



Comparative Evaluation of Two Process Bus Solutions for a Distribution Substation

Arun Shrestha and Sathish Kumar Mutha
Schweitzer Engineering Laboratories, Inc.

**Devika Kattula, Nathaniel McAfee,
Rosa Vergara, Miles Webb, and Dr. Valentina Cecchi**
University of North Carolina at Charlotte

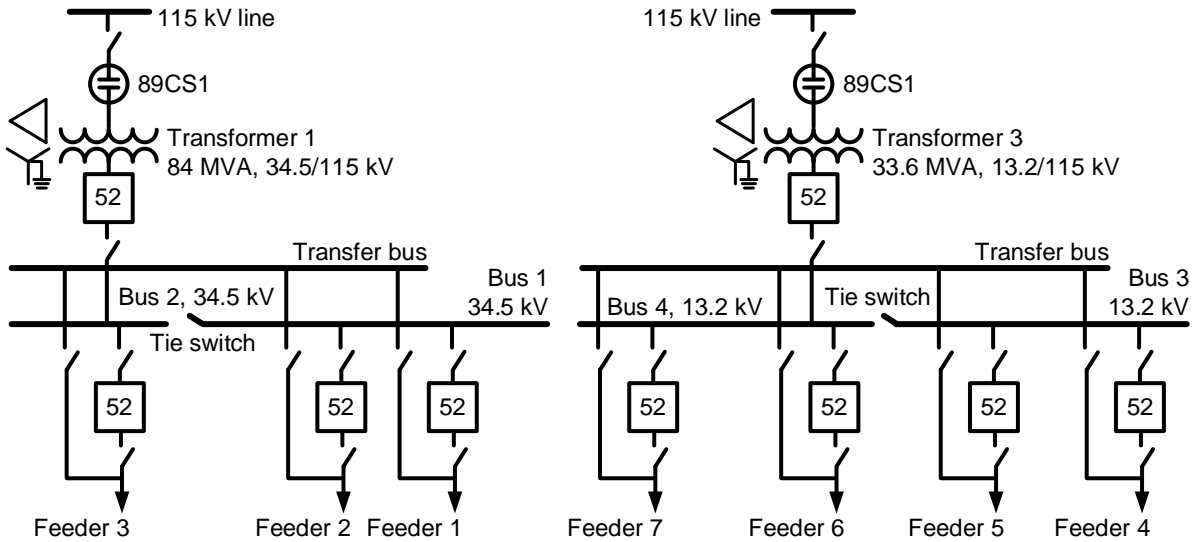
© 2022 University of North Carolina at Charlotte and SEL

Outline


- Utility's distribution substation
- Process bus solutions
 - Point to point (P2P)-based
 - IEC 61850-based
- Process bus solutions design
- Comparative evaluations
 - P&C equipment cost
 - Protection scheme reliability
 - Protection system performance
- Conclusion





Utility's distribution substation



Process bus solutions

 Improve personnel safety

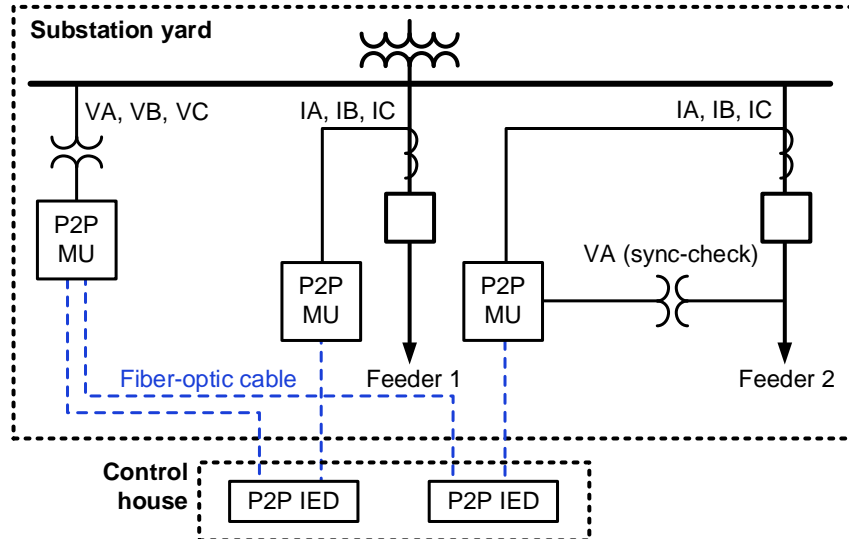
 Reduce substation construction cost and time

