

| | |
|-------------------------|---|
| 1. Record Nr. | UNINA9910140499503321 |
| Autore | Sutherland Peter E. |
| Titolo | Principles of electrical safety // Peter E. Sutherland |
| Pubbl/distr/stampa | Hoboken, New Jersey : , : IEEE Press/Wiley, , [2015] [Piscataqay, New Jersey] : , : IEEE Xplore, , [2014] |
| ISBN | 1-118-88639-9 1-118-95034-8 1-118-95035-6 |
| Descrizione fisica | 1 online resource (795 p.) |
| Collana | IEEE press series on power engineering |
| Disciplina | 621.3028 621.30289 |
| Soggetti | Electrical engineering - Safety measures Electricity - Safety measures Electric apparatus and appliances - Safety measures |
| 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 (pages 352-360) and index. |
| Nota di contenuto | LIST OF FIGURES xiii -- LIST OF TABLES xxv -- PREFACE xxix -- ACKNOWLEDGMENTS xxxvii -- CHAPTER 1 MATHEMATICS USED IN ELECTROMAGNETISM 1 -- 1.1 Introduction 1 -- 1.2 Numbers 2 -- 1.3 Mathematical Operations with Vectors 17 -- 1.4 Calculus with Vectors- The Gradient 18 -- 1.5 Divergence, Curl, and Stokes' Theorem 23 -- 1.6 Maxwell's Equations 25 -- CHAPTER 2 ELECTRICAL SAFETY ASPECTS OF THE RESISTANCEPROPERTY OF MATERIALS 30 -- 2.1 Introduction 30 -- 2.2 Hazards Caused by Electrical Resistance 31 -- 2.3 Resistance and Conductance 38 -- 2.4 Example-Trunk of a Human Body 42 -- 2.5 Example-Limb of a Human Body 43 -- 2.6 Power and Energy Flow 44 -- 2.7 Sheet Resistivity 47 -- 2.8 Example-Square of Dry Skin 48 -- 2.9 Spreading Resistance 48 -- 2.10 Example-Circle of Dry Skin 49 -- 2.11 Particle Conductivity 50 -- 2.12 Examples-Potassium, Sodium, and Chlorine Ions 53 -- 2.13 Cable Resistance 53 -- CHAPTER 3 CAPACITANCE PHENOMENA 59 -- 3.1 Fundamentals of Capacitance 59 -- 3.2 Capacitance and Permittivity 62 -- 3.3 Capacitance in Electrical Circuits 65 -- 3.4 Capacitance of Body Parts 69 -- 3.4.1 Example-Skin Capacitance 69 -- 3.4.2 Example-Capacitance of Trunk and Limb 70 -- |

3.5 Electrical Hazards of Capacitance 71 -- 3.6 Capacitance of Cables 72 -- CHAPTER 4 INDUCTANCE PHENOMENA 74 -- 4.1 Inductance in Electrical Theory 74 -- 4.2 Inductance of Wires 76 -- 4.3 Example-Inductance of a Conductor 76 -- 4.4 Example-Inductance of Trunk and Limb 77 -- 4.5 Inductors or Reactors 77 -- 4.6 Skin Effect 77 -- 4.7 Cable Inductance 81 -- 4.8 Surge Impedance 83 -- 4.9 Bus Bar Impedance Calculations 84 -- CHAPTER 5 CIRCUIT MODEL OF THE HUMAN BODY 90 -- 5.1 Calculation of Electrical Shock Using the Circuit Model of the Body 90 -- 5.2 Frequency Response of the Human Body 93 -- CHAPTER 6 EFFECT OF CURRENT ON THE HUMAN BODY 101 -- 6.1 Introduction to Electrical Shock 101 -- 6.2 Human and Animal Sensitivities to Electric Current 102 -- 6.3 Human Body Impedance 104 -- 6.4 Effects of Various Exposure Conditions 107.

