

1. Record Nr.	UNINA9910133703003321
Autore	Ibrahim Mohamed A. <1943->
Titolo	Disturbance analysis for power systems // Mohamed A. Ibrahim
Pubbl/distr/stampa	Hoboken, New Jersey : , : Wiley, , c2012 [Piscataway, New Jersey] : , : IEEE Xplore, , [2011]
ISBN	1-118-17211-6 1-118-17209-4 1-118-17210-8
Descrizione fisica	1 online resource (737 p.)
Disciplina	621.319
Soggetti	Electric power system stability Transients (Electricity) Electric power failures Electric network analysis
Lingua di pubblicazione	Inglese
Formato	Materiale a stampa
Livello bibliografico	Monografia
Note generali	Description based upon print version of record.
Nota di bibliografia	Includes bibliographical references and index.
Nota di contenuto	Preface xvii -- 1 POWER SYSTEM DISTURBANCE ANALYSIS FUNCTION 1 -- 1.1 Analysis Function of Power System Disturbances 2 -- 1.2 Objective of DFR Disturbance Analysis 4 -- 1.3 Determination of Power System Equipment Health Through System Disturbance Analysis 5 -- 1.4 Description of DFR Equipment 6 -- 1.5 Information Required for the Analysis of System Disturbances 7 -- 1.6 Signals to be Monitored by a Fault Recorder 8 -- 1.7 DFR Trigger Settings of Monitored Voltages and Currents 10 -- 1.8 DFR and Numerical Relay Sampling Rate and Frequency Response 11 -- 1.9 Oscillography Fault Records Generated by Numerical Relaying 11 -- 1.10 Integration and Coordination of Data Collected from Intelligent Electronic Devices 12 -- 1.11 DFR Software Analysis Packages 12 -- 1.12 Verification of DFR Accuracy in Monitoring Substation Ground Currents 21 -- 1.13 Using DFR Records to Validate Power System Short-Circuit Study Models 24 -- 1.14 COMTRADE Standard 31 -- 2 PHENOMENA RELATED TO SYSTEM FAULTS AND THE PROCESS OF CLEARING FAULTS FROM A POWER SYSTEM 33 -- 2.1 Shunt Fault Types Occurring in a Power System 33 -- 2.2 Classification of Shunt Faults 34 -- 2.3 Types of

Series Unbalance in a Power System 39 -- 2.4 Causes of Disturbance in a Power System 39 -- 2.5 Fault Incident Point 40 -- 2.6 Symmetric and Asymmetric Fault Currents 41 -- 2.7 Arc-Over or Flashover at the Voltage Peak 44 -- 2.8 Evolving Faults 48 -- 2.9 Simultaneous Faults 51 -- 2.10 Solid or Bolted (RF1/40) Close-in Phase-to-Ground Faults 52 -- 2.11 Sequential Clearing Leading to a Stub Fault that Shows a Solid (RF1/40) Remote Line-to-Ground Fault 53 -- 2.12 Sequential Clearing Leading to a Stub Fault that Shows a Resistive Remote Line-to-Ground Fault 54 -- 2.13 High-Resistance Tree Line-to-Ground Faults 56 -- 2.14 High-Resistance Line-to-Ground Fault Confirming the Resistive Nature of the Fault Impedance When Fed from One Side Only (Stub) 58 -- 2.15 Phase-to-Ground Faults on an Ungrounded System 59 -- 2.16 Current in Unfaulted Phases During Line-to-Ground Faults 60.

