Consideration of Field Test Accuracies and P2PRUNB Measurements

Theo Brillhart

James Withey

Jeffrey Bottman

Fluke Networks

802.3bt Berlin Mar 2015

FLUKE networks®

Introduction

- This presentation examines the use of legacy field test results for calculating P2PDCRU.

- Examines the accuracy of the field tester for this parameter.

- Reviews current requirements and standards useful for testing P2PDCRU.

Legacy Testers and P2PDCRU

- Testing of P2PDCRU is not, and has not, been required for field testing.

- DC loop resistance test is not required by TIA for installed cabling.

  - However some field testers measure and store this parameter information.

- Testing of DC loop resistance is required by ISO cabling standards.

Legacy DC Loop Resistance test

- According to IEC 61935-1
  - The required resolution is 0.1Ω.

  - The accuracy requirement is ± (1Ω+1%)

- There are no TIA requirements for C6A and below.

- It should be noted that this resolution and accuracy are the published specifications for the vast majority of deployed field testers.

FLUKE
networks.

Calculation of P2PDCRU

- It is possible to use DC loop resistance data (if available) to estimate P2PDCRU.

- It can be assumed that the parallel resistance of pair is approximately ¼ of the DC loop resistance.

  ○ This has been shown to be a reasonable approximation as long as the resistance unbalance *within the pair* meets current standards.[1]

- These parallel approximations can be used to calculate P2PDCRU.

