

Index

a

activity plan 318
 agricultural enterprise 21
 annual increase factor 12
 annuity factor 44, 156
 annuity method 38
 ANSI code numbers 237
 arrester, protection level 245
 assessment of losses 38–40, 42–43
 – added losses 42
 – energy costs 43
 – energy loss factor 41
 – loss hours 42
 – production costs 43
 atmospheric correction factor 254
 autoreclosure 230
 autotransformers 83

b

back-flashover 245
 biomass 207
 breakers 74
 buchholz protection 235
 busbar sectionalizer 193
 business enterprises 18

c

cable abbreviation codes 111
 cable loading 130
 – cross-bonding 130
 – example 127
 – flat formation 130
 – thermally unfavorable areas 129
 – triangle formation 130
 cable losses 118
 cable routes 127
 cable screens 134
 – constants of materials 135
 – short-circuit temperatures 135

cable 112–117, 132
 – alphanumeric abbreviations 112
 – charging currents 115
 – dare for capacitances 115
 – electrical parameters 114
 – impregnated paper insulation 112
 – inductive reactances 116
 – maximal permissible temperature 117
 – permissible short-circuit current 132, 134
 – plastic insulation 113
 – rated short-time current density 132
 – short-circuit 132
 cables trenches 127
 – minimum distance 128
 – rights-of-way 128
 – water pipe 128
 circuit-breakers 74
 conductor sag 150, 156
 conductor shape 111
 continuous power frequency voltage 239, 242
 contracting 289
 – project definition 289
 contracting 317
 contribution of motors 177, 183
 coordination withstand voltage 252–253
 – deterministic coordination factor 253
 – deterministic procedure 252
 – external insulation 254
 – internal insulation 253
 – statistical procedure 252
 corona damping 246, 248
 corona discharges 148
 cost estimate 156
 cost 38
 coupling of busbars 192

- current transformer 75, 77, 221
 - accuracy 75
 - categories 77
 - IEC 60044 76
 - overcurrent factor 76
 - remanence flux 77
- currents through earth 175–176
 - capacitive earth-fault current 176
 - ground fault residual current 176
 - single-phase short-circuit current 176

d

- daily load curves 17
- degree of electrification 16
- design criteria 290
- development banks 293
- differential protection 231, 233
 - intermediate transformers 233
- disconnecting switches 75
- distance protection 229
 - grading time 229
 - single-phase faults 229
 - threshold value 229
- distance protection 234
- distance 226
- dynamization factor 17

e

- earth conductivity 251
- earth fault factor 242
- earth resistance 251
- earth-fault compensation 224
- earth-fault factors 267
- earthing impedance 199
- earthing of neutrals 284
 - HV side and LV side 284
- earthing of neutrals 9
- earthing resistance 251
- earthing with current limitation 268
- economy 9
- electrical length 159
- electromagnetic fields 9
- EMTP/ATP 257
- EN 50052 74
- EN 50064 74
- EN 50341-1 149
- EN 50423-1 149
- equivalent voltage source* 176
- evaluation of tender 312
- evaluation 317
 - financial evaluation 317
 - technical evaluation 317
- external insulation 240

f

- FACTS 8
- FACTS, see flexible AC transmission system 159
- fast-front overvoltage 239
- fast-front overvoltages 245–246, 249–250, 252
 - calculation 252
 - detailed calculation 246
 - direct strokes 249
 - failure rate 249
 - impact radius 249
 - representative overvoltage 250
 - simplified approach 245
 - steepness 250
- ferranti effect 244
- ferro-resonances 80
- FIDIC 294, 298
- flexible AC transmission system 159
- flicker 187, 207, 213–214
- fuel-cell 207
- full-load hours 41
- fuses 75, 194

g

- gas losses 303
- GDP 13
- GEC 13
- GNP 13
- grading time 224, 228, 235
- green-energy 47, 205, 208
 - connection 205
 - Flicker 213
 - harmonics 211
 - interharmonics 211
 - PCC 205
 - protection 209
 - reactive power compensation 209
 - short-circuit currents 209
 - system studies 208
 - unbalance factor 215
 - voltage increase 211
- gridstations and substations 71, 72, 73
 - double busbar 72
 - reserve busbar 73
 - single busbar with sectionalizer 71
 - special H-arrangement 71
- gridstations and substations 69
 - single busbar 69
- ground-fault protection 231
 - “cos Ω ” measurement 232
 - “sin Ω ” measurement 232
 - fifth harmonic 232
 - isolated neutral 232

