

Index

Note: ***Bold italic*** type refers to entries in the Table of Contents, * refers to a Standard Title and Reference number and # refers to a specific standard within the buff book

- 91, 40, 48*
100, 8, 22*, 101*, 131*
11.10 #242, 47*, 77, 99
C37.1, 22*
C37.2, 48*, 81, 311
C37.91, 48, 238, 241*
C37.93, 138, 157*
C37.96, 160, 177, 193*
C37.97, 238, 241*
C37.99, 236, 241*
C37.102, 159, 179, 193*
C37.106, 177, 212, 194*, 223*
C37.109, 233, 241*
C37.111-1999, 309*
C37.113-1999, 151, 157*
C37.118-2005, 309*
C57.12.01, 177, 194*
C50.13, 178, 194*
C57.13, 54, 72*
- Abnormal frequency***, 159, 177
Abnormal voltage, 159, 177
Adaptive Relaying, 273
 Hidden failures, 275
 regions of vulnerability, 276
Alarms, 303
 analog, 303
 annunciator, 304
 attended stations, 303
 digital, 304
 unattended stations, 304
Analog recorder, 289
Apparent impedance, 116, 119, 246
Automatic reclosing, 12, 77
Auxiliary current transformers, 60
Auxiliary system design, 180
Autotransformer, 95
- Back-up protection, 10, 102, 146
Battery, 13
Breaker failure, 11, 284
Blinders, 270
Blocking pilot systems, 138, 141
Breaker and a half configuration, 6, 232
Broken delta connection, 94, 167
Brushless generator field, 174
Buchholz relay, 213
Burden, 50
Bus configuration, 4, 214–220, 230
Bus protection, 225
 differential, 226–229, 231–232
 combined bus-transformer, 240–241
 directional comparison, 230
 high impedance voltage, 227
 linear couplers, 229
 moderately high impedance, 229
 overcurrent, 226
 static var compensator, 237
 statcon, 239
Bus transfer schemes, 184
Bushing current transformer, 16
- Cables
 fiber optic, 133, 136
 pilot wire, 136, 151
Capacitance potential device, 48, 64
 (see also *CCVT*),
Capacitor protection
 series capacitor, 125
 shunt capacitor, 235

- Capacitor protection (*Continued*)
 SVC filter, 239
 SVC thyristor, 237, 239
- Carrier current, 64, 133, 134, 135
blocking pilot scheme, 138
unlocking pilot scheme, 142
- Circuit breakers, 6, 13, 14, 181, 185
- Co-generation, 79
- Communication channels*, 134, 138
- Compensation devices*, 125, 126
- COMTRADE**, 305
- Computer** (Digital) *relays*, 41, 283
- Constant percentage differential relay, 162
- Control Circuits**, 42, 44, 80, 104, 189
- Coordination
 fundamentals, 85, 101, 134
 loop system, 79, 90
 time interval, 83, 86, 102
- Couplers, linear*, 62, 229
- Coupling capacitor voltage transformer (CCVT)*, 237, 239
 transient performance, 272
- Current Differential**, 151
- Current transformer**, 49
 accuracy classification, 54
 auxiliary, 59
 burden, 50
 bushing, 14
 connections, 56, 110
 DC component, 56, 58
electronic, 62
 equivalent circuit, 49, 228
 free-standing, 14
 function, 49
 magnetizing current, 52, 200, 201
 neutral connection, 165
 parallel connections, 56
 polarity, 55
 ratios, 53
 residual connection, 168
 residual flux (toroidal), 62, 168
 saturation, 58, 206, 296
special connections, 59
 standard ratios, 55
steady-state performance, 50, 243, 246
 toroidal (flux summing), 52, 168, 562, 43
 zero-sequence shunt, 61
- DC circuit, 44, 80, 104
 DC component, 56, 58
 DC offset, 56, 58
 DC supply, 13
 Delta connection, broken, 94, 167
 Dependability, 7, 160
- Device numbers**, 45, 161, 311
- Differential protection, 26, 160, 183, 199, 201, 206, 209, 210
- Differential relays
 bus, 226–229, 231
 generator, 160
 motor, 160, 170, 183
 reactor, 234
 transformer, 199, 206, 209, 215
 transmission line, 133
- Digital (computer) relays**, 41, 283
setting program, 283
- Digital fault recorder, 290, 299
- Direct transfer trip, 142
- Directional comparison**,
blocking, 138
bus protection, 226–231
 direct transfer trip, 142
permissive overreaching, 146
transfer trip,
permissive underreaching,
transfer trip, 147
 pilot systems, 133, 138
unlocking, 142
underreaching transfer trip, 142
- Directional control, 91
- Directional overcurrent relay**, 36, 76, 90, 92
application, 90
 fault directional, 93
polarizing, 92
 power directional, 92
- Distance relays, 76, 101
 characteristics, 117
 connections, 108, 109, 112
 generator protection, 179
 ground, 110
 infeed effect, 120
 line application, 101
loadability of relays, 127
loss-of-excitation, 172
multi-terminal lines, 119
 operating fundamentals, 24, 36
out-of-step application, 249
 overreaching, 102, 146
polarizing, 92
R-X diagram, 104
 series capacitor application, 125
 series reactor application, 126
stepped distance protection, 101
three phase relay, 108
types, 117
underreaching transfer trip, 142
 unfaulted phases, 114
zero voltage, 117
- Distribution circuit protection, 77, 79
- Distribution transformer grounding, 171
- Drop out (see also reset), 30, 43

