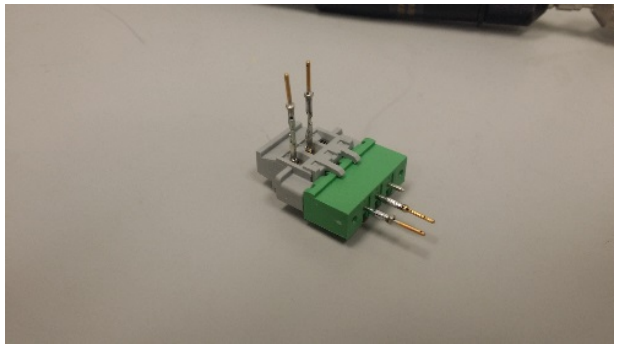
- Pairs of DIN rail mounted terminals arranged in high density fashion
- Controller and/or I/O wiring landed on one row
- Corresponding field wiring landed on the opposite row
- Cross connection between terminal strips to make final connection

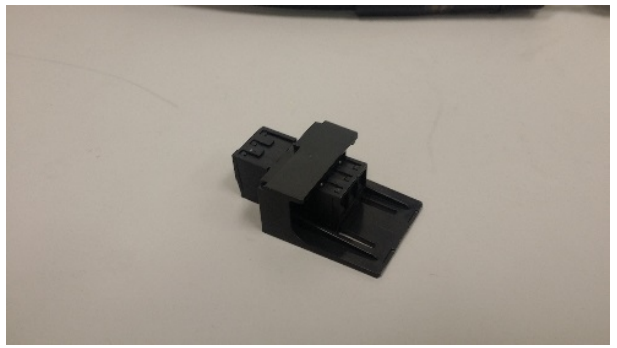


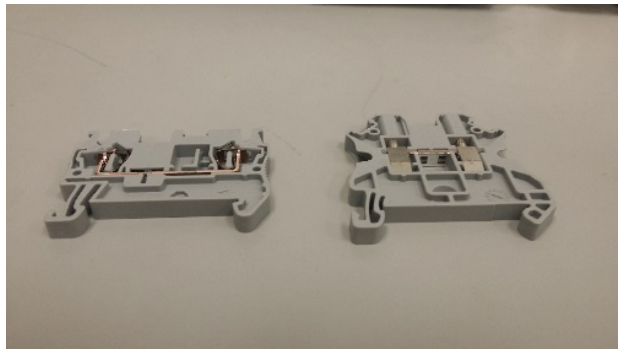
DIN rail terminal types commonly used for this application. Spring loaded contacts (left) and screw compression contacts (right)

Junction Box Connection

- Fieldbus wiring installations are often provided with an intermediate breakout point
- Essential if multi-conductor fieldbus cable is used
- Desirable in all cases
- Terminals are used to facilitate maintenance of installation
- 3 types tested – see photos