1. TR42.7-2015-02-039-P2PResUnbal.xlsx
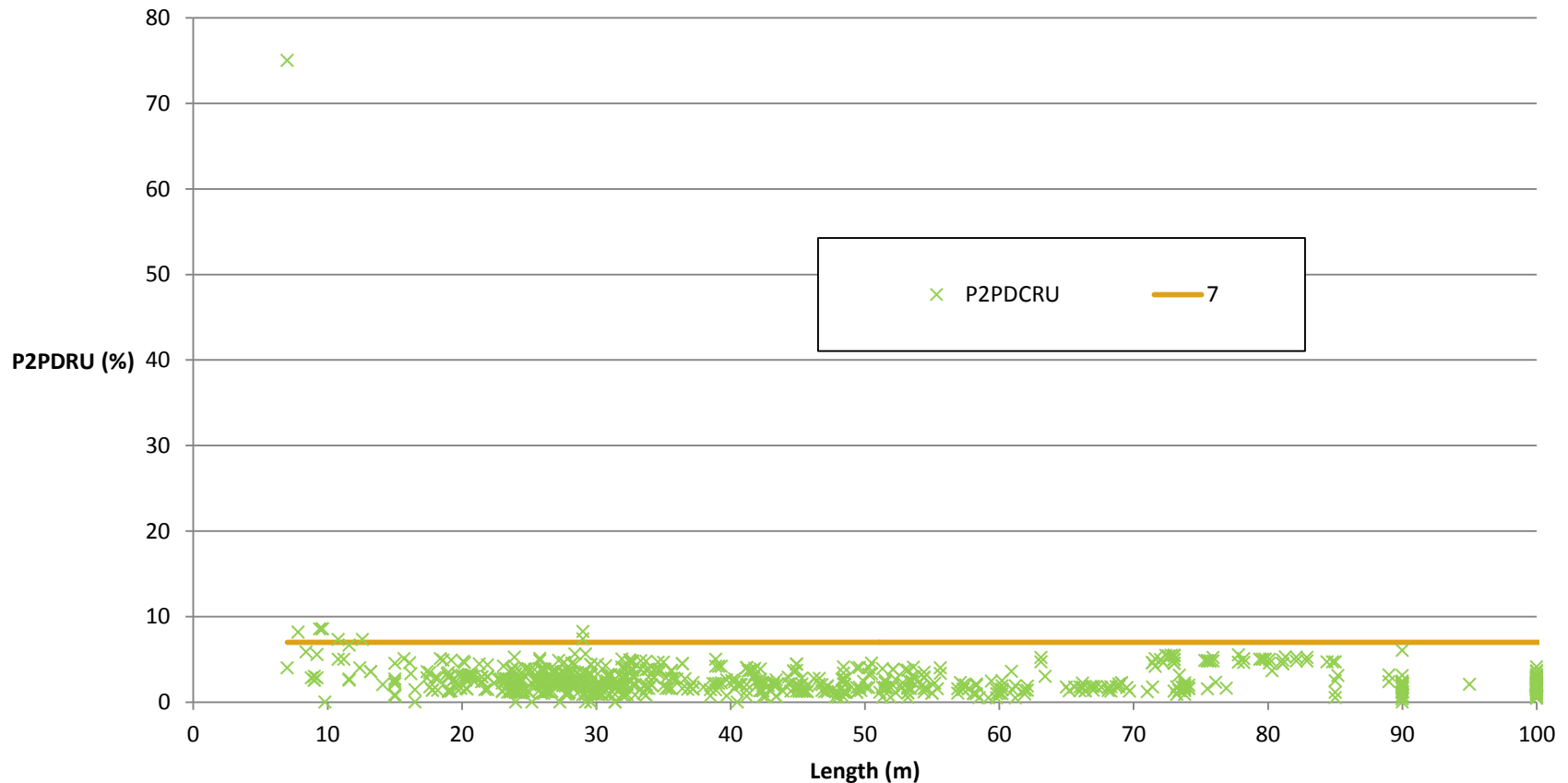
FLUKE *networks*.

A P2PDCRU Equation

$$\frac{R_{max} - R_{min}}{R_{max} + R_{min}} 100\%$$

Where:

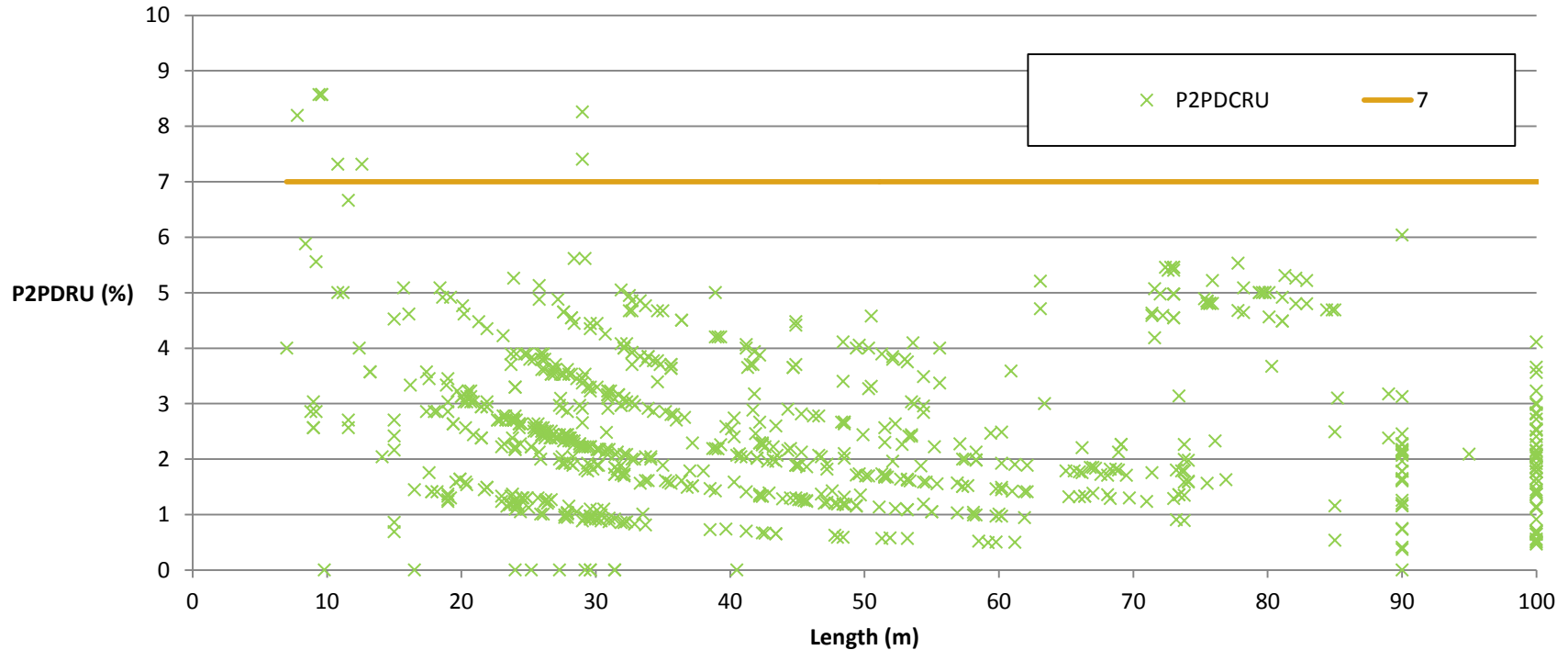R_{max} = ¼ maximum loop resistance of the four pairs