6.4.1 Bare Feet, Wet Conditions, and Other Variations 107 -- 6.4.2 Shoes and Other Insulated Objects and the Earth 108 -- 6.5 Current Paths Through the Body 108 -- 6.6 Human Response to Electrical Shock Varies with Exposure Conditions, Current Magnitude, and Duration 113 -- 6.7 Medical Imaging and Simulations 114 -- CHAPTER 7 FUNDAMENTALS OF GROUND GRID DESIGN 118 -- 7.1 Introduction to Ground Grid Design 118 -- 7.2 Summary of Ground Grid Design Procedures 119 -- 7.2.1 Site Survey 119 -- 7.2.2 Conductor Sizing 119 -- 7.2.3 Step and Touch Voltages 122 -- 7.2.4 Ground Grid Layout 124 -- 7.2.5 Ground Resistance Calculation 124 -- 7.2.6 Calculation of Maximum Grid Current 125 -- 7.2.7 Calculation of Ground Potential Rise (GPR) 125 -- 7.2.8 Calculation of Mesh Voltage, E_m 125 -- 7.2.9 Calculation of Step Voltage, E_s 127 -- 7.2.10 Detailed Design 127 -- 7.3 Example Design from IEEE Standard 80 128 -- CHAPTER 8 SAFETY ASPECTS OF GROUND GRID OPERATION AND MAINTENANCE 138 -- 8.1 Introduction 138 -- 8.2 Effects of High Fault Currents 138 -- 8.3 Damage or Failure of Grounding Equipment 142 -- 8.3.1 Thermal Damage to Conductors Due to Excessive Short-Circuit Currents 142 -- 8.3.2 Connector Damage Due to Excessive Short-Circuit Stresses 143 -- 8.3.3 Drying of the Soil Resulting in Increased Soil Resistivity 144 -- 8.4 Recommendations 145 -- CHAPTER 9 GROUNDING OF DISTRIBUTION SYSTEMS 147 -- 9.1 Stray Currents in Distribution Systems 147 -- 9.2 Three-Phase Multigrounded Neutral Distribution Line 148 -- 9.3 Secondary Systems: 120/240 V Single Phase 154 -- 9.3.1 Example of Stray Currents-Touching a Grounded Conductor 158 -- 9.3.2 Example of Stray Currents-With One Conductor Shorted to Neutral 159 -- 9.4 Remediation of Stray-Current Problems 160 -- 9.5 Grounding and Overvoltages in Distribution Systems 163 -- 9.6 High-Resistance Grounding of Distribution Systems 167 -- 9.6.1 Methods of Determining Charging Current 169 -- CHAPTER 10 ARC FLASH HAZARD ANALYSIS 172 -- 10.1 Introduction to Arc Flash Hazards 172. 10.2 Factors Affecting the Severity of Arc Flash Hazards 176 -- 10.3 Example Arc Flash Calculations 179 -- 10.4 Remediation of Arc Flash Hazards 180 -- 10.4.1 Example: Correcting an Arc Flash Problem When a Coordination Problem Requires Replacing Trip Units 180 -- 10.4.2 Example: Correcting a Coordination Problem Without Introducing an Arc Flash Problem 182 -- 10.5 Coordination of Low-Voltage Breaker Instantaneous Trips for Arc Flash Hazard Reduction 185 -- 10.5.1 Hospital #1-Time-Current Curve Examples 189 -- 10.5.2 Hospital #2-Time-Current Curve Examples 194 -- 10.5.3 Hospital #3-Time-Current Curve Examples 200 -- 10.6 Low-Voltage Transformer Secondary Arc Flash Protection using Fuses 205 -- CHAPTER 11 EFFECT OF HIGH FAULT CURRENTS ON PROTECTION AND METERING 216 -- 11.1 Introduction 216 -- 11.2 Current Transformer Saturation 217 -- 11.3 Saturation of Low-Ratio CTs 219 -- 11.3.1 AC Saturation 219 -- 11.3.2