 Increase flexibility by replacing copper with fiber



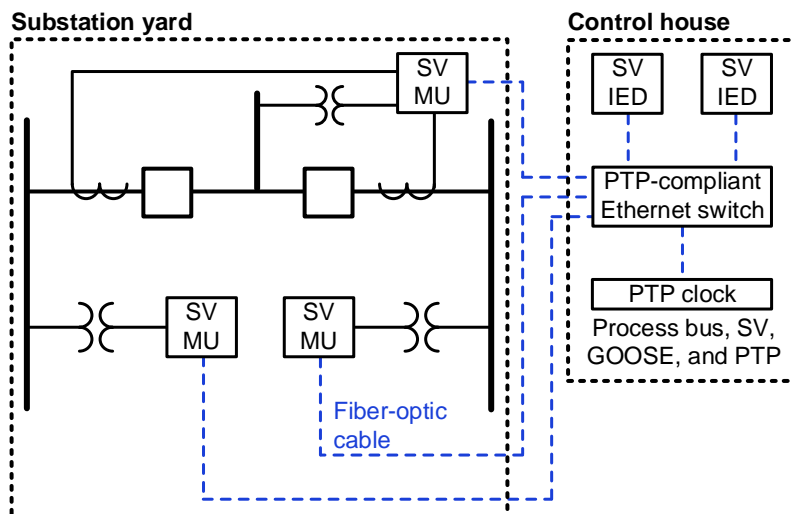
P2P-based process bus architecture

- Simplicity
- No external time source required for protection
- No merging unit configuration
- No network switches
- No network engineering