R_{min} = ¼ minimum loop resistance of the four pairs

Calculated P2PDCRU
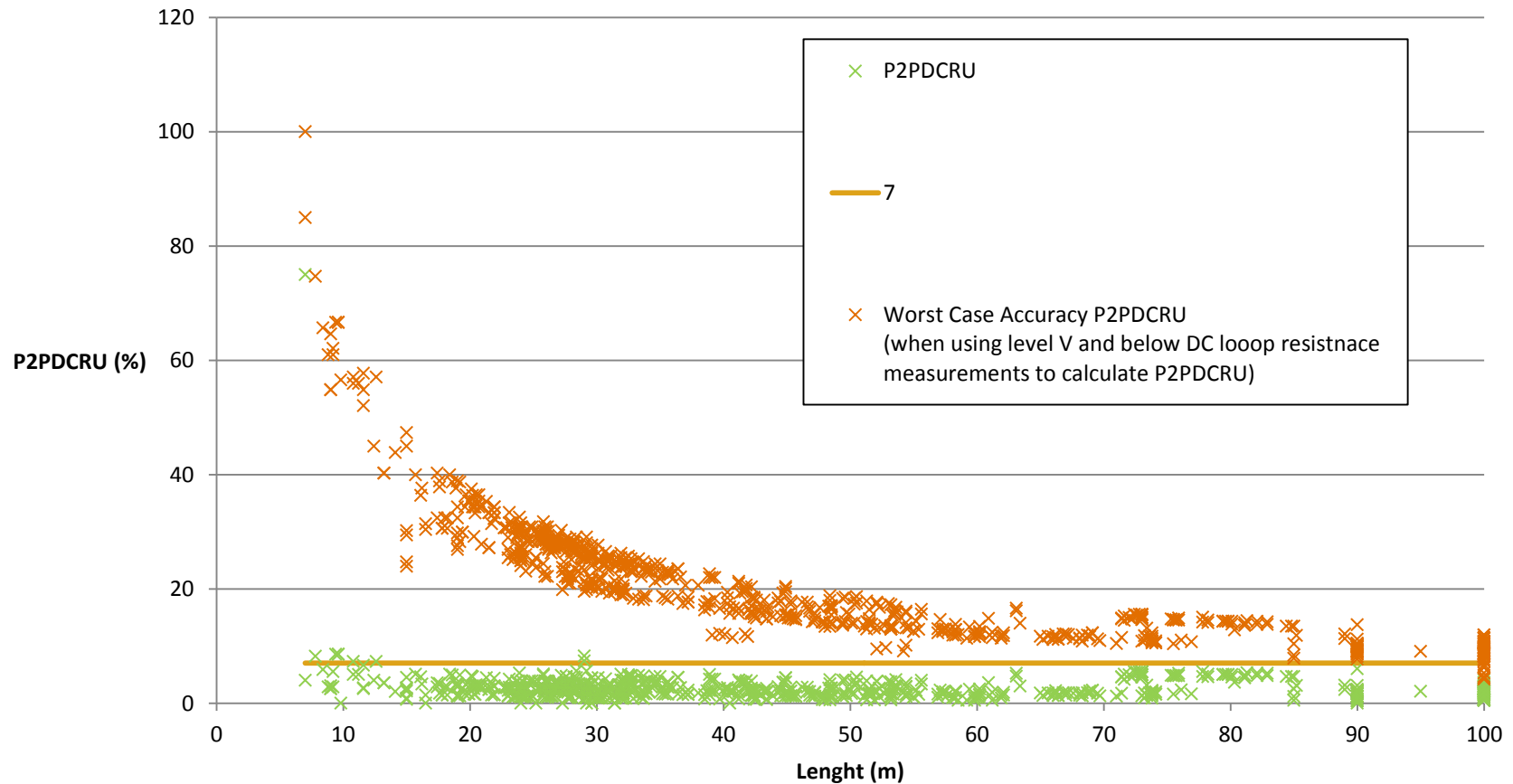# (measured ~800 installed links)