2.17 Line-to-Ground Fault on the Grounded-Wye (GY) Side of a Delta/GY Transformer 63 -- 2.18 Line-to-Line Fault on the Grounded-Wye Side of a Delta/GY Transformer 65 -- 2.19 Line-to-Line Fault on the Delta Side of a Delta/GY Transformer with No Source Connected to the Delta Winding 66 -- 2.20 Subcycle Relay Operating Time During an EHV Double-Phase-to-Ground Fault 68 -- 2.21 Self-Clearing of a C-g Fault Inside an Oil Circuit Breaker Tank 69 -- 2.22 Self-Clearing of a B-g Fault Caused by a Line Insulator Flashover 70 -- 2.23 Delayed Clearing of a Pilot Scheme Due to a Delayed Communication Signal 71 -- 2.24 Sequential Clearing of a Line-to-Ground Fault 72 -- 2.25 Step-Distance Clearing of an L-g Fault 74 -- 2.26 Ground Fault Clearing in Steps by an Instantaneous Ground Element at One End and a Ground Time Overcurrent Element at the Other End 76 -- 2.27 Ground Fault Clearing by Remote Backup Following the Failures of Both Primary and Local Backup (Breaker Failure) Protection Systems 78 -- 2.28 Breaker Failure Clearing of a Line-to-Ground Fault 79 -- 2.29 Determination of the Fault Incident Point and Classification of Faults Using a Comparison Method 81 -- 3 POWER SYSTEM PHENOMENA AND THEIR IMPACT ON RELAY SYSTEM PERFORMANCE 85 -- 3.1 Power System Oscillations Leading to Simultaneous Tripping of Both Ends of a Transmission Line and the Tripping of One End Only on an Adjacent Line 86 -- 3.2 Generator Oscillations Triggered by a Combination of L-g Fault, Loss of Generation, and Undesired Tripping of Three 138-kV Lines 91 -- 3.3 Stable Power Swing Generated During Successful Synchronization of a 200-MW Unit 95 -- 3.4 Major System Disturbance Leading to Different Oscillations for Different Transmission Lines Emanating from the Same Substation 96 -- 3.5 Appearance of 120-Hz Current at a Generator Rotor During a High-Side Phase-to-Ground Fault 98 -- 3.6 Generator Negative-Sequence Current Flow During Unbalanced Faults 101 -- 3.7 Inadvertent (Accidental) Energization of a 170-MW Hydro Generating Unit 102.

3.8 Appearance of Third-Harmonic Voltage at Generator Neutral 104 -- 3.9 Variations of Generator Neutral Third-Harmonic Voltage Magnitude During System Faults 106 -- 3.10 Generator Active and Reactive Power Outputs During a GSU High-Side L-g Fault 107 -- 3.11 Loss of Excitation of a 200-MW Unit 108 -- 3.12 Generator Trapped (Decayed) Energy 110 -- 3.13 Nonzero Current Crossing During Faults and Mis-Synchronization Events 112 -- 3.14 Generator Neutral Zero-Sequence Voltage Coupling Through Step-Up Transformer Interwinding Capacitance During a High-Side Ground Fault 113 -- 3.15 Energizing a Transformer with a Fault on the High Side within the Differential Zone 115 -- 3.16 Transformer Inrush Currents 118 -- 3.17 Inrush Currents During Energization of the Grounded-Wye Side of a YG/Delta Transformer 120 -- 3.18 Inrush Currents During Energization of a