DC Saturation 221 -- 11.4 Testing of Current Transformer Saturation 224 -- 11.5 Effect of High Fault Currents on Coordination 228 -- 11.6 Protective Relay Ratings and Settings 230 -- 11.7 Effects of Fault Currents on Protective Relays 232 -- 11.7.1 Examples 233 -- 11.8 Methods for Upgrading Protection Systems 233 -- 11.8.1 Update Short-Circuit Study 233 -- 11.8.2 Update Protective Device Coordination Study 233 -- CHAPTER 12 EFFECTS OF HIGH FAULT CURRENTS ON CIRCUIT BREAKERS 235 -- 12.1 Insufficient Interrupting Capability 236 -- 12.2 High Voltage Air Circuit Breakers 236 -- 12.3 Vacuum Circuit Breakers 237 -- 12.4 SF6 Circuit Breakers 239 -- 12.5 Loss of Interruption Medium 241 -- 12.6 Interrupting Ratings of Switching Devices 242 -- 12.7 Circuit Breakers 243 -- 12.8 Fuses 244 -- 12.9 Case Studies 245 -- 12.9.1 Example: Diablo Canyon 245 -- 12.9.2 Example: Dresden and Quad Cities 248 -- 12.10 Low-Voltage Circuit Breakers 249 -- 12.11 Testing of Low-Voltage Circuit Breakers 251 -- 12.11.1 Testing of Low-Voltage Molded-Case Circuit Breakers According to UL Standard 489 252. 12.11.2 Testing of Low-Voltage Molded-Case Circuit Breakers for Use With Uninterruptible Power Supplies According to UL Standard 489 259 -- 12.11.3 Testing of Supplementary Protectors for Use in Electrical Equipment According to UL Standard 1077 261 -- 12.11.4 Testing of Transfer Switch Equipment According to UL Standard 1008 272 -- 12.11.5 Testing of Low-Voltage AC Power Circuit Breakers According to ANSI Standard C37.50-1989 276 -- 12.11.6 Testing of Low-Voltage DC Power Circuit Breakers According to IEEE Standard C37.14-2002 280 -- 12.11.7 Testing of Low-Voltage Switchgear and Controlgear According to IEC Standard 60947-1 284 -- 12.11.8 Testing of Low-Voltage AC and DC Circuit Breakers According to IEC Standard 60947-2 285 -- 12.11.9 Testing of Circuit Breakers Used for Across-the-Line Starters for Motors According to IEC /Standard 60947-4-1 288 -- 12.11.10 Testing of Circuit Breakers Used in Households and Similar Installations According to IEC Standard 60898-1 and -2 290 -- 12.11.11 Testing of Circuit Breakers Used in Equipment such as Electrical Appliances According to IEC Standard 60934 293 -- 12.12 Testing of High-Voltage Circuit Breakers 296 -- CHAPTER 13 MECHANICAL FORCES AND THERMAL EFFECTS IN SUBSTATION EQUIPMENT DUE TO HIGH FAULT CURRENTS 299 -- 13.1 Introduction 299 -- 13.2 Definitions 299 -- 13.3 Short-Circuit Mechanical Forces on Rigid Bus Bars 300 -- 13.3.1 Short-Circuit Mechanical Forces on Rigid Bus Bars-Circular Cross Section 300 -- 13.3.2 Short-Circuit Mechanical Forces-Rectangular Cross Section 302 -- 13.4 Dynamic Effects of Short Circuits 302 -- 13.5 Short-Circuit Thermal Effects 304 -- 13.6 Flexible Conductor Buses 305 -- 13.6.1 Conductor Motion During a Fault 307 -- 13.6.2 Pinch Forces on Bundled Conductors 311 -- 13.7 Force Safety Devices 316 -- 13.8 Substation Cable and Conductor Systems 318 -- 13.8.1 Cable Thermal Limits 318 -- 13.8.2 Cable Mechanical Limits 319 -- 13.9 Distribution Line Conductor Motion 319 -- 13.10 Effects of High Fault Currents on Substation Insulators 320. 13.10.1 Station Post Insulators for Rigid Bus Bars 320 -- 13.10.2 Suspension Insulators for Flexible Conductor Buses 322 -- 13.11 Effects of High Fault Currents on Gas-Insulated Substations (GIS) 322 -- CHAPTER 14 EFFECT OF HIGH FAULT CURRENTS ON TRANSMISSION LINES 325 -- 14.1 Introduction 325 -- 14.2 Effect of High Fault Current on Non-Ceramic Insulators (NCI) 325 -- 14.3 Conductor Motion Due to Fault Currents 328 -- 14.4 Calculation of Fault Current Motion for Horizontally Spaced Conductors 329 -- 14.5 Effect of Conductor Shape 330 -- 14.6 Conductor Equations of Motion

331 -- 14.7 Effect of Conductor Stretch 332 -- 14.8 Calculation of Fault Current Motion for Vertically Spaced Conductors 332 -- 14.9 Calculation Procedure 333 -- 14.10 Calculation of Tension Change with Motion 334 -- 14.11 Calculation of Mechanical Loading on Phase-to-Phase Spacers 335 -- 14.12 Effect of Bundle Pinch on Conductors and Spacers 336 -- CHAPTER 15 LIGHTNING AND SURGE PROTECTION 338 -- 15.1 Surge Voltage Sources and Wave shapes 338 -- 15.2 Surge Propagation, Refraction, and Reflection 343 -- 15.3 Insulation Withstand Characteristics and Protection 346 -- 15.4 Surge Arrester Characteristics 349 -- 15.5 Surge Arrester Application 350 -- REFERENCES 352 -- INDEX 361.

Sommario/riassunto

This book fills a void in the market by describing current knowledge in electrical safety as industry needs electrical engineers who have been trained in safety engineering education. Electrical safety is an often-neglected area of electrical power engineering, and electrical safety measures in industry are not always applied in electrical engineering laboratories of educational institutions. Since the industry is in need of electrical engineers who have been properly trained in safety engineering education, Sutherland has presented several up-to-date topics in the field. . Provides a high-level introduction to the educated electrical engineer in any field who needs to know about electrical safety. Presents the subject of electrical safety to a wider audience. Includes an introduction to theory followed by a series of practical applications. Examines the electrical fundamentals of resistance, inductance and capacitance as applied to the human body. With an in-depth evaluation of electrical engineering safety measures, this book is designed to become part of the preparation of every current and future engineer. Principles of Electrical Safety will also be a suitable guide for lab setting in academic institutions.