Effect of 0.1Ω Resolution

- Quantisation of results

P2PDCRU Equation
(IEC 61935-1 worst case accuracy)

$$\frac{(R_{max}+error) - (R_{min}-error)}{(R_{max}+error) + (R_{min}-error)}100\%$$

Worst Possible Reality
(assumes worst case accuracy)

Is worst case realistic?

- Quality testers are typically much more accurate than required by the standard. (Probably shouldn't rely on this.)

- Measurement temperatures can impact accuracy (e.g. basement vs. wiring closet).

- Worst case is unlikely, due in part to the uncertainty of a resistance measurement being almost always in the same direction (+/-) for any given tester design.

FLUKE
networks.

# P2PDCRU Equation
(Constant offset direction w/Jitter error)

$$\frac{(R_{max}+error_{Jitter1}) - (R_{min}+error_{Jitter2})}{(R_{max}+error_{Jitter1}) + (R_{min}+error_{Jitter2})} 100\%$$

- Taking a single value of error for all measurements is not realistic either, as any tester has a jitter associated with multiple measurements (e.g. 10.0, 10.1, 9.9, 10.2, 9.8, etc.)

- A similar quality of jitter can be seen across measurements made with multiple testers.

FLUKE
networks.

Simulating P2PDCRU measurements

- Mote Carlo technique was used to simulate a population of 1,000 nominal links with loop resistances corresponding to a length range; we used 5 to 100 meters in .1 meter increments.

- Assumed 16 ohms per 100 meters, which mimics the average value of the ~800 installed links.

- For each link, the simulation makes 4 "pairs" by adding 4 random resistances to the nominal loop resistance for that length. The normally distributed, variance increases with length of cable, and closely mimics the measured data set.