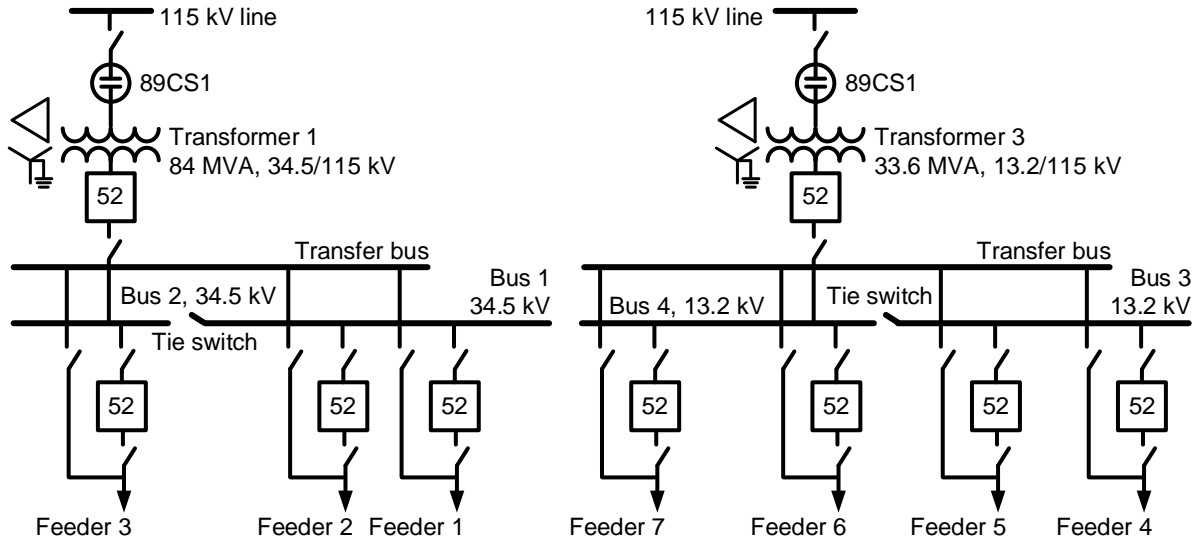


IEC 61850-based process bus architecture

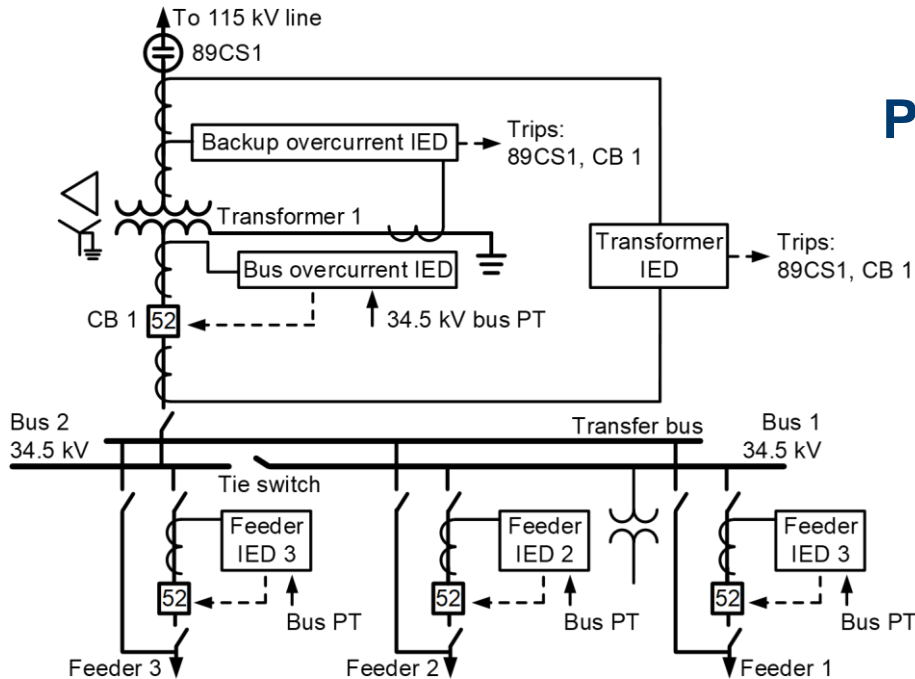
- Is based on international standard
- Promises interoperability
- Requires external time source for protection
- Requires network switches and network engineering