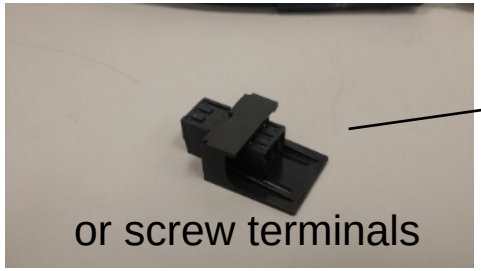


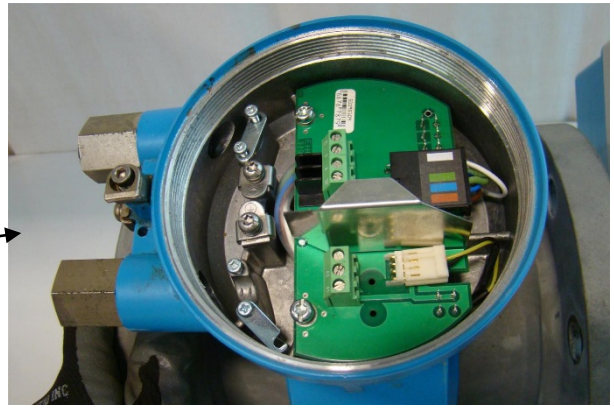


End Device Connections

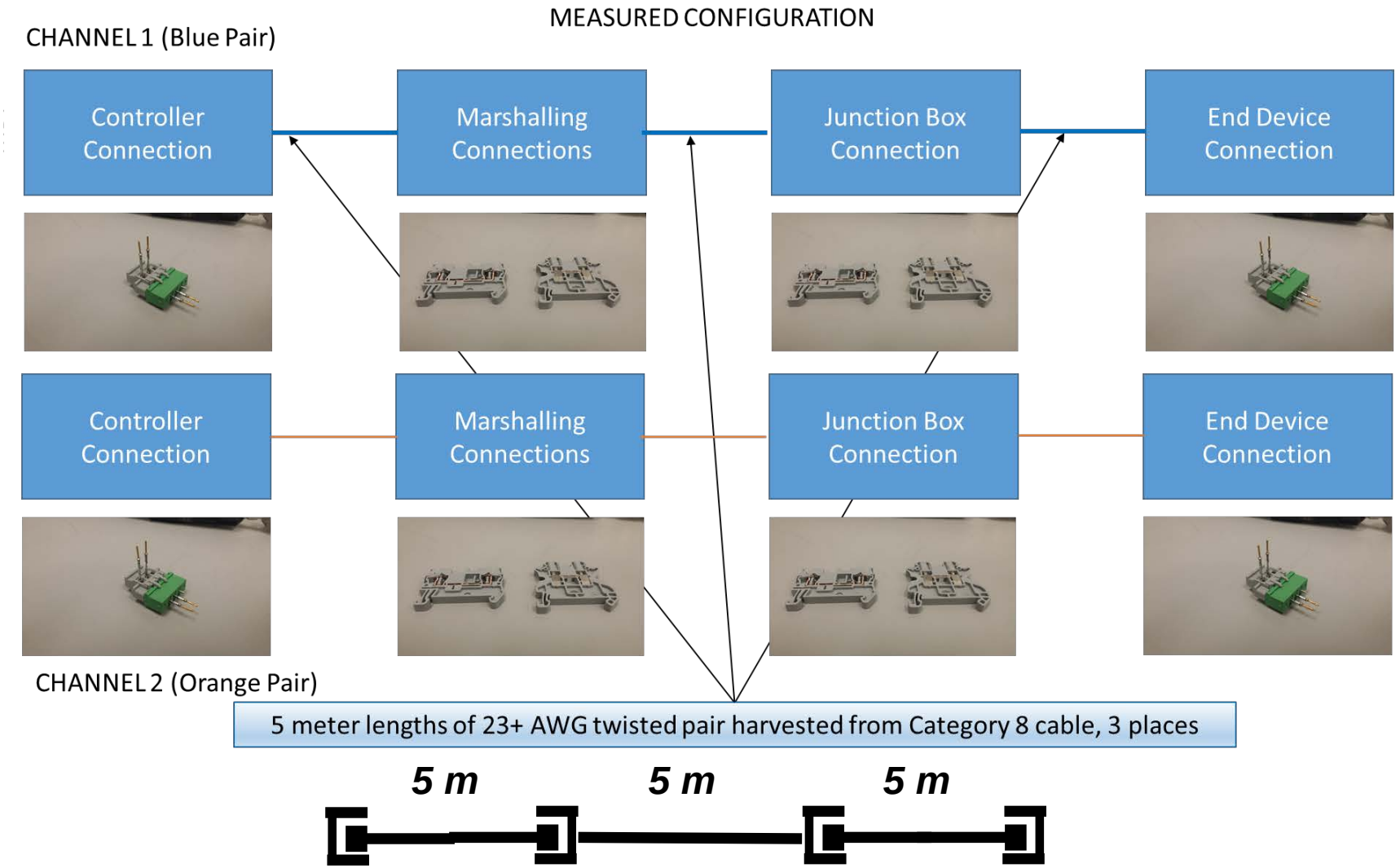
- Two connection scenarios
  - Hardened fieldbus connection on device exterior
  - Fieldbus wiring connected inside of an enclosure
- Two types tested

Hardened device connections (typical)