- Simulation then runs for the test error and no test error conditions.
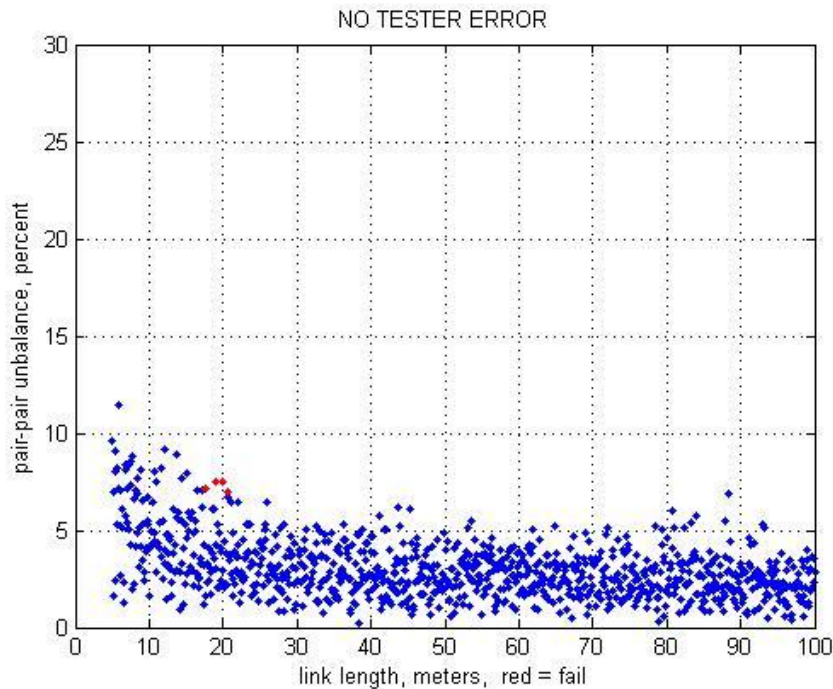
Simulated accuracy w/jitter error
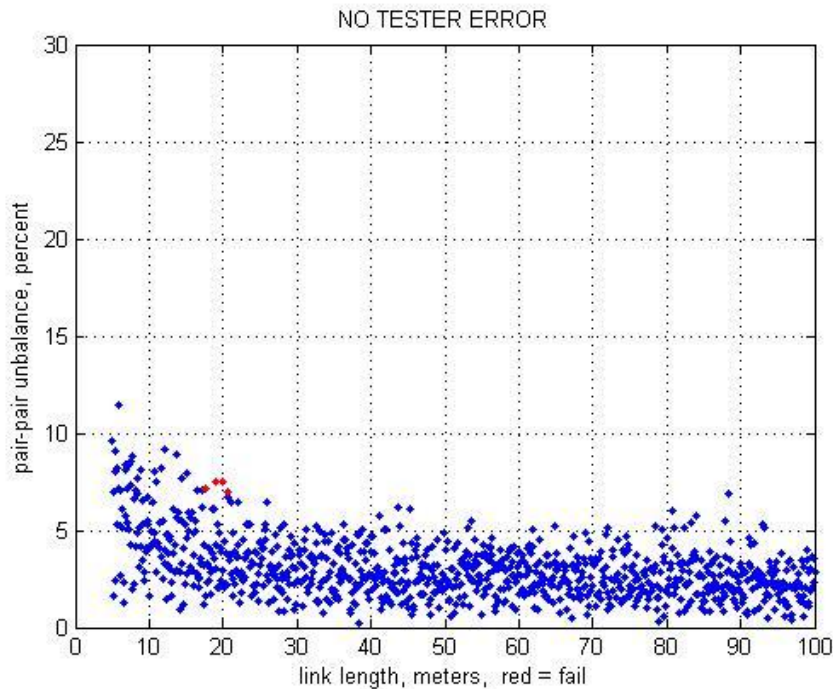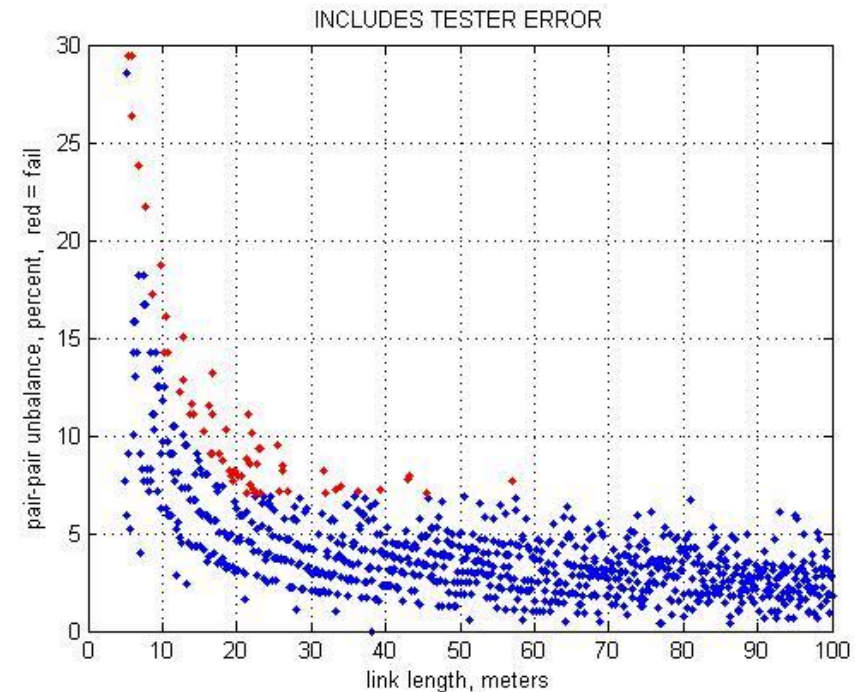

