# IEC 61851-23

Edition 2.0 2023-12

# INTERNATIONAL STANDARD

colour inside

## Electric vehicle conductive charging system – Part 23: DC electric vehicle supply equipment

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 43.120

ISBN 978-2-8322-7961-8

**Warning! Make sure that you obtained this publication from an authorized distributor.**

® Registered trademark of the International Electrotechnical Commission

CONTENTS

FOREWORD ..... 15
1 Scope ..... 18
2 Normative references ..... 19
3 Terms and definitions ..... 22
3.1 Electric supply equipment ..... 22
3.2 Insulation ..... 22
3.3 Functions ..... 26
3.4 Vehicle ..... 30
3.5 Cords, cables and connection means ..... 31
3.6 Service and usage ..... 32
3.7 General terms ..... 33
4 General requirements ..... 40
5 Classification ..... 40
5.101 Characteristics of EV supply equipment ..... 40
5.101.1 Separation type ..... 40
5.101.2 Control system ..... 40
5.101.3 System ..... 40
5.101.4 Thermal management system ..... 40
5.101.5 Power distribution system ..... 41
6 Charging modes and functions ..... 41
6.2 Charging modes ..... 41
6.2.1 Mode 1 ..... 41
6.2.2 Mode 2 ..... 41
6.2.3 Mode 3 ..... 41
6.3 Functions provided in Mode 4 ..... 41
6.3.1 Mandatory functions in Mode 4 ..... 41
6.3.2 Optional functions for Mode 4 ..... 62
7 Communications ..... 63
7.1 Digital communication between the EV supply equipment and the EV ..... 63
7.1.101 Basic communication interface ..... 64
8 Protection against electric shock ..... 64
8.101 General provisions ..... 64
8.101.1 General ..... 64
8.101.2 Intended use and reasonably foreseeable misuse ..... 65
8.101.3 Limitation of touch current or touch voltage ..... 65
8.101.4 Threshold of perception and startle reaction ..... 65
8.102 Basic protection ..... 68
8.102.1 General ..... 68
8.102.2 Protection by means of basic insulation of live parts ..... 68
8.102.3 Protection by means of enclosures or barriers ..... 68
8.102.4 Protection by means of limitation of voltage ..... 68
8.102.5 Protection by means of limitation of steady-state touch current ..... 70
8.103 Fault protection ..... 70
8.103.1 General ..... 70
8.103.2 Protective-equipotential-bonding ..... 70

8.103.3 Effective protective conductor continuity between the enclosure and the external protective circuit ... 70
8.103.4 Automatic disconnection of supply ... 71
8.103.5 Supplementary insulation ... 71
8.103.6 Electrically protective screening ... 71
8.104 Enhanced protective provision ... 71
8.104.1 General ... 71
8.104.2 Double or reinforced insulation ... 71
8.104.3 Protective separation between circuits ... 72
8.105 Requirements for separated EV supply equipment ... 72
8.105.1 General ... 72
8.105.2 Equipotential bonding on side B ... 74
8.105.3 Impedance to protective conductor on side B ... 74
8.105.4 Degrees of protection against access to hazardous-live-parts ... 75
8.105.5 Insulation barriers ... 76
8.105.6 Stored energy ... 77
8.105.7 Disconnection from vehicle ... 78
8.105.8 Protective (earthing) conductor from the supply network ... 78
8.105.9 Residual current protective devices ... 79
8.105.10 Safety requirements for auxiliary circuits between the EV supply equipment and the EV ... 79
8.105.11 Protective conductor dimension cross-sectional area ... 79
9 Conductive electrical interface requirements ... 80
9.1 General ... 80
9.5 Functional description of the DC interface ... 80
9.7 Wiring of the neutral conductor ... 80
9.101 Avoidance of breaking under load ... 80
10 Requirements for adaptors ... 81
11 Cable assembly requirements ... 82
11.1 General ... 82
11.6 Strain relief ... 82
11.6.101 Strain relief of the EV supply equipment's side B cable assembly ... 82
11.6.102 Test of the anchorage of the side B cable assembly ... 83
11.101 Cable breakaway ... 85
11.102 Surface temperature of the side B cable assembly ... 85
12 EV supply equipment constructional requirements and tests ... 87
12.1 General ... 87
12.2 Characteristics of mechanical switching devices ... 87
12.2.5 Relays ... 87
12.3 Clearances and creepage distances ... 87
12.4 IP degrees ... 87
12.4.1 Degrees of protection against solid foreign objects and water for the enclosures ... 87
12.5 Insulation resistance ... 88
12.6 Touch current ... 88
12.6.101 Touch current limit ... 88
12.6.102 Test ... 88
12.6.103 Protection measures for the test touch current more than 3,5 mA ... 89
12.7 Dielectric withstand voltage ... 90