Transformer Delta Side 121 -- 3.19 Two-Phase Energization of an Autotransformer with a Delta Winding Tertiary During a Simultaneous L-g Fault and an Open Phase 124 -- 3.20 Phase Shift of 30° Across the Delta/Wye Transformer Banks 127 -- 3.21 Zero-Sequence Current Contribution from a Remote Two-Winding Delta/YG Transformer 128 -- 3.22 Conventional Power-Regulating Transformer Core Type Acting as a Zero-Sequence Source 129 -- 3.23 Circuit Breaker Re-Strikes 130 -- 3.24 Circuit Breaker Pole Disagreement During a Closing Operation 132 -- 3.25 Circuit Breaker Opening Resistors 133 -- 3.26 Secondary Current Backfeeding to Breaker Failure Fault Detectors 134 -- 3.27 Magnetic Flux Cancellation 136 -- 3.28 Current Transformer Saturation 138 -- 3.29 Current Transformer Saturation During an Out-of-Step System Condition Initiated by Mis-Synchronization of a Generator Breaker 141 -- 3.30 Capacitive Voltage Transformer Transient 143 -- 3.31 Bushing Potential Device Transient During Deenergization of an EHV Line 144 -- 3.32 Capacitor Bank Breaker Re-Strike Following Interruption of a Capacitor Normal Current 146 -- 3.33 Capacitor Bank Closing Transient 147. 3.34 Shunt Capacitor Bank Outrush into Close-in System Faults 149 -- 3.35 SCADA Closing into a Three-Phase Fault 153 -- 3.36 Automatic Reclosing into a Permanent Line-to-Ground Fault 154 -- 3.37 Successful High-Speed Reclosing Following a Line-to-Ground Fault 155 -- 3.38 Zero-Sequence Mutual Coupling-Induced Voltage 156 -- 3.39 Mutual Coupling Phenomenon Causing False Tripping of a High-Impedance Bus Differential Relay During a Line Phase-to-Ground Fault 159 -- 3.40 Appearance of Nonsinusoidal Neutral Current During the Clearing of Three-Phase Faults 162 -- 3.41 Current Reversal on Parallel Lines During Faults 164 -- 3.42 Ferranti Voltage Rise 166 -- 3.43 Voltage Oscillation on EHV Lines Having Shunt Reactors at their Ends 168 -- 3.44 Lightning Strike on an Adjacent Line Followed by a C-g Fault Caused by a Separate Lightning Strike on the Monitored Line 172 -- 3.45 Spill Over of a 345-kV Surge Arrester Used to Protect a Cable Connection, Prior to its Failure 173 -- 3.46 Scale Saturation of an A/D Converter Caused by a Calibration Setting Error 174 -- 3.47 Appearance of Subsidence Current at the Instant of Fault Interruption 176 -- 3.48 Energizing of a Medium Voltage Motor that has an Incorrect Formation of the Stator Winding Neutral 177 -- 3.49 Phase Angle Change from Loading Condition to Fault Condition 179 -- 4 CASE STUDIES RELATED TO GENERATOR SYSTEM DISTURBANCES 183 -- 4.1 Generator Protection Basics 184 -- Case Studies 186 -- Case Study 4.1 Appearance of Double-Frequency (120-Hz) Current in a Hydrogenerator Rotor Due to Stator Negative-Sequence Current Flow During a 115-kV Phase-to-Ground Fault 186 -- Case Study 4.2 Inadvertent (Accidental) Energization of a 170-MW Hydro Unit 193 -- Case Study 4.3 Loss of Excitation for a 200-MW Generating Unit Caused by Human Error 204 -- Case Study 4.4 Loss-of-Excitation Trip in an 1100-MW Unit 212 -- Case Study 4.5 Mis-synchronization of a 50-MW Steam Unit for a Combined-Cycle Plant 214 -- Case Study 4.6 Mis-synchronization of a 200-MW Hydro Unit 222. Case Study 4.7 Undesired Tripping of a Numerical Differential Relay During Manual Synchronization of a Hydro Unit 231 -- Case Study 4.8 Tripping of a 500-MW Combined-Cycle Plant Triggered by a High-Side 138-kV Phase-to-Ground Fault 236 -- Case Study 4.9 Tripping of a 110-MW Combustion Turbine Unit in a Combined-Cycle Plant During a Power Swing 244 -- Case Study 4.10 Analysis of an 800-MW Generating Plant DFR Record for a Normally Cleared 345-kV Phase-to-Ground Fault 247 -- Case Study 4.11 Tripping of a 150-MW Combined-Cycle Plant Due to a Failed Lead of One Generator Terminal