< 0.5% Failure

~55% Failure

FLUKE
networks.
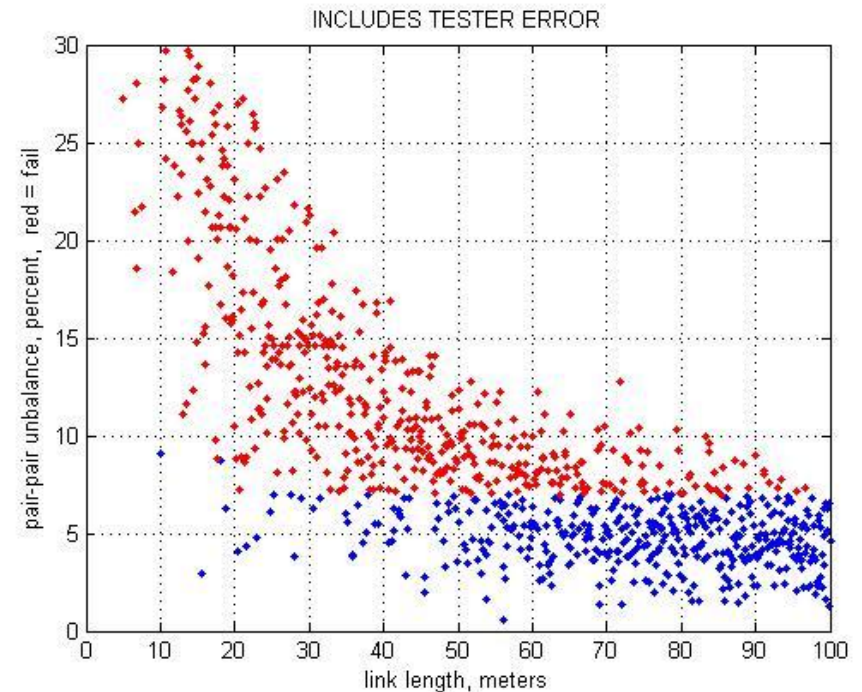
Simulated accuracy w/jitter error

< 0.5% Failure

~6% Failure

Is this a problem?

- This contribution is not flagging a problem with installed cabling.
- This contribution thus far highlights two things:
  - legacy field test instruments based on IEC requirements for measurement of DC loop resistance can provide reasonable *confidence* of P2PDCRU performance
  - …but should not be used when *assurance of* standards compliance is required.

IEC 61935-1-2 NP

- ISO is addressing this with a project requested in IEC-TC46, currently in circulation as an NP.
- This document provides specific requirements for testers designed to take unbalance measurements.

Test parameter	Baseline accuracy at perm. link limits	Permanent link accuracy at perm. link limits	Channel accuracy at channel limits
d.c loop resistance	±(0.5Ω+1% d.c. loop resistance) (0.1Ω Resolution)		
d.c loop resistance unbalance between pairs	±(0.035Ω+0.7% Sum of d.c. loop resistances) (0.01Ω Resolution)		
d.c loop resistance unbalance within a pair	±(0.025Ω +0.3% d.c. loop resistance) (0.01Ω Resolution)		

Note: Most current contributions propose a P2PDCRU accuracy of ± (0.025Ω + 0.3% DC loop resistance).