- resonance earthing 232
- transient 231–232
- ground-fault protection 234

h

- harmonic 211
- holmgreen 221
- hot-spot temperature 93
 - actual temperature profile 93
 - simulated temperature profile 93
 - weighted ambient temperature 93
- households 16
- HV transmission systems 62

i

- IEC 60038 28, 47, 188, 210, 242
- IEC 60044 302
- IEC 60066 303
- IEC 60071 241
- IEC 60071-1 242
- IEC 60071-2 243, 245, 252
- IEC 60076-7 91, 95
- IEC 60085 90
- IEC 60287 126
- IEC 60354 90, 92–93
 - hot-spot temperature 92
 - reduction of lifetime 92
- IEC 60354 95
- IEC 60617-7 237
- IEC 60853-2 126
- IEC 60865 108, 175
- IEC 60865-1 106, 152
- IEC 60890 74
- IEC 60905 84, 102–103
- IEC 60909 175, 178
 - voltage factor 178
- IEC 60909-0 107
- IEC 60947 74
- IEC 61000 211
- IEC 61000-3-11 213
- IEC 61000-3-12 211
- IEC 61000-3-2 211
- IEC 61000-3-3 213
- IEC 61660 175
- IEC 77A/136/CDV 214
- IEC/TR 62095 126
- IEEE C37.2 237
- impedance voltage 199
- individual load profiles 17
- initial short-circuit current 179
- insulation coordination 241
 - range I 241
 - range II 241

- insulation coordination 257
 - example 257
 - insulation coordination 8
 - insulation materials 114
 - interest factor 38
 - interest rate 38
 - interference 9
 - interharmonic 211
 - internal insulation 240
 - I_p limiter 194
 - ISO 9000 295
 - isoceraunic level 249
 - isolated neutral 270–275
 - earth-fault current 271
 - overvoltage factor 275
 - recovery voltage 273
 - reignition of fault 274
 - self-extinguishing 272
 - transient frequency 274
 - voltage displacement 273
- I**
- large generation plants 206
 - length of insulation 148
 - lightning currents 247
 - parameters 247
 - lightning impulse withstand voltage 149
 - lightning overvoltage 245
 - lightning protection angle 244
 - limit distance 246, 248
 - limitation of short-circuit currents 187
 - examples 187
 - line corridor, width 155
 - load assumptions 16
 - load densities 15
 - load factor 41, 126
 - load forecast 11–14, 17
 - degrees of electrification 14
 - economic characteristic data 13
 - estimated values 14
 - load increase factors 12
 - specific loads 14
 - standardized load curves 17
 - load profile 18, 21
 - household 18
 - other consumer 18
 - load 174
 - constant current 174
 - constant impedance 174
 - constant power 174
 - load pattern 175
 - measurement 174
 - load-break switches 74

- load-flow analysis 7, 173–175
 - FACTS 173
 - PQ busbars 174
 - PV busbar 174
 - slack 174
- loading of cables 125–126
 - characteristic diameter 125
 - cyclic rating 126
 - emergency rating 126
 - standard conditions 125
 - thermal parameters 124
- load-shedding 243
- losses 39
 - energy losses 39
 - no-load losses 39
- low-impedance earthing 264, 285

m

- maximal conductor sag 149
- maximum load portion 39
 - degree of utilization 40
 - power losses 40
- meshed systems 62, 64–65, 226
 - HV and MV levels 62
 - LV level 65
 - multiple-line supply 65
 - MV systems 64
 - single-line supply 65
 - station-by-station 65
- multiple busbar operation 193

n

- natural power 159
- negative-sequence component 178
- network protection 9
- neutral earthing 263
- non-self-restoring insulation 240
- norms 321

o

- OHL loading 137–138, 142–145
 - convection 142
 - correction factor 143
 - emission coefficients 143
 - example 145
 - forced convection 144
 - grashof factor 144
 - heat balance 138
 - modulus of elasticity 137
 - nusselt factor 144
 - prandtl factor 144
 - radiation 142
 - reynolds factor 144
 - tensile strength 137