Surge Capacitor 250 -- Case Study 4.12 Generator Stator Ground Fault in an 800-MW Fossil Unit 260 -- Case Study 4.13 Three-Phase Fault at the Terminal of an 800-MW Generator Unit 265 -- Case Study 4.14 Three-Phase Fault at the Terminal of a 50-MW Generator Due to a Cable Connection Failure 271 -- Case Study 4.15 Generator Stator Phase-to-Phase-to-Ground Fault Caused by Failure of the Rotor Fan Blade 276 -- Case Study 4.16 Undesired Tripping of a Pump Storage Plant During a Close-in Phase-to-Ground 345-kV Line Fault 286 -- Case Study 4.17 Tripping of an 800-MW Plant and the Associated EHV Lines During a 345-kV Bus Fault 293 -- Case Study 4.18 Tripping of a 150-MW Combined-Cycle Plant During an External 138-kV Three-Phase Fault 296 -- Case Study 4.19 Tripping of a 150-MW Combined-Cycle Plant During a Disturbance in the 138-kV Transmission System 303 -- Case Study 4.20 Undesired Tripping of a 150-MW Combined-Cycle Plant Following Successful Clearing of a 138-kV Double-Phase-to-Ground Fault 308 -- Case Study 4.21 Undesired Tripping of an Induction Generator by a Differential Relay Having a Capacitor Bank Within the Protection Zone 311 -- Case Study 4.22 Undesired Tripping of a Steam Unit Upon Its First Synchronization to the System During the Commissioning Phase of a Combined-Cycle Plant 314 -- Case Study 4.23 Sequential Shutdown of a Steam-Driven Generating Unit as Part of a 500-MW Combined-Cycle Plant 318. Case Study 4.24 Wiring Errors Leading to Undesired Generator Numerical Differential Relay Operation During the Commissioning Phase of a New Unit 320 -- Case Study 4.25 Phasing a New Generator into the System Prior to Commissioning 324 -- Case Study 4.26 Third-Harmonic Undervoltage Element Setting Procedure for 100% Stator Ground Fault Protection 327 -- Case Study 4.27 Basis for Setting the Generator Relaying Elements to Provide System Backup Protection 330 -- 5 CASE STUDIES RELATED TO TRANSFORMER SYSTEM DISTURBANCES 335 -- 5.1 Transformer Basics 336 -- 5.2 Transformer Differential Protection Basics 344 -- 5.3 Case Studies 347 -- Case Study 5.1 Energization of a 5-MVA 13.8/4.16-kV Station Service Transformer with a 13.8-kV Phase-to-Phase Bus Fault Within the Transformer Differential Protection Zone 347 -- Case Study 5.2 Lack of Protection Redundancy for a Generator Step-up Transformer Leads to Interruption of a 230-kV Area 353 -- Case Study 5.3 Undesired Operation of a Numerical Transformer Differential Relay Due to a Relay Setting Error in the Winding Configuration 357 -- Case Study 5.4 Location of a 13.8-kV Switchgear Phase-to-Phase Fault Using Transformer Differential Numerical Relay Fault Records 363 -- Case Study 5.5 Operation of a Unit Step-Up Transformer with an Open Phase on the 13.8-kV Delta Winding 370 -- Case Study 5.6 Using a Transformer Phasing Diagram, Digital Fault Recorder Record, and Relay Targets to Confirm the Damaged Phase of a Unit Auxiliary Transformer Failure 375 -- Case Study 5.7 Failure of a 450-MVA 345/138/13.2-kV Autotransformer 381 -- Case Study 5.8 Failure of a 750-kVA 13.8/0.480-kV Station Service Transformer Due to a Possible Ferroresonance Condition 387 -- Case Study 5.9 Undesired Tripping of a Numerical Transformer Differential Relay During an External Line-to-Ground Fault 394 -- Case Study 5.10 Undesired Operation of Numerical Transformer Differential Relays During Energization of Two 75-MVA 138/13.8-kV GSU Transformers 407 -- Case Study 5.11 Undesired Operation of a Numerical Transformer Differential Relay During Energization of a 5-MVA 13.8/4.16-kV Station Service Transformer 411. Case Study 5.12 Phase-to-Phase Fault Evolving into a Three-Phase Fault at the High Side of a 5-MVA 13.8/4.16-kV Station Service Transformer 414 -- Case Study 5.13 Phase-to-Phase Fault Evolving