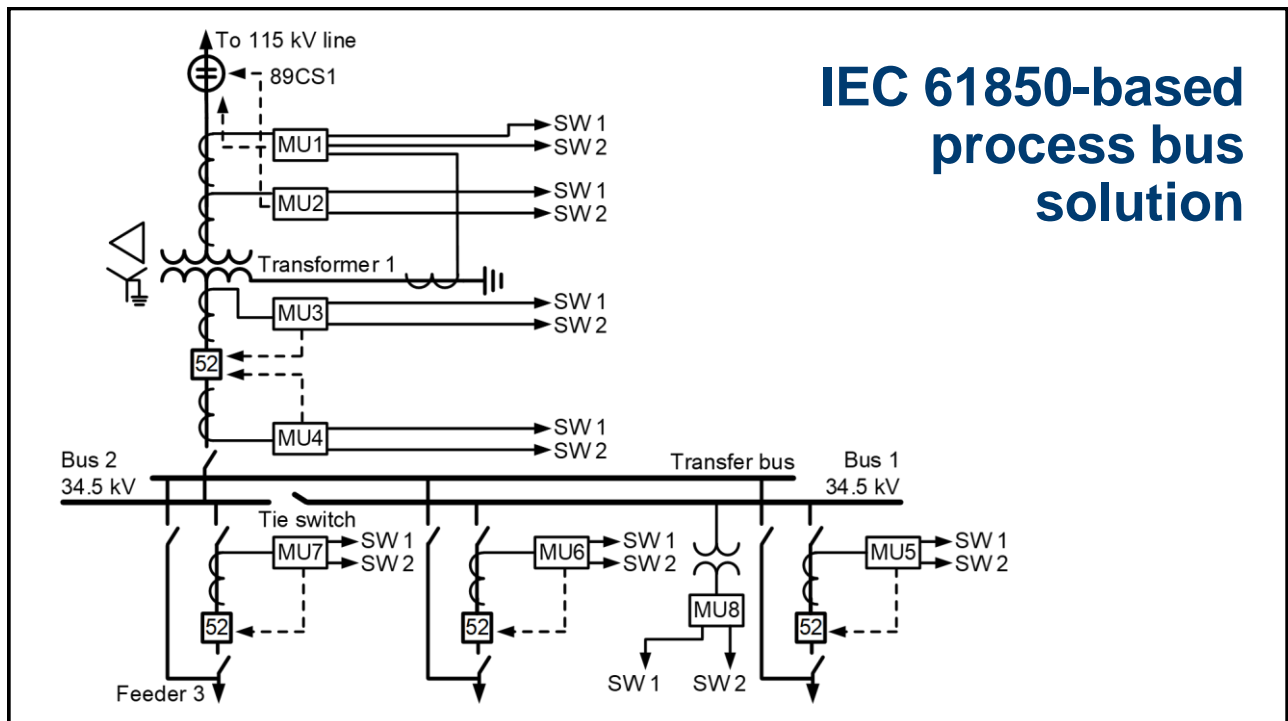
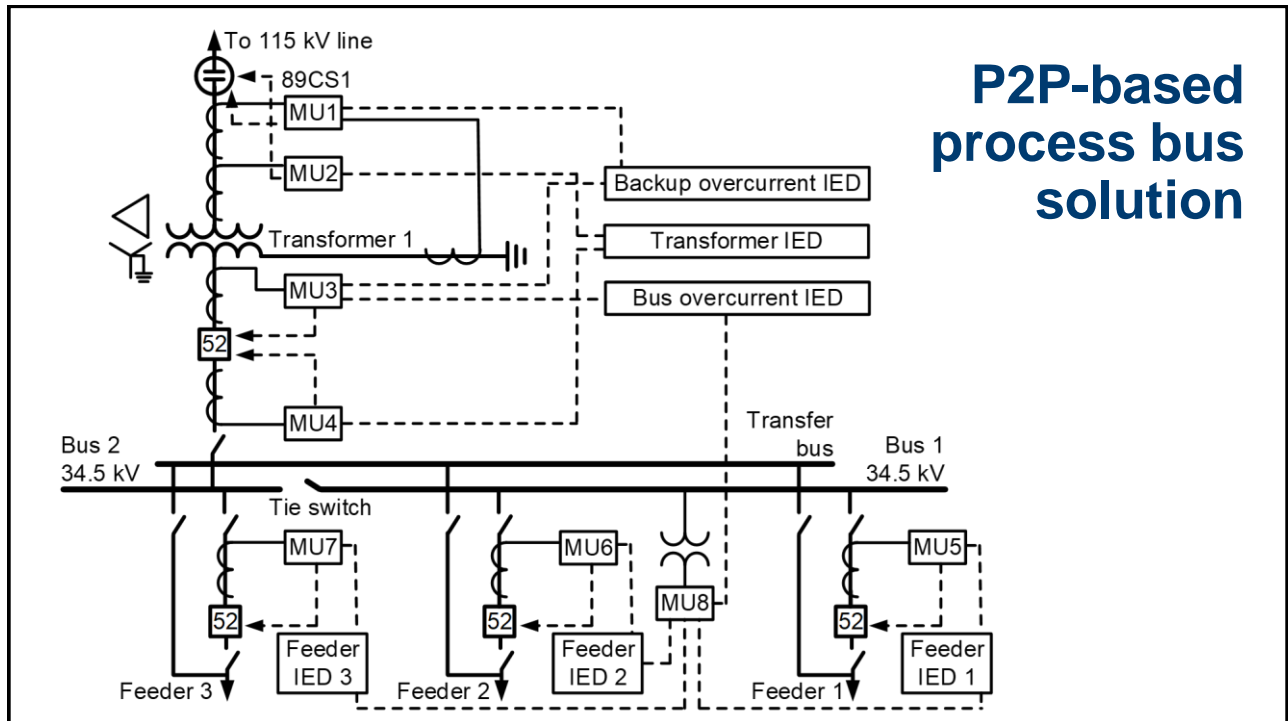


