



IEE POWER AND ENERGY SERIES 33

Overvoltage protection of low voltage systems

2nd Edition

Peter Hasse

The Institution of Electrical Engineers

Contents

1	Introduction	1
2	Damage due to lightning and surges	5
2.1	Damage statistics	5
2.2	Examples	10
2.2.1	Damage in hazardous areas	10
2.2.2	Damage to industrial plants	15
2.2.3	Damage to power supply systems	24
2.2.4	Damage to a house	27
2.2.5	Damage to aircraft and airports	36
2.2.6	Damage to wind power stations	38
2.2.7	Catastrophic damage	39
3	Origin and effect of surges	43
3.1	Atmospheric overvoltages	45
3.1.1	Direct and close-up strikes	45
3.1.1.1	Voltage drop at the impulse earthing resistance	48
3.1.1.2	Induced voltages in metal loops	49
3.1.2	Remote strikes	56
3.1.3	Coupling of surge currents on signal lines	57
3.1.3.1	Ohmic coupling	58
3.1.3.2	Inductive coupling	58
3.1.3.3	Capacitive coupling	59
3.1.4	Magnitude of atmospheric overvoltages	60
3.2	Switching overvoltages	61
4	Protective measures, standards	67
4.1	Lightning protection	69
4.1.1	Risk analysis, protection levels	74
4.1.2	External and internal lightning protection, DIN VDE 0185 Part 1, DIN V ENV 61024-1 (VDE V 0185 Part 100)	78

4.1.3 Concept of lightning protection zones, DIN VDE 0185-103 (VDE 0185 Part 103)	79
4.1.3.1 LEMP-protection planning	83
4.1.3.1.1 Definition of lightning protection levels	83
4.1.3.1.2 Definition of lightning protection zones	83
4.1.3.1.3 Room shielding measures	84
4.1.3.1.4 Equipotential bonding networks	90
4.1.3.1.5 Equipotential bonding measures for supply lines and electric lines at the boundaries of the lightning protection zones	92
4.1.3.1.6 Cable routing and shielding	94
4.1.3.2 Realization of LEMP protection	97
4.1.3.3 Installation and supervision of LEMP protection	99
4.1.3.4 Acceptance inspection of LEMP protection	100
4.1.3.5 Periodic inspection	101
4.1.3.6 Costs	101
4.2 Surge protection for electrical systems of buildings, IEC 60364, DIN VDE 0100	103
4.2.1 IEC 60364-4-443/DIN VDE 0100 Part 443	104
4.2.2 IEC 60664-1/DIN VDE 0110 Part 1	105
4.2.3 IEC 60364-5-534/DIN VDE 0100 Part 534	109
4.3 Surge protection for telecommunications systems, DIN VDE 0800, DIN VDE 0845	110
4.4 Electromagnetic compatibility including protection against electromagnetic impulses and lightning, VG 95 372	112
4.5 Standards for components and protective devices	112
4.5.1 Connection components, E DIN EN 50164-1 (VDE 0185 Part 201)	113
4.5.2 Arresters for lightning currents and surges	113
4.5.2.1 Arresters for power engineering, IEC 61643-1/E DIN VDE 0675 Part 6	113
4.5.2.1.1 Important data for arrester selection	119
4.5.2.1.2 Coordination of the arresters according to requirements and locations	120
4.5.2.1.3 N-PE arrester, E DIN VDE 0675 Part 6/A2	121
4.5.2.2 Arresters for information technology, IEC SC 37A/E DIN VDE 0845 Part 2	122
4.5.2.2.1 Important data for arrester selection	124
4.5.2.2.2 Arrester coordination according to requirements and locations	125
4.5.2.3 Arrester coordination	125

5 Components and protective devices: construction, effect and application	127
5.1 Air terminations	127
5.2 Building and room shields	129
5.3 Shields for lines between screened buildings	138
5.4 Shields for cables in buildings	141
5.5 Optoelectronic connections	143
5.5.1 Optical fibre transmission system	144
5.5.2 Optocoupler	145
5.6 Equipotential bonding	145
5.7 Isolating spark gaps	150
5.8 Arresters	153
5.8.1 Arresters for power engineering	155
5.8.1.1 Surge arresters for low-voltage overhead lines, class A	155
5.8.1.2 Lightning current arresters for lightning protection equipotential bonding, class B	157
5.8.1.3 Surge arresters for protection of permanent installation, class C	167
5.8.1.4 Surge arresters for application at socket outlets, class D	174
5.8.1.5 Surge arresters for application at equipment inputs	175
5.8.1.6 Application of lightning current arresters and surge arresters	175
5.8.1.6.1 Graded application of arresters, energetic coordination between surge arresters and equipment to protect	178
5.8.1.6.2 Application of arresters in different system configurations	182
5.8.1.6.3 Selection of arrester backup fuses	196
5.8.2 Arresters for information technology	206
5.8.2.1 Arresters for measuring and control systems	209
5.8.2.1.1 Blitzduktor®CT: Construction and mode of functioning	210
5.8.2.1.2 Blitzduktor®CT: Selection criteria	223
5.8.2.1.3 Blitzduktor®CT: Examples of application	228
5.8.2.1.4 Arresters for intrinsically safe measuring and control circuits and their application	238
5.8.2.1.5 Arresters for cathodic protection systems	246
5.8.2.1.6 Arresters in Euro-card format	248
5.8.2.1.7 Arresters in LSA-Plus technology	248
5.8.2.2 Combined protective devices for power supply inputs and information technology inputs	253

5.8.2.3 Protective devices for data networks/systems	255
5.8.2.3.1 Protective devices for application-neutral cabling	255
5.8.2.3.2 Protective devices for token ring-cabling	262
5.8.2.3.3 Protective devices for Ethernet twisted pair-cabling	265
5.8.2.3.4 Protective devices for Ethernet coax-cabling	267
5.8.2.3.5 Protective devices for standard cabling	271
5.8.2.3.6 Protective devices for data telecontrol transmission by ISDN base terminal	277
5.8.2.3.7 Protective devices for data telecontrol transmission by ISDN primary multiplex terminal	284
5.8.2.3.8 Protective devices for data telecontrol transmission by analogous a/b-wire terminal	286
6 Application in practice: Some examples	293
6.1 Industrial plants	295
6.1.1 Fabrication hall	295
6.1.2 Store and dispatch building	296
6.1.3 Factory central heating	302
6.1.4 Central computer	307
6.1.5 European installation bus (EIB)	309
6.1.6 Other bus systems	313
6.1.7 Fire and burglar alarm system	313
6.1.8 Video control system	316
6.1.9 Radio paging system	318
6.1.10 Electronic vehicle weighbridge	320
6.2 Peak-load power station	323
6.3 Mobile radio systems	328
6.4 Television transmitter	334
6.5 Mobile telecommunication facility	339
6.6 Airport control tower	343
7 Prospects	351
Index	353