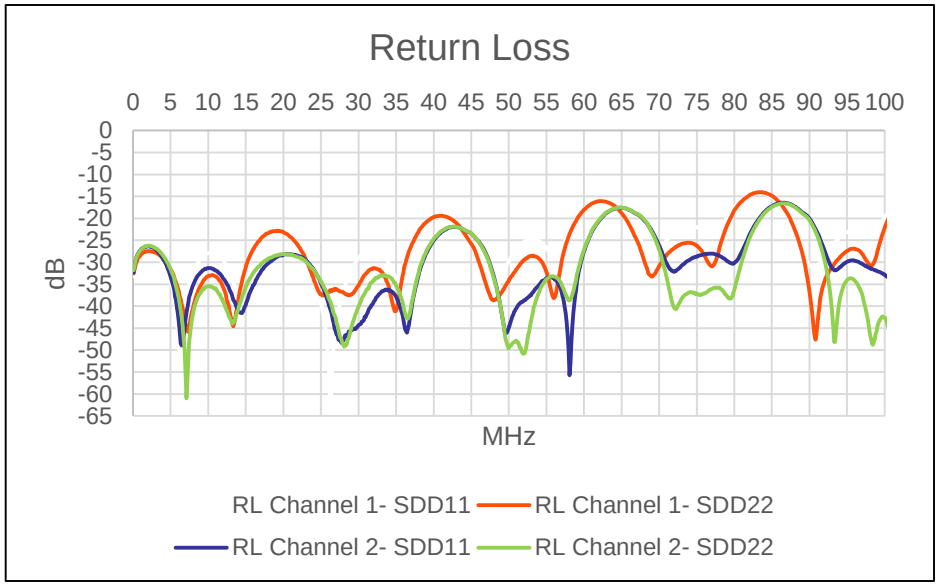


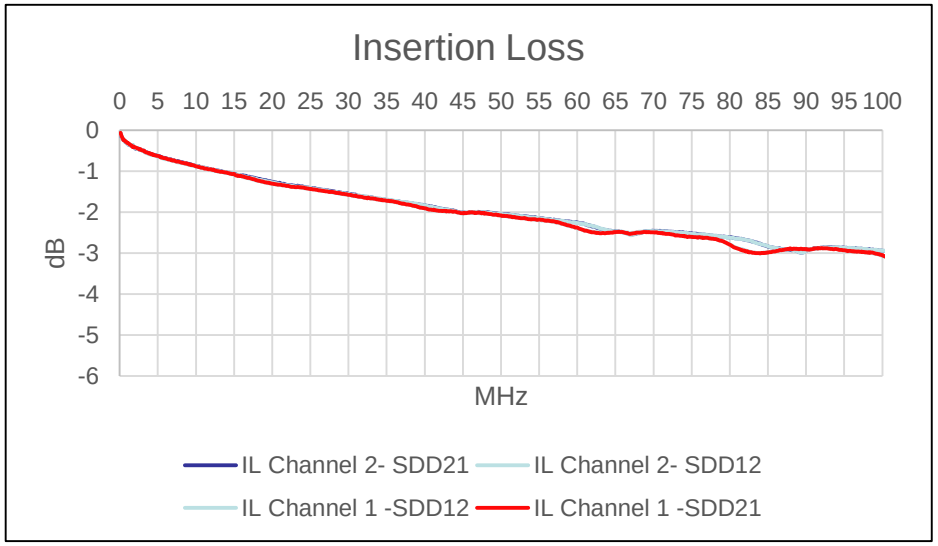


Link Segment Measurements

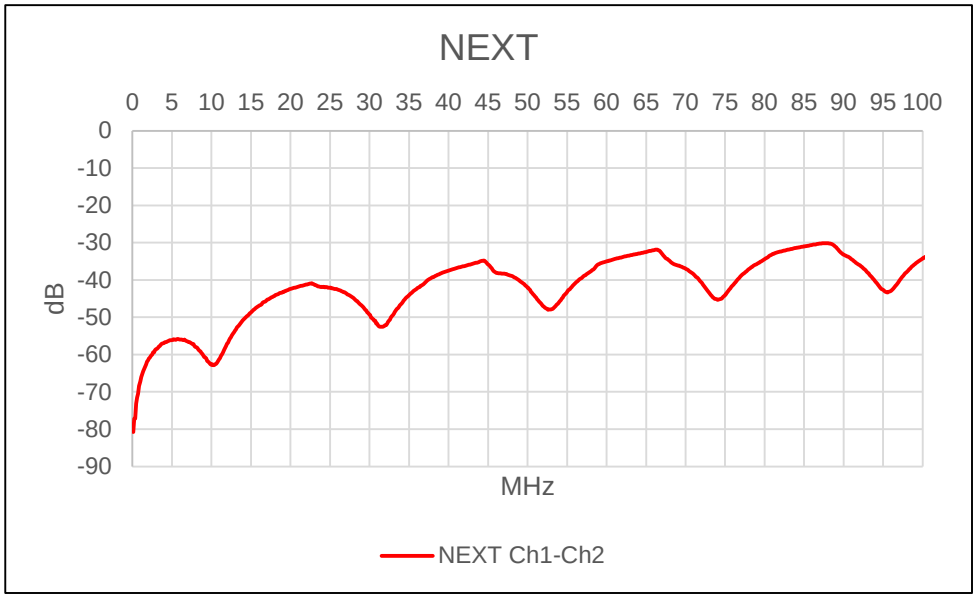


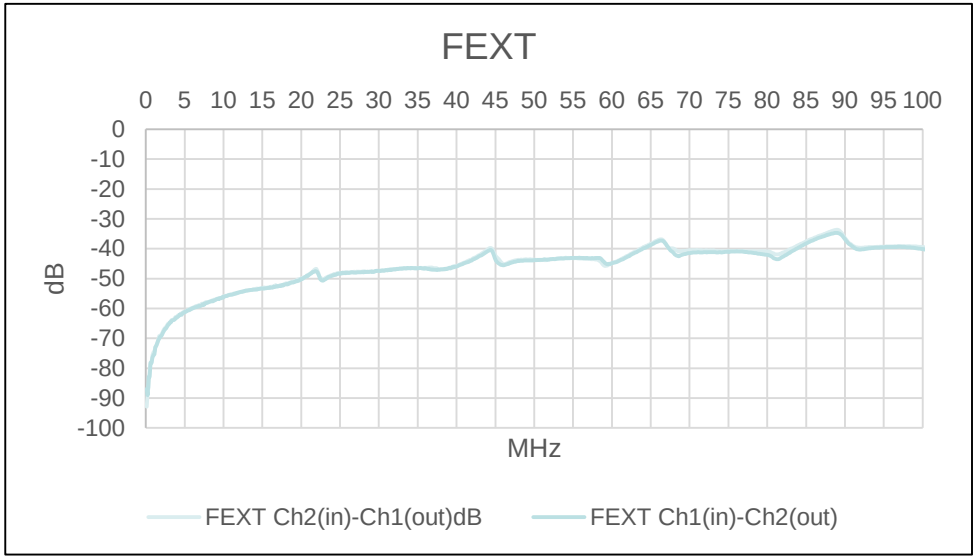
Link Segment Measurements





Link Segment Measurements





Cable insertion loss – 20 deg C

- **Link Segment Insertion Loss Specifications**

AWG	Diameter(in)	Diameter(mm)	dB/m at 50 MHz solid	dB/m at 100 MHz solid	dB/m at 500 MHz solid	dB/m at 50 MHz stranded	dB/m at 100 MHz stranded	dB/m at 500 MHz stranded
14	0.064085	1.627754	0.05	0.07	0.16	0.06	0.08	0.19
15	0.057069	1.449551	0.05	0.08	0.18	0.06	0.09	0.21
16	0.050821	1.290858	0.06	0.08	0.20	0.07	0.10	0.24
17	0.045257	1.149538	0.07	0.10	0.23	0.08	0.11	0.27
18	0.040303	1.023689	0.07	0.11	0.25	0.09	0.13	0.30
19	0.035890	0.911618	0.08	0.12	0.28	0.10	0.14	0.34
20	0.031961	0.811816	0.09	0.14	0.32	0.11	0.16	0.38
21	0.028462	0.722941	0.11	0.15	0.36	0.13	0.18	0.43
22	0.025346	0.643795	0.12	0.17	0.40	0.14	0.20	0.48
23	0.022571	0.573314	0.13	0.19	0.45	0.16	0.23	0.54
24	0.020100	0.510549	0.15	0.21	0.51	0.18	0.26	0.61
25	0.017900	0.454655	0.17	0.24	0.57	0.20	0.29	0.68
26	0.015940	0.404881	0.19	0.27	0.64	0.23	0.33	0.77
27	0.014195	0.360555	0.21	0.30	0.72	0.25	0.37	0.86