Existing P&C system

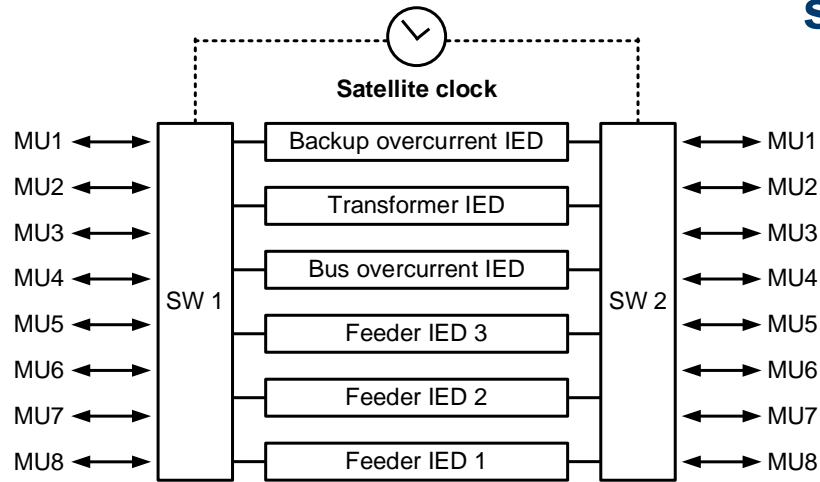


Existing P&C system





IEC 61850-based process bus solution



Comparative evaluation

P&C equipment cost

Traditional

Description	Units	Cost (\$)
Copper cables	36,070 ft	85,018
Test switches	39	9,141
Fuses	24	94
Backup overcurrent IEDs	2	5,140
Transformer IEDs	2	11,980
Bus overcurrent IEDs	2	9,340
Feeder IEDs	7	17,990
Lockout IEDs	6	6,408
		145,111

P2P-based

Description	Units	Cost (\$)
Fiber-optic cables	8,400 ft	8,424
Merging units	18	52,380
Overcurrent IEDs	11	73,150
Transformer IEDs	2	18,340
		152,294

IEC 61850-based

Description	Units	Cost (\$)
Fiber-optic cables	12,160 ft	13,858
Merging units	17	84,490
Overcurrent IEDs	11	66,000
Transformer IEDs	2	17,460
Ethernet switches	4	15,540
Satellite clock	1	2,540
GNSS antenna	1	260
		200,148

Comparative evaluation

P&C equipment cost

Substation type **Cost (\$)**

Traditional 145,111

P2P-based solution 152,294

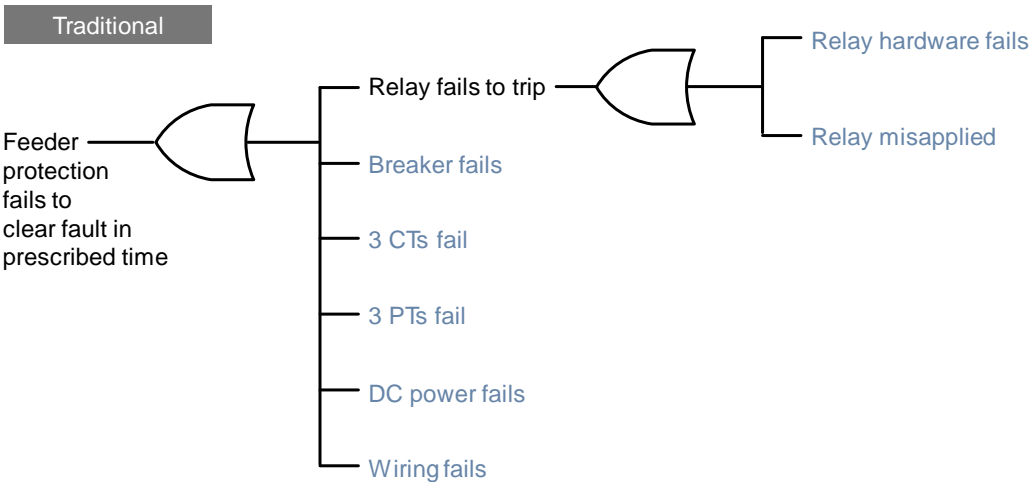
IEC 61850-based solution 200,148

75% of traditional P&C system installation cost in North America is related to labor



