2021 74th Conference for Protective Relay Engineers (CPRE 2021)

College Station, Texas, USA 22 – 25 March 2021



IEEE Catalog Number: CFP21557-POD **ISBN:**

978-1-7281-4197-8

Copyright © 2021 by the Institute of Electrical and Electronics Engineers, Inc. All Rights Reserved

Copyright and Reprint Permissions: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

For other copying, reprint or republication permission, write to IEEE Copyrights Manager, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854. All rights reserved.

*** This is a print representation of what appears in the IEEE Digital Library. Some format issues inherent in the e-media version may also appear in this print version.

CF
978
978
247

CFP21557-POD 978-1-7281-4197-8 978-1-7281-4196-1 2474-9745

Additional Copies of This Publication Are Available From:

Curran Associates, Inc 57 Morehouse Lane Red Hook, NY 12571 USA Phone: (845) 758-0400 Fax: (845) 758-2633 E-mail: curran@proceedings.com Web: www.proceedings.com



2021 74th Conference for Protective Relay Engineers (CPRE)

Table of Contents

PAPER TITLE

5	A Novel Control Scheme for Utility-Scale Inverter-Based Resources to Emulate Synchronous-Generator
	Fault Response and Retain Existing Protection Infrastructure1
6	A Troubleshooting Methodology for Issues Discovered During End-to-End Testing8
7	Achieving Reliable Generator 100% Stator Ground Fault Protection14
8	AEP Misop Event of 2/23/201922
9	AEP Outage Event of 3/20/201830
10	Analysis of Fundamental Differences in Transformer 87T Differential Protection42
11	Application and Integration of Automation-Based Tools for Efficient and Accurate Modeling of Transmission System Protection62
12	Auto-tuned Solution to Wide Area Coordination Issues of Distance and Directional Time Overcurrent Relay Settings70
13	Can compensated networks be an alternate solution to reduce the risk of ground faults causing forest fires?78
14	Case Studies in Analyzing Transformer Installation Faults - Part 1112
15	Case Study - Transformer Differential Incorrect Operation Due to System Grounding131
16	Complex Faults - Using High-Quality Waveform Data to Understand Faults That Misbehave149
17	Cross Country Faults - Protection Challenges and Improvements153
18	Factors influencing CT saturation and its implications on Distance Protection Scheme: Analysis and Testing168
19	Effective System Grounding. Analysis of the effect of High penetration of IBRs179
20	Electromechanical Differential Relays Misoperation and Investigation189
21	Application of Ethernet Networking Devices Used for Protection and Control Applications in Electric Power Substations194
22	Experience with Point-to-Point Process Bus in a Substation Pilot275
23	Fast Load Shedding Scheme for Enhancing Reliability and Stability of Expanded Liquified Gas Plant297
24	Ground Fault Protection of Microgrid Interconnection Line Using Residual Voltage Compensation304
25	How a measurement you may not be doing can improve relay operations310
26	Impact of IEC 61850 Edition 2 on the Object Modeling of Complex Multifunctional Protection IEDs325
27	Increase of Investor based Descurres on Increasing Descention Functions 220
	Impact of Inverter-based Resources on Impedance-based Protection Functions
28	Implementation of a New Algorithm to Detect Turn-to-Turn Faults in Shunt Reactors and Identify the Faulted Phase339
28 29	Implementation of a New Algorithm to Detect Turn-to-Turn Faults in Shunt Reactors and Identify the Faulted Phase339 Improving Protection Applications for Modern Industrial Switchgear Systems351
28 29 30	Implementation of a New Algorithm to Detect Turn-to-Turn Faults in Shunt Reactors and Identify the Faulted Phase339 Improving Protection Applications for Modern Industrial Switchgear Systems351 International Drive distribution loop protection361
28 29 30 31	Implet of Inverter-based Resources on Impedance-based Protection Functions330 Implementation of a New Algorithm to Detect Turn-to-Turn Faults in Shunt Reactors and Identify the Faulted Phase339 Improving Protection Applications for Modern Industrial Switchgear Systems351 International Drive distribution loop protection361 Interoperability of line differential protection367
28 29 30 31 32	Implementation of a New Algorithm to Detect Turn-to-Turn Faults in Shunt Reactors and Identify the Faulted Phase339 Improving Protection Applications for Modern Industrial Switchgear Systems351 International Drive distribution loop protection361 Interoperability of line differential protection367 Modernization of an Industrial Power Distribution and Automation System - Lessons Learned373
28 29 30 31 32 33	Impact of Inverter-based Resources on Impedance-based Protection Functions330 Implementation of a New Algorithm to Detect Turn-to-Turn Faults in Shunt Reactors and Identify the Faulted Phase339 Improving Protection Applications for Modern Industrial Switchgear Systems351 International Drive distribution loop protection361 Interoperability of line differential protection367 Modernization of an Industrial Power Distribution and Automation System - Lessons Learned373 New Methods in Power Line Carrier Monitoring and Analysis: Real-World Examples and Implications for Protection System Reliability382