- Double bus configuration, 6, 232
Dual phase comparison, 150
Dual polarizing, 90, 96
- Electromechanical relays**, 29
 induction disk, 32
 plunger, 30
- Electronic current transformers**, 62
Electronic voltage transformers, 70
Extra High Voltage (EHV), 7, 10, 76, 217
- False residual current, 124
Fault
 resistance, 115
 types, 108–116, 315, 316
- Fault detectors**, 24
 frequency, 27
 distance, 26
 harmonics, 27
 level, 24
 magnitude, 25
 differential, 26
 phase angle, 27
 pilot
- Fault location**, 299
Fault recorder, 289
 analog, 289
 digital, 290, 299
- Fiber optic cable, 133, 136
Flux linkage, 58
 residual (remanent), 58
- Frequency
 generator protection, 159, 177
 load shedding, 254, 265
- Frequency shift (FSK), 142, 143, 147
- Fuses**, 28, 76, 77, 195
 characteristics, 78, 196
 current limiting, 78
 minimum melt, 77
 speed ratio, 196
 total clearing, 77
 transformer, 196
- Generating station design**, 180, 217, 219
- Generator auxiliary systems**, 180
 auxiliary system design, 180
 bus transfer schemes, 184
 circuit breaker applications, 181
 generator breaker, 185
 ground fault protection, 184
 phase fault protection, 182
 generator protection, 159, 175
 abnormal voltages and frequency, 159, 175
- back-up ground, 172
 capability curve, 179, 180
 connections, 185
 cross-compound, 187
 differential protection, 160
 distance protection, 179
 field ground, 160
 frequency, 177, 178
 grounding, 164
 impedances, 164, 317
 inadvertent energization, 189
 loss of excitation, 177, 179
 loss of synchronism, 180.248
 motoring, 187
 negative sequence, 174
 off-frequency operation, 177
 overload, 175
 overspeed, 177
 overvoltage, 177
 out-of-step, 180
 reclosing, 268
 rotor faults, 174
 sequential tripping, 168
 split-phase winding, 185
 start up, 187
 stator faults, 160
 subsynchronous resonance, 189
 third harmonic ground
 protection, 164
 tripping vs alarming, 160, 179
 torsional vibration, 189
 unbalanced currents, 174
 undervoltage, 178
 unit connected generator, 171
- Generator winding connection**, 185
- Ground detector, 167
- Ground distance relays, 110
 application, 110, 121
 mutual effect, 121
 pilot systems, 138–147
- Ground fault protection, 84, 110, 124, 164
- Grounding
 high impedance, 165
 high resistance, neutral, 165
 low impedance, 165
 low resistance, 165
 moderate impedance, 167
 neutral impedance, 2, 165
 reactor (resonant), 173
 residual, 168
 solid, 165
 transformer, 171
 ungrounded, 167
- Global Positioning Satellite, 297