FLUKE networks

IEC 61935-1-2 Worst case Accuracy
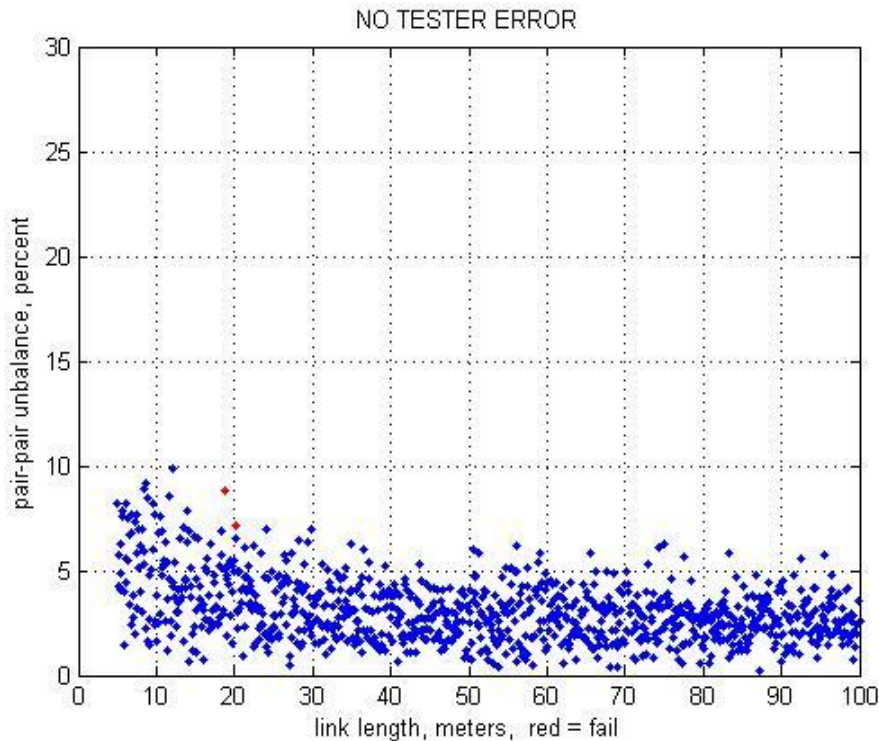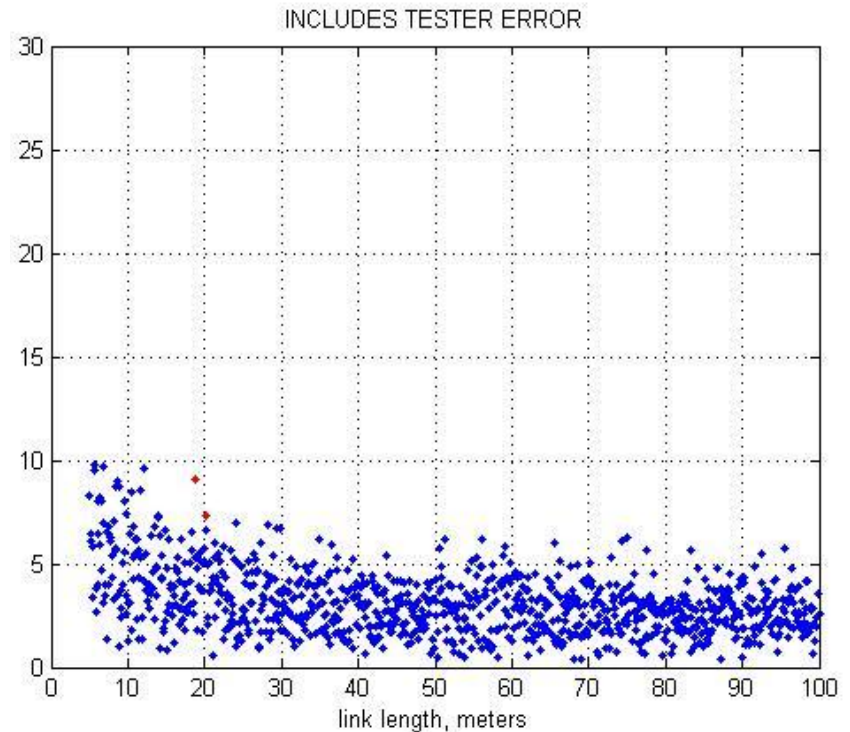
< 0.5% Failure   < 0.5% Failure

- Measurement accuracy is virtually indistinguishable from the ideal condition under these simulation conditions.

FLUKE
networks.

Conclusion

- Where *assurance* of P2PDCRU performance is required, a tester that measures Resistance Unbalance as opposed to D.C. Loop resistance should be used.

- IEC 61935-1-2 will specify accuracy requirements for Resistance Unbalance measurements.

Recommendation

- Communicate to ISO/IEC SC25 and TIA TR42 that it is desirable for any standards that are expected to include channel pair-to-pair resistance unbalance specifications, should also contain reference to the latest measurement accuracy requirements (IEC 61935-1-2) to reduce non-conformance.

FLUKE
networks.

Thank you.

Theodore Brillhart
Sr. Mgr. – Advanced Development
Everett, WA USA
+1 425-446-6101
theo.brillhart@flukenetworks.com