12.7.2 Impulse dielectric withstand (1,2 µs/50 µs) ... 90
12.7.101 Suppression of transient overvoltage at side A (insulation coordination) ... 90
12.7.102 Protection against transient overvoltages of atmospheric origin or due to switching ... 92
12.8 Temperature rise ... 94
12.9 Damp heat functional test ... 94
12.10 Minimum temperature functional test ... 94
12.11 Mechanical strength ... 94
12.101 Side A current ... 95
12.102 Power supply cords ... 96
12.102.1 General ... 96
12.102.2 Cross-sectional area ... 96
12.102.3 Cord anchorages and strain relief for non-detachable power supply cords ... 97
12.103 Stress relief test ... 98
12.104 Abnormal operation and simulated fault condition tests ... 99
12.104.1 General ... 99
12.104.2 Pass criteria ... 99
12.104.3 Breakdown of components test ... 100
12.104.4 Loss of AC supply phase test ... 100
12.104.5 Inoperative blower/fan motor test ... 100
12.104.6 Clogged filter test ... 101
12.105 Protection against electrically caused fire ... 101
12.105.1 General ... 101
12.105.2 Fire enclosure ... 101
12.106 Protection against chemical hazards ... 101
12.106.1 Type of coolant ... 101
12.106.2 Flammability ... 102
12.106.3 Material compatibility ... 102
12.107 Enclosures ... 102
12.107.1 General ... 102
12.107.2 Strength of materials and parts ... 103
12.107.3 Enclosure integrity tests ... 103
12.108 Components bridging insulation ... 103
12.108.1 General ... 103
12.108.2 Capacitors ... 104
12.109 Isolating transformers ... 104
13 Overload and short-circuit protection ... 104
13.1 General ... 104
13.2 Overload protection of the cable assembly ... 104
13.3 Short-circuit protection of the charging cable ... 104
13.101 Short-circuit protection of the DC connection during energy transfer ... 105
14 Automatic reclosing of protective devices ... 106
15 Emergency switching or disconnect (optional) ... 106
16 Marking and instructions ... 106
16.1 Installation manual of EV charging stations ... 106
16.2 User manual for EV supply equipment ... 107
16.3 Marking of EV supply equipment ... 108
16.4 Marking of charging cable assemblies case B ... 108

101 Specific requirements for EV supply equipment ..... 108
101.1 Specific requirements for separated EV supply equipment ..... 108
101.1.1 Operating ranges for voltage, current, and power at side B ..... 108
101.1.2 Voltage and current tolerance at side B ..... 109
101.1.3 Control delay of present current at side B in CCM ..... 111
101.1.4 Descending rate of present current at side B ..... 114
101.1.5 Periodic and random deviation (current ripple at side B during CCM) ..... 114
101.1.6 Periodic and random deviation (voltage ripple at side B during CVM) ..... 115
101.1.7 Load dump ..... 117
101.1.8 Side B inductance ..... 117
101.2 Specific requirement for energy transfer with a thermal management system or thermal sensing only ..... 118
101.2.1 General ..... 118
101.2.2 Temperature limits and self-diagnostics ..... 118
101.2.3 Temperature monitoring ..... 119
101.2.4 Tests for thermal management system performance of the EV supply equipment ..... 120
101.3 Specific requirements for temperature-controlled energy transfer ..... 129
102 Test methods ..... 130
102.1 Technical data ..... 130
102.2 General test conditions ..... 130
102.2.1 Ambient test conditions ..... 130
102.2.2 Measuring instruments ..... 131
102.2.3 Test setups ..... 131
102.2.4 Test load ..... 134
102.2.5 Operating points for tests ..... 136
Annexes ..... 138
Annex AA (normative) EV supply equipment of system A ..... 139
AA.1 General ..... 139
AA.2 Circuit diagram ..... 139
AA.3 Specific safety requirements ..... 142
AA.3.1 Fault protection in side B ..... 142
AA.3.2 De-energization of the power supply to the EV ..... 146
AA.3.3 Voltage measurement of side B live parts (DC+/DC–) for vehicle connector unlatch ..... 147
AA.3.4 Overcurrent protection of side B ..... 147
AA.3.5 Short-circuit protection of side B ..... 147
AA.3.6 Latch monitoring for the vehicle connector ..... 148
AA.3.7 Protection of the EV disconnection device ..... 149
AA.3.8 Fault conditions and criteria for transfer to error and emergency shutdown ..... 149
AA.3.9 Inrush current limitation by the EV supply equipment ..... 154
AA.3.10 Regulation of the present current at side B in CCM ..... 155
AA.3.11 Periodic and random deviation (current ripple at side B during CCM) ..... 156
AA.3.12 Overvoltage protection including load dump ..... 157
AA.3.13 Power supply to the EV for the actuation of EV disconnection device ..... 158
AA.3.14 Impedance of the side B circuit ..... 158
AA.3.15 Assistance of welding detection ..... 158
AA.3.16 Specific requirements for temperature-controlled energy transfer ..... 159