- Harmonics, 200
 - CT performance, 200, 203, 204
 - inrush current, 183, 189, 190
 - restraint relay, 206
- High impedance bus differential**, 227
 - grounding, 164
- High speed, 9
- High voltage (HV), 10

- Impedance, 173
 - apparent, 116
 - arc, 115
 - characteristic, 317
 - fault, 115
 - generator 164–167, 317
 - line, 318
 - load, 50
 - negative sequence, 174, 313
 - relay, 36, 117
 - subtransient, 244, 317
 - synchronous, 175, 317
 - transformer, 317
 - inadvertent energization**, 189
- Independent power producers (IPP), 79
- Induction
 - cup*, 33
 - disk, 32
 - mutual, 314
 - negative sequence, 123, 314
 - positive sequence, 123
 - zero sequence, 123
- Infeed effect, 91, 119, 153
- Input devices, 43
- Inrush current, 183, 187, 190
- Instantaneous overcurrent relays**, 76, 88
 - application**, 88
 - protection, 88
 - relays, 29, 38, 88, 198
 - time, defined, 10
- International practices**, 4, 17, 214
- Inverse time delay relays**, 76, 80
 - application, 80
 - setting rules, 81

- Linear couplers**, 62, 229
- Line transfer trip, 138, 142, 146, 147
- Line trap, 134
- Line tuner, 134
- Load restoration**, 254
- Load tap changing, 200
- Loadability**, 127, 142
- Local back-up, 10, 102
- Long line, definition, 76
- Loop switching, 76, 90

- loss of excitation**, 159, 179
- loss of synchronism**, 180, 248

- Magnetizing current, 52, 200, 201
- Maximum torque angle, 36
- Mho (admittance) relay, 37, 117
- Microwave channel, 134, 135, 138
- Modal analysis, 135
- Moderately high impedance relay**, 229
- Motor protection**, 159, 168–171, 175, 181, 182, 183
- Motoring**, 187
- Multi-terminal lines**, 119, 153
- Mutual coupling, 121, 124, 314

- National Electric Code, 176
- Negative sequence
 - definition, 313
 - current, 174
 - current relays, 175, 234
 - impedance, 314
 - motor heating effect, 175
- Network, 5, 79, 91
- Neutral
 - definition, 165
 - impedance, 165
 - shift, 3
- Non-Pilot Overcurrent Protection of Transmission Lines** (see also Overcurrent protection), 75
 - directional overcurrent relay**, 90
 - fuses**, 76
 - graded system, 77, 78
 - instantaneous overcurrent relay**, 88, 94
 - inverse, time-delay overcurrent relay**, 80
 - long line, definition 76
 - non-unit system, 76
 - polarizing**,
 - reclosers*, 76, 77
 - relatively selective system, 77
 - sectionalizers**, 77
 - short line, definition, 76
- North American Electric Reliability Council (NERC), 255

- Oscillograph Analysis**
 - circuit breaker restrike, 295
 - CT saturation, 295
 - current, 296
 - high speed reclose, 293
 - system swing, 295, 294
 - transients, 297
 - triggers, 290
 - unequal-pole-close, 291
 - voltage, 296

- Out-of-step relaying**, 291
 - distance protection, 268
 - generator protection, 269
 - system operation, 179, 180
- Outfeed effect, 153
- Overcurrent protection
 - bus**, 226
 - generator**, 175
 - static var compensation (SVC)**, 237
 - transformer**, 238
 - transmission line Overexcitation, 238
- Overfrequency, 178
- Overlapping protection, 9
- Overload**, 159, 175, 214
- Overreaching transfer trip**, 146
 - settings, 147
- Overspeed**, 159, 177
- Overtravel, relay, 896
- Overvoltage generator, 177
 - static var compensation (SVC)**, 239