Comparative evaluation

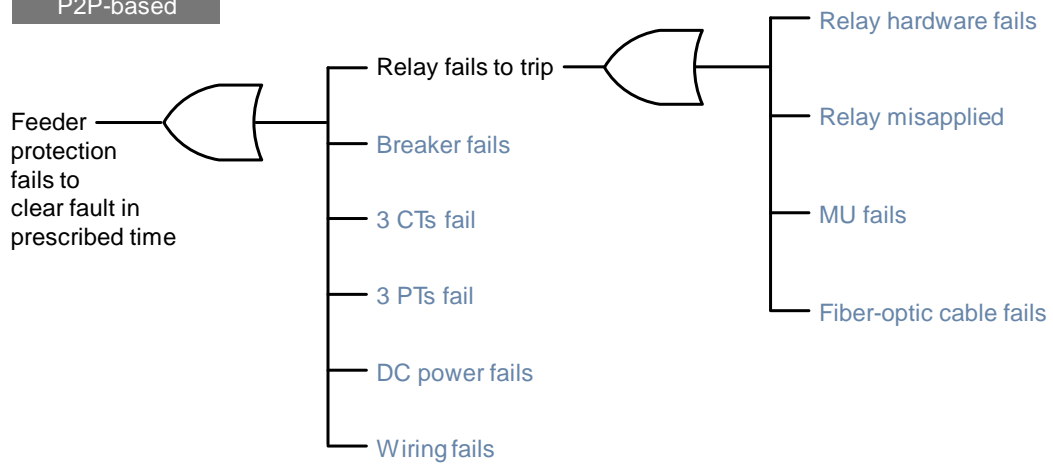
Protection scheme reliability



Comparative evaluation

Protection scheme reliability

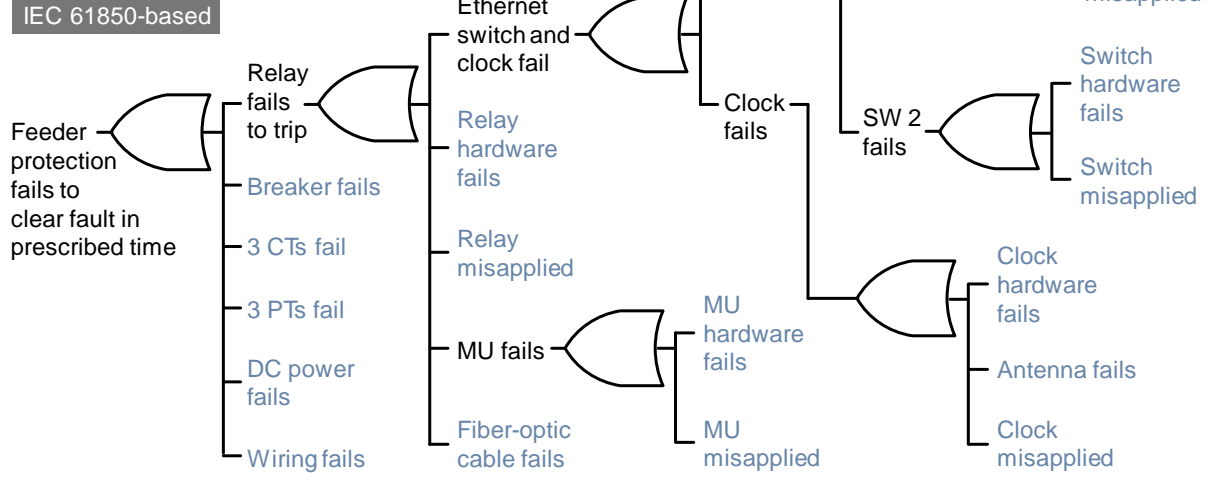
P2P-based



Comparative evaluation

Protection scheme reliability

IEC 61850-based



Comparative evaluation

Protection scheme reliability

Overall unavailability (10^{-6})

Solution	Feeder protection	Transformer protection
Traditional	423.45	440.55
P2P-based solution	446.58	440.55
IEC 61850-based solution	487.86	465.17