into a Three-Phase Fault at the 13.8-kV Bus Connection of a 2-MVA 13.8/0.480-kV Station Service Enclosure 420 -- Case Study 5.14 Phase-to-Phase Fault in a 13.8-kV Switchgear Caused by Heavy Rain Evolving into a Three-Phase Fault 426 -- Case Study 5.15 Undesired Operation of a Numerical Transformer Differential Relay Due to a Missing CT Cable Connection as an Input to the Relay Wiring 430 -- Case Study 5.16 Phase-to-Ground Fault Caused by Flashover of a Transformer 115-kV Bushing Due to a Bird Droppings 434 -- Case Study 5.17 Using a Transformer Numerical Relay Oscillography Record to Analyze Phase-to-Ground Faults in a 4.16-kV Low-Resistance Grounding Supply 439 -- Case Study 5.18 Phase-to-Phase Fault Caused by a Squirrel in a 13.8-kV Cable Bus Which Evolves into a Three-Phase Fault 447 -- Case Study 5.19 13.8-kV Transformer Lead Phase-to-Phase Fault Due to Animal Contact, Evolving into a 115-kV Transformer Bushing Fault 451 -- Case Study 5.20 Undesired Tripping of a Numerical Multifunction Transformer Relay by Assertion of a Digital Input Wired to the Buchholz Relay Trip Output 456 -- 6 CASE STUDIES RELATED TO OVERHEAD TRANSMISSION-LINE SYSTEM DISTURBANCES 461 -- 6.1 Line Protection Basics 463 -- 6.2 Case Studies 466 -- Case Study 6.1 Using a DFR Record From One End Only to Determine Local and Remote-End Clearing Times for a Line-to-Ground Fault 466 -- Case Study 6.2 Analysis of Clearing Times for a Phase-to-Ground Fault from Both Ends of a 345-kV Transmission Line Using Oscillograms from One End Only 469 -- Case Study 6.3 Analysis of a Three-Phase Fault Caused by Lightning 471 -- Case Study 6.4 Analysis of a Double-Phase-to-Ground 765-kV Fault Caused by Lightning 473 -- Case Study 6.5 Assessment of Transmission Tower Footing Resistance by Analyzing a Three-Phase-to-Ground Fault Caused by Lightning 476. Case Study 6.6 115-kV Phase-to-Ground Fault Cleared First from a Solidly Grounded System, Then Connected and Cleared from an Ungrounded System 478 -- Case Study 6.7 345-kV Phase-to-Ground Fault (C-g) Caused by an Act of Vandalism 485 -- Case Study 6.8 345-kV Phase-to-Ground (A-g) Fault Due to an Accident Along the Line Right-of-Way 489 -- Case Study 6.9 False Tripping of a 138-kV Current Differential Relaying System During an External Phase-to-Ground Fault 495 -- Case Study 6.10 Undesired Operation of a 13.8-kV Feeder Ground Relay During a Three-Phase Fault Due to an Extra CT Circuit Ground 502 -- Case Study 6.11 Correction of a System Model Error from Analysis of a Failure of a Post Insulator Associated with a 115-kV Disconnect Switch 512 -- Case Study 6.12 Location of a 345-kV Line Fault Protected by Electromechanical Distance Relays Using Information from a DFR Record 519 -- Case Study 6.13 Location of an Outdoor 13.8-kV Switchgear Fault at a Cogeneration Facility Using a DFR Fault Record from a Remote Substation 524 -- Case Study 6.14 Breakage (Failure) of a 345-kV Subconductor Bundle During a High-Resistance Tree Fault, Due to the Heavily Loaded Line Sagging to a Tree 529 -- Case Study 6.15 115-kV Phase-to-Phase Fault Caused by Failure of a Circuit Switcher 536 -- Case Study 6.16 Undesired Tripping of a 115-kV Feeder Due to a Setting Application Error in the Time Overcurrent Element for a Numerical Line Protection Relay 539 -- Case Study 6.17 Mitigation of Mutual Coupling Effects on the Reach of Ground Distance Relays Protecting High and Extra-high-Voltage Transmission Lines 544 -- 7 CASE STUDIES RELATED TO CABLE TRANSMISSION FEEDER SYSTEM DISTURBANCES 571 -- Case Studies 572 -- Case Study 7.1 Optimum Design of Relaying Protection Zones Leads to Quick Identification of a Faulted 345-kV Submarine Cable Section 572 -- Case Study 7.2 Undesired Operation of a 138-kV Cable