- Parallel lines**, 121
- Partial differential protection**, 231
- Percentage differential relays**, 162, 226
- Permissive overreaching transfer trip**, 146
- Permissive underreaching transfer trip**, 147
- Petersen coil, 3
- Phase comparison relays**, 148
 - dual comparison, 150
 - non-segregated phase, 150
 - single comparison, 150
 - segregated phase, 150
- Phase packaging, 118
- Phasors, 3, 27, 93, 94105, 115, 252, 253
- Pickup, 24, 29, 30, 44
- pilot relaying channels**, 27, 134
 - directional comparison**,
 - blocking**, 138
 - directional comparison**, 101
 - unblocking**, 142
- Phase comparison relays**, 148
 - permissive overreaching transfer trip**, 142
 - permissive underreaching transfer trip**, 147
- pilot wire relaying 1**, 151
- tripping vs blocking**, 138
- pilot wire cable, 134, 136, 151
- Pilot wire relaying**, 151
 - tripping pilot, 152
 - blocking pilot, 152
- Plunger relay, 29
- Polarity, 55, 209
- Polarizing**, 92
 - autotransformer, 96
 - current, 94
 - dual comparison, 94
- Potential transformer, 94
- Polyphase relays**, 118
- Positive sequence, 108, 111, 164, 166, 313
- Potential transformer, 49, 63, 70, 135
 - connections, 110
 - function, 51, 134
 - electronic**, 67
 - equivalent circuit, 64
 - Thevenin impedance** 64
 - transient performance, 47
- Power line carrier, 133
 - coupling, 133
- Power system monitoring**, 289
 - analog recorders, 289
 - digital recorders, 289
 - oscilloperturbograph, 289
 - portable oscillograph, 289
 - photographic oscillograph, 289
 - sequence-of-event (SER), 289
- Power system stability**, 243
- Pressure devices, 213
- Primary protection, 10
- Protection baqk.up, 10, 81, 103
 - elements**, 13
- primary, 10
 - selectivity, 8
 - speed, 10
 - zones of protection, 8, 76, 102
- Protective relays application principles, 76, 80, 88, 102
 - computer (digital)**, 41, 176, 283
 - connections, 108, 111, 185, 209, 235
 - contacts, 42, 44, 189
 - coordination, 77, 86, 102, 134
 - dependability, 7
 - designs**, 28, 37, 41
 - device numbers**, 42, 161, 311
 - differential, 26, 160, 182, 198, 209, 200, 215, 231, 234
 - directional overcurrent**, 36, 76, 90, 92
 - distance, 26, 36, 101, 179
 - electromechanical**, 29
 - function, 1
 - high speed, 10
 - impedance (ohm), 36, 140–142
 - instantaneous, 10, 38, 88, 102
 - induction, 32
 - logic representation, 40, 139, 143
 - operating time, 25, 32, 44, 86, 270
 - overcurrent**, 80, 88, 176
 - pickup, 24, 31, 44, 83, 90
 - plunger, 29
 - polarity, 54, 299
 - Ratio Correction Factor (RCF), 51
 - reliability, 7
 - reset, 32, 33, 44, 86