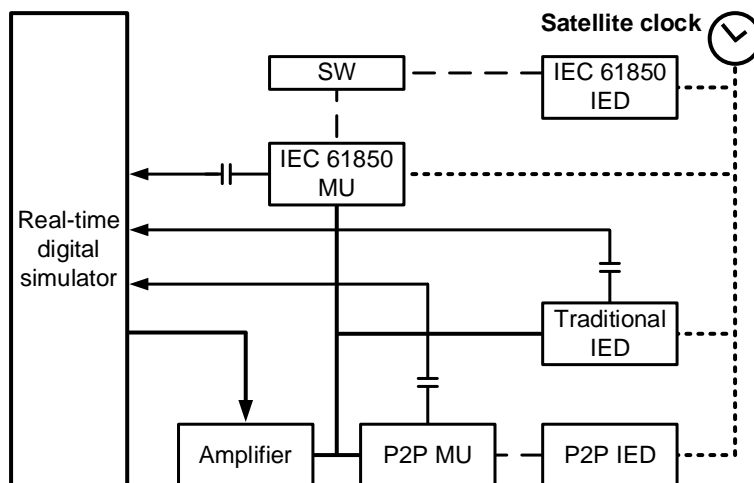
Lower unavailability numbers are better



Comparative evaluation

Protection system performance

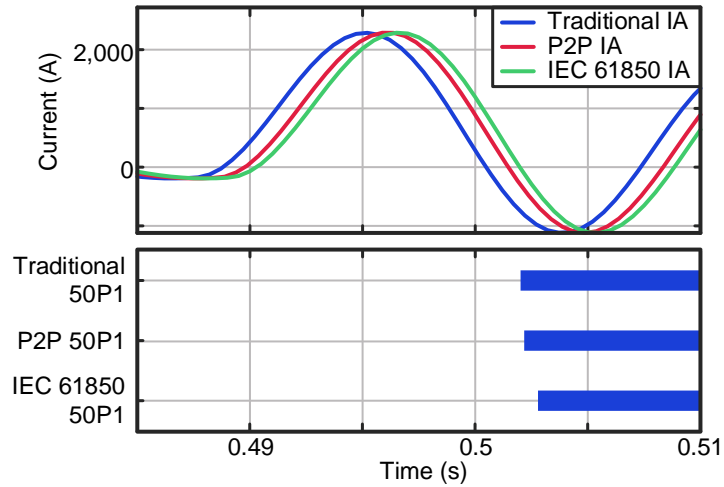
Test setup



Comparative evaluation

Protection system performance

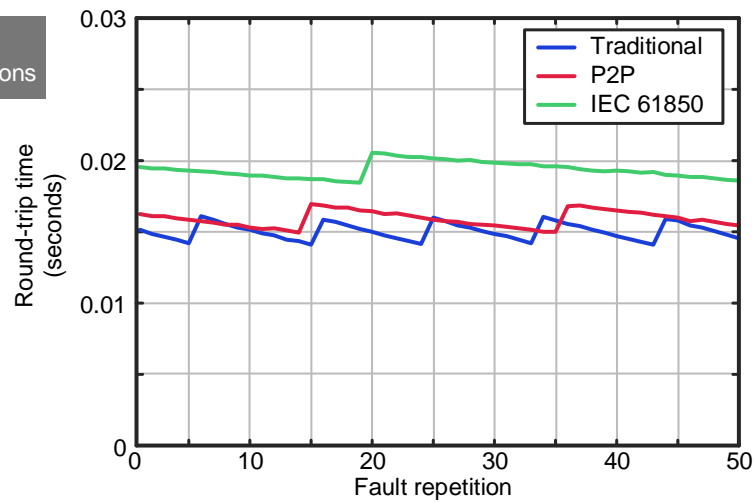
50P1 element operation time



Comparative evaluation

Protection system performance

Round-trip time for three different solutions



Comparative evaluation

Protection system performance

Solution	50P element (ms)	Time difference (ms)
Traditional	15.038	0
P2P-based solution	15.913	0.875
IEC 61850-based solution	19.347	4.309



Conclusion

- Process bus solutions
 - Improve personnel safety
 - Reduce substation construction cost and time
- Between the two solutions, P2P-based solution for the distribution substation under study
 - Has lower device count and cost
 - Has lower unavailability
 - Has protection system performance close to traditional system

Utility partner plans to use this information for development of process bus-based substations





Questions?