- OHL 141, 145, 148, 151
 - AC resistance 141
 - electric field strength 145
 - mechanical design 148
 - minimum distances 148
 - polluted areas 148
 - short-circuit 151
 - specific creepage distance 148
- overcurrent protection 234
- overhead line, see OHL 137
- overvoltage return rate 245
- overvoltages 239

p

- parallel compensation 162–163
- peak short-circuit current 179
 - accuracy 182
 - equivalent frequency 182
 - meshed power system 181
 - peak factor 179
 - safety factor 182
- permissible current of cables 116
- permissible thermal loading 8
- petersen coil 275, 282
 - limits 282
 - plunger-coil 282
 - tuning 282
- phase-shifting 162, 166
- photovoltaic 207
- planning criteria 30, 31, 32, 33, 34
 - extra-high-voltage 32
 - faults 34
 - high-voltage 32
 - IEC 60038 30
 - independent outages 33
 - loading of equipment 33
 - load-shedding 34
 - loss of generation 34
 - loss of load 34
 - low-voltage 31
 - medium-voltage 32
 - multiple outages 33
 - single outage 32–33
 - stability 34
 - voltage band 30
 - voltage tolerance 31
- planning principle 23–25
 - disturbance statistics 24
 - energy not supplied 25
 - frequency of outages 24
 - loss of power 25
 - reliability 23

planning, basics 26–28, 30

- economy 30
- frequency control 28
- generation 27
- IEC 60038 28
- loading of the equipment 26
- preloading conditions 27
- realization times 28
- short-circuit currents 27
- voltage level 28

 positive-sequence component 178, 266

 power quality 205

 power system planning 4, 5, 7

- needs 4
- systematic approach 4

 power system planning 5, 7

- basic planning 5
- instruments 7
- objective 5
- project planning 7
- system development planning 5

 power system 45

- sub-transmission 45
- transmission grid 45

 power system 46

- distribution 46

 power systems topology 48, 67

- meshed systems 48
- operating considerations 67
- radial systems 48
- ring-main systems 48

 present value 37, 44, 105

 primary reserve 35

 project funding 293

 project implementation schedule 290

 project schedule 319

 protection of busbars 236

- current criteria 236
- differential protection 236
- high-impedance protection 237
- impedance criteria 237
- switching image 237
- UMZ 236

 protection of lines 223

 protection of transformers 233

- ground-fault protection 235
- protection measures 234

 protection 217, 226

- criteria 219
- faults 219
- general 220

 proximity effect 119, 139

r

radial power system 224

 radial system 48, 49, 50

 rated voltage 254

- IEC 60071-1 254

 regulations 2

 reliability 1, 23

 representative overvoltage 242

 required withstand voltage 252

 resonance earthing 275, 277–279, 281, 285, 287

- asymmetry 279, 281
- damping 277, 281
- detuning factor 277, 281
- displacement voltage 279, 281
- earth-fault current 278
- example 285
- harmonics 278
- resonance frequency 277
- self-extinguishing 278

 restrictions, legal, political, social 2

 restructuring of power system 193

 right-of-way 153

- example 155

 ring-main systems 50, 52, 53, 54, 56, 57, 58, 59, 60

- application 52–54, 56–59
- base station 59
- cross-link 58
- remote station 52, 56
- reserve line 53
- special-spare cable system 60
- topology 50
- triple 57