28	0.012641	0.321083	0.24	0.34	0.81	0.29	0.41	0.97
29	0.011257	0.285931	0.27	0.38	0.91	0.32	0.46	1.09
30	0.010025	0.254628	0.30	0.43	1.02	0.36	0.52	1.22
31	0.008927	0.226752	0.34	0.48	1.14	0.41	0.58	1.37
32	0.007950	0.201928	0.38	0.54	1.28	0.46	0.65	1.54

*Reference IL =1.82*SQRT(f)+0.0091*f+0.25/SQRT(f)*

**commercially available specified to 500 MHz*
***~12% increase per gauge*
****20% increase for stranded*

Link Segment Cable IL =(TBD Coieficient)(1.82*SQRT(f)+0.0091*f+0.25/SQRT(f)*

Link segment specifications

- Link Segment IL= Link Segment Cable IL + Link Segment connector IL + ILD channel
  - Link Segment Cable IL =(TBD coefficient)*(1.82*SQRT(f)+0.0091*f+0.25/SQRT(f))
  - Link Segment connector IL = 0.04*SQRT(f)
  - ILD channel (TBD)
  - Temperature dependencies (TBD - 70 deg C)
- Link Segment RL
  - Link Segment Cable 100 +/- 20%
  - Link connector RL = TBD from measured connectors
  - Model of concatenation of cables and connectors –configurations TBD
- Link Segment crosstalk
  - Link Segment measurements (TBD)
  - Cable, connector, measurements (TBD)
  - Shielding (alien crosstalk) (TBD)

Summary

- **Link segment considerations for industrial applications**
  - **Insertion Loss**
  - **Return Loss**
  - **Crosstalk**