- Protective relays application principles, (*Continued*)
 seal-in, 43
 security, 7
 selectivity, 8
 settings, 81, 82, 88, 102, 121, 139, 145, 147,
 150, 166, 169, 170, 182, 228
 solid-state, 38
 targets, 42
testing, 281
time overcurrent, 35, 76, 77, 80, 176, 196, 233,
 321
- Radial lines, 4, 75, 77, 79
 Reactance relay, 117
Reclosers, 77
 Reclosing, 12, 77, 124, 189, 286, 293
 Recorders analog, 289
 Recovery inrush, 204
 Regulating transformers, 212
 Reliability, 7
 Remote back-up, 11
 Reset (see also dropout), 30–32, 43, 86
 Resonant grounding, 173
 Restraint relay, 206
 Reverse power relays, 92
 Ring bus, 6, 286
 Ring type (toroidal) CT, 62, 168
Rotor faults, 174
R-X diagram, 36, 104
- Safety factor, 85
 Saturation, current transformer, 58, 202, 296
 Seal-in, 43
Sectionalizers, 77
 Security, 7
 Segregated phase comparison, 149
 Selectivity, 8
 Sequence networks, 106–111, 164, 166, 174, 313
Sequential tripping, 190
 Series capacitor, 125
 Series reactor, 126
 Short line, definition, 76
 Shunt capacitor, 126, 235
 Shunt reactor, 126, 233
Shunt Capacitor Bank,
Protection, 235
Shunt Reactor Protection, 233
 dry-type, 233
 oil immersed, 234
- Single bus, 6, 231, 285
 Single phase
 reclosing, 12, 125
 tripping, 12, 125
- Solid grounding, 165
Solid state relays, 37
- Speed
 relays, 10
 system swings, 249
- Split phase winding, 187
- Stability*, 243
- Static Var Compensator*, 237
Protection (SVC),
 transformer protection, 239
 bus protection, 239
 typical protection schemes, 239
- Station battery voltage, 13
- Start-up and Motoring*, 187
- Stator phase faults*, 160
- Stator ground faults, 164
- Stepped distance protection*, 102
- Subsidence transients, 67
- Subsynchronous oscillations, 189
- Subsynchronous resonance, 189
- Subtransient impedance, 243, 318
- Sudden pressure relays, 213
- Symmetrical components*, 313
- Sympathetic inrush, 204
- Synchronized sampling*, 297
 Global Positioning Satellite, 297
- Synchrophasor*, 305
- Synchronous impedance, Section 13.6
- Synchronizing, Section 11.2
 automatic, Section 11.5
 check,
- System Integrity Protection*, 265
- System swing, 149, 180, 244, 248
- Tapped lines, 119, 153
- Testing*, 281
- Third harmonic, 165, 172, 202
- Three phase distance relays*, 12, 32, 82, 86
 delay, 10, 83, 86
 interval, 86, 102
 overcurrent relay, 25, 32, 80, 176, 234, 321–323
- Toroidal flux current transformer, 62, 168
- Torsional vibration*, 189
- Transfer trip, 138, 142–147
 direct, 142
permissive overreaching, 146
permissive underreaching, 147
- Transformer protection*, 195
 connections, 209, 210
 differential, 198, 199, 210, 206
 generator step-up, 165, 185
 impedances, 318
 inrush, 203–206
overcurrent protection, 196
 overexcitation, 205
percentage differential protection, 198
static var compensator, 237

- Static Compensator*, 239
- sudden pressure relay, 213
- temperature devices, 214
- three phase*, 207
- Volts per hertz*, 212
- Transmission line protection compensation*, 125, 126
 - differential, 134
 - impedances, 318
 - loop, 79, 91
 - radial, 4, 75, 77, 79
 - reclosing, 12, 77, 125, 293
 - relay types, 80, 88, 101, 138, 142, 146, 147, 148, 151
 - voltage classification, 75
- Transfer tripping pilot, schemes*, 138, 142–148
 - direct, 144
 - permissive overreaching*, 146
 - permissive underreaching*, 147
- Ultra-high-speed (UHS)
 - reclosing, 10
- Underexcitation, 159, 179
- Underfrequency, 159, 179
- Underfrequency Load Shedding*, 266
- Undervoltage Load Shedding*, 268
- Underground residential distribution (URD), 77
- Undervoltage, 177
- Unbalanced currents*, 174
- Variable percentage
 - differential relay, 162
- Voltage Transformer*, 64
 - (see potential transformer)
- Volts per Hertz relay, 177, 212
- Zero sequence impedance, 112, 123, 166
- Zero sequence shunt, 61
- Zero voltage operation*, 117
- Zones of protection, 8, 9, 102
- Zone packaging, 118