Feeder Differential Relay During the Commissioning Phase of a 500-MW Plant 578 -- Case Study 7.3 Phase-to-Ground Fault Caused by Failure of a 345-kV Cable Connection Between the Generator and the Switchyard, Accompanied by Mechanical Failure of One of the Cable Pot Head Phases 588.

Case Study 7.4 Troubleshooting a 345-kV Phase-to-Ground Fault Using Relay Targets Only 595 -- Case Study 7.5 Failure of a 345-kV Cable Connection Between a 300-MW Generator and a 345-kV Switchyard, Causing a Phase-to-Ground Fault 603 -- Case Study 7.6 138-kV Cable Pot Head Failure Analysis Using Numerical Current Differential Relay Oscillography and Event Records 607 -- 8 CASE STUDIES RELATED TO BREAKER FAILURE PROTECTION SYSTEM DISTURBANCES 615 -- 8.1 Breaker Failure Protection Basics 616 -- Case Studies 626 -- Case Study 8.1 Tripping of a Combined-Cycle 150-MW Plant by Undesired Operation of a Solid-State Breaker Failure Relaying System 626 -- Case Study 8.2 115-kV Dual Breaker Failures Resulting in the Loss of a 1000-MW Plant and Associated Substations 634 -- Case Study 8.3 230-kV Substation Outage Due to Circuit Breaker Problems During the Clearing of a Close-in Phase-to-Ground Fault 640 -- Case Study 8.4 Failure of a 230-kV Circuit Breaker Leading to Isolation of a 1000-MW Plant and Associated Substations 646 -- Case Study 8.5 Generator CB Failure During Automatic Synchronization of the Circuit Breaker 654 -- Case Study 8.6 Circuit Breaker Re-strikes While Clearing Simultaneous Phase-to-Ground Faults on a 230-kV Double-Circuit Tower 660 -- Case Study 8.7 345-kV Capacitor Bank Breaker Fault Coupled with an Additional Failure of a Dual SF6 Pressure 345-kV Breaker During the Clearing of the Fault 664 -- Case Study 8.8 Oil Circuit Breaker Failure Following the Clearing of a Failed 230-kV Surge Arrester 671 -- Case Study 8.9 Detection of a Remote Circuit Breaker Problem from Analysis of a Local Oscillogram Monitoring Line Currents and Voltages 676 -- Case Study 8.10 Blackout of a 138-kV Load Area Due to a Primary Relay System Failure and the Lack of DC Control Power for the Secondary Relay System Circuit 678 -- Case Study 8.11 Installation of Two 345-kV Breakers in Series Within a Ring Substation Configuration to Mitigate the Loss of Critical Lines During Breaker Failure Events 682. Case Study 8.12 Design of Two 138-kV Circuit Breakers in Series to Fulfill the Need of Breaker Failure Protection 682 -- 9 PROBLEMS 685 -- Index 715.

Sommario/riassunto

More than ninety case studies shed new light on power system phenomena and power system disturbances. Based on the author's four decades of experience, this book enables readers to implement systems in order to monitor and perform comprehensive analyses of power system disturbances. Most importantly, readers will discover the latest strategies and techniques needed to detect and resolve problems that could lead to blackouts to ensure the smooth operation and reliability of any power system. Logically organized, Disturbance Analysis for Power Systems begins with an introduction to the