 ring-main systems 61

- application 61, 62
- double-T connection 61, 62

s

saturation level 12

 scope of activities 292

- construction phase 292
- power system studies 292
- tender evaluation 292

 scope of supply 308–309

- reactors 309
- switchgear 308
- transformers 309

 scope of work 308

 security 2

security 218

 selection of recommended voltage 189

selectivity 217

 self-protection of substation 248

- self-restoring insulation 240
 - self-restoring insulation 272
 - sensitivity* 217
 - serial compensation 162
 - serial compensation 165
 - sheath losses 119
 - short-circuit current calculations 7
 - short-circuit current density 108
 - short-circuit current 180
 - impedance correction 180
 - short-circuit currents 175, 187
 - far-from-generator 176
 - interference 175
 - limitation 187
 - near-to-generator 176
 - protection 175
 - stability 175
 - voltage factor 178
 - short-circuit limiting reactor 199
 - short-circuit strength 106
 - short-circuit withstand 132, 151, 185
 - electromagnetic effect 185
 - maximal permissible temperatures 151
 - thermal effects 185
 - short-time current density 153
 - skin effect 119, 139
 - slow-front overvoltage 239
 - slow-front overvoltages 243–244
 - autoreclosing 244
 - case-related analysis 244
 - load-shedding 244
 - phase-related analysis 244
 - statistical dispersion 243
 - small hydro plants 206
 - soil characteristic 120
 - thermally stabilized 123
 - soil characteristics 120
 - humidity content 120
 - temperature 120
 - thermal conductivity 120
 - solar radiation 140
 - irradiation angle 140
 - solar radiation 141
 - degree of latitude 141
 - special-spare cable system 60
 - specification 290
 - speed* 218
 - spirality-effect 140
 - stability analyses 8
 - stability 168
 - FACTS 170
 - improvement 168
 - stability 187
 - standard insulation levels 255–256
 - in range II 256
 - range I 255
 - standard test voltages 254
 - standards 321
 - statistic 218
 - steady-state short-circuit current 183
 - stefan–boltzmann law 142
 - subtransient reactance 201
 - surge impedance 159
 - switches 74
 - switching impulse withstand voltage 149
 - symmetrical short-circuit breaking current 182
 - system separation 189
- t**
- T-connections 49
 - application 50
 - technical data sheets 310–315
 - sample 311–315
 - technical specifications 300–304, 306–307
 - AC-supply 307
 - breakers 302
 - cables 306
 - DC-supply 307
 - general parameters 301
 - medium-voltage switchgear 303
 - metal-clad switchgear 301
 - overhead lines 304
 - protection 304
 - reactors 306
 - scope of tender 301
 - switches 302
 - transformers 306
 - temporary overvoltage 239, 242
 - tender documents 294–297, 308
 - approval 294
 - awarding of contracts 294
 - environmental aspects 297
 - general technical requirements 296
 - planning and design 295
 - prequalification 294
 - short listing 295
 - tender structure 297–299
 - conditions of contract 298
 - lots 297
 - sample price sheet 299
 - tender set-up 298
 - tendering 289
 - project definition 289
 - tensile stress 149
 - terms of reference 291

- test conversion factor 256
 - three-winding transformers 83
 - TOR, see terms of reference 291
 - tower arrangement 153
 - transducers 220
 - transferable power 164–165
 - transferable power, general 161
 - transferable 167
 - transformer loading 95–104
 - continuous loading 96, 98
 - current 97
 - distribution transformers 95
 - dry-type transformers 102
 - example 99, 101, 104
 - hot-spot temperature 100, 103
 - large power transformers 96
 - loading conditions 96
 - long-time emergency operation 96, 100
 - maximal permissible temperature rise 103
 - medium-sized transformers 95
 - normal cyclic load 96, 98
 - oil-immersed transformers 95
 - short-time emergency operation 96, 100
 - temperature 97
 - thermal class 103
 - transformer 81, 83–84, 86–90, 92, 94, 105–106
 - climatic classes 84
 - dry-type 83
 - economical operation 105
 - efficiency curve 105
 - environmental class 84
 - oil-immersed 83
 - rated apparent power 81
 - short-circuit strength 106
 - standard operating conditions 84
 - temperature correction 94
 - transformers 85
 - cooling 85, 91
 - insulation 85
 - kapp's triangle 86
 - montsinger's law 90
 - permissible loading of neutral 88
 - phase-shift 88
 - tap-changers 87
 - thermal classes of insulation 91
 - thermal permissible loading 88
 - vector group 89
 - voltage drop 86
 - transient overvoltage 239
 - transient stability 8
 - trip-release 220
 - type testing 253
 - types of cooling 98
- u**
- UCTE 34
 - UCTE 45
 - UMZ 224
- v**
- VDE 0276-1000 124
 - very-fast-front overvoltage 240
 - voltage factor 177
 - voltage fluctuation 210
 - voltage increase 210
 - voltage level 188, 206
 - voltage transformer 78–79, 221
 - accuracy 79
 - rate voltage factor 79
 - voltage unbalance 214
- w**
- width of the line corridor 154–155
 - wind energy plants 207
- z**
- zero-sequence component 178, 266, 287