28 29 30 31 32 33 33	Impact of Inverter-based Resources on Impedance-based Protection Functions330 Implementation of a New Algorithm to Detect Turn-to-Turn Faults in Shunt Reactors and Identify the Faulted Phase339 Improving Protection Applications for Modern Industrial Switchgear Systems351 International Drive distribution loop protection361 Interoperability of line differential protection367 Modernization of an Industrial Power Distribution and Automation System - Lessons Learned373 New Methods in Power Line Carrier Monitoring and Analysis: Real-World Examples and Implications for Protection System Reliability382 Benefits of using IEC 61850 messages for testing conventional protection schemes396
28 29 30 31 32 33 34 35	Impact of Inverter-based Resources on Impedance-based Protection Functions330 Implementation of a New Algorithm to Detect Turn-to-Turn Faults in Shunt Reactors and Identify the Faulted Phase339 Improving Protection Applications for Modern Industrial Switchgear Systems351 International Drive distribution loop protection361 Interoperability of line differential protection367 Modernization of an Industrial Power Distribution and Automation System - Lessons Learned373 New Methods in Power Line Carrier Monitoring and Analysis: Real-World Examples and Implications for Protection System Reliability382 Benefits of using IEC 61850 messages for testing conventional protection schemes396 Phasor-based Transient Earth-Fault Protection415
28 29 30 31 32 33 33 34 35	Impact of Inverter-based Resources on Impedance-based Protection Functions330 Implementation of a New Algorithm to Detect Turn-to-Turn Faults in Shunt Reactors and Identify the Faulted Phase339 Improving Protection Applications for Modern Industrial Switchgear Systems351 International Drive distribution loop protection361 Interoperability of line differential protection367 Modernization of an Industrial Power Distribution and Automation System - Lessons Learned373 New Methods in Power Line Carrier Monitoring and Analysis: Real-World Examples and Implications for Protection System Reliability382 Benefits of using IEC 61850 messages for testing conventional protection schemes396 Phasor-based Transient Earth-Fault Protection415 PRACTICAL ASPECTS OF DESIGNING SAFE AND COMPACT MV SWITCHGEAR USING "AIR CORE CT".
28 29 30 31 32 33 33 34 35 36	Implect of Inverter-based Resources on Impedance-based Protection Functions330 Implementation of a New Algorithm to Detect Turn-to-Turn Faults in Shunt Reactors and Identify the Faulted Phase339 Improving Protection Applications for Modern Industrial Switchgear Systems351 International Drive distribution loop protection361 Interoperability of line differential protection367 Modernization of an Industrial Power Distribution and Automation System - Lessons Learned373 New Methods in Power Line Carrier Monitoring and Analysis: Real-World Examples and Implications for Protection System Reliability382 Benefits of using IEC 61850 messages for testing conventional protection schemes396 Phasor-based Transient Earth-Fault Protection415 PRACTICAL ASPECTS OF DESIGNING SAFE AND COMPACT MV SWITCHGEAR USING "AIR CORE CT", "RESISTOR VOLTAGE DIVIDER VT" AND MODERN INTELLIGENT MICROPROCESSOR RELAYS441
28 29 30 31 32 33 34 35 36 37	Impact of inverter-based Resources on Impedance-based Protection Functions330 Implementation of a New Algorithm to Detect Turn-to-Turn Faults in Shunt Reactors and Identify the Faulted Phase339 Improving Protection Applications for Modern Industrial Switchgear Systems351 International Drive distribution loop protection361 Interoperability of line differential protection367 Modernization of an Industrial Power Distribution and Automation System - Lessons Learned373 New Methods in Power Line Carrier Monitoring and Analysis: Real-World Examples and Implications for Protection System Reliability382 Benefits of using IEC 61850 messages for testing conventional protection schemes396 Phasor-based Transient Earth-Fault Protection415 PRACTICAL ASPECTS OF DESIGNING SAFE AND COMPACT MV SWITCHGEAR USING "AIR CORE CT", "RESISTOR VOLTAGE DIVIDER VT" AND MODERN INTELLIGENT MICROPROCESSOR RELAYS441 Process Improvement of Distribution Protective Relays Coordination449

- 39 Restricted Earth-Fault (REF) Protection Challenges due to extensive use of Cables: A Case Study...462
- 40 Selecting, Implementing and Overcoming Challenges when Selecting a Coordination Criteria for Wide Area Applications...468
- 41 Testing IEC-61850 Sampled Values-Based Transformer Differential Protection Scheme...475

42 Tutorial on Sub-synchronous Resonance Protection Applied to Inverter Based Renewables...483

43 Using Virtual Synchronous Generators to Resolve Microgrid Protection Challenges...489

44 Validation Testing of IEC 61850 Process Bus Architecture in a Typical Digital Substation...496

45 Wide Area GOOSE and its Applications to System Integrity Protection Schemes...505