AA.4 FPT process and communication between the EV supply equipment and the EV for energy transfer control ... 159
AA.4.1 Forward power transfer states ... 159
AA.4.2 Communication measures ... 161
AA.4.3 Forward power transfer control process ... 162
AA.4.4 Measuring current and voltage at side B ... 168
AA.5 Response to an EV command on charge current ... 170
AA.6 Bidirectional power transfer (optional) ... 172
AA.6.1 General ... 172
AA.6.2 Circuit diagram ... 172
AA.6.3 Functional requirements ... 174
AA.6.4 Bidirectional power transfer control process ... 176
AA.7 Optional functions ... 181
AA.7.1 General ... 181
AA.7.2 Compatibility check ... 181
AA.7.3 Dynamic control ... 181
AA.7.4 High-current control ... 182
AA.7.5 High-voltage control ... 182
AA.8 Compliance test for user-initiated shutdown ... 182
AA.9 Specific requirement for energy transfer with thermal management system ... 183
Annex BB (normative) EV supply equipment of system B ... 184
BB.1 General ... 184
BB.2 Circuit diagrams ... 184
BB.2.1 Circuit diagram ... 184
BB.2.2 Requirements of IMD and discharge circuit ... 186
BB.3 Parameters of control pilot circuit ... 186
BB.4 Forward power transfer control process under normal condition ... 187
BB.4.1 Side B regulation ... 187
BB.4.2 Measuring current and voltage ... 187
BB.4.3 Vehicle coupler mating confirmation ... 189
BB.4.4 Forward power transfer control sequence ... 189
BB.4.5 Normal shutdown ... 191
BB.5 Safety requirements under failure mode ... 191
BB.5.1 Error shutdown and emergency shutdown ... 191
BB.5.2 Terminate energy transfer due to an EV supply equipment fault ... 193
BB.5.3 Terminate energy transfer due to an EV fault ... 194
BB.5.4 Digital communication timeout ... 194
BB.5.5 Loss of electrical continuity of the control pilot ... 195
BB.5.6 Overvoltage fault ... 195
BB.5.7 Load dump ... 196
BB.5.8 Short-circuit protection of side B ... 197
BB.5.9 Lock and latch monitoring for vehicle connector ... 198
BB.5.10 Overcurrent protection of side B ... 198
BB.5.11 Insulation fault monitoring ... 198
BB.6 Timing sequence diagram of forward power transfer ... 199
BB.7 Side B current regulation in CCM ... 200
BB.8 Insulation resistance check before energy transfer ... 202
BB.9 Side B voltage regulation in CVM ... 204
BB.10 Periodic and random deviation (voltage ripple at side B in CVM) ... 206

BB.11 Energy transfer control mode ... 206
BB.11.1 Definition ... 206
BB.11.2 Typical forward power transfer process ... 207
BB.12 Standby mode ... 208
BB.13 Smart charging ... 209
BB.14 Minimum cross-sectional area of the protective conductor ... 209
Annex CC (normative) EV supply equipment of system C ... 210
CC.1 General ... 210
CC.2 Circuit diagrams ... 210
CC.2.1 General ... 210
CC.2.2 Circuit diagram for configuration EE ... 210
CC.2.3 Circuit diagram for configuration FF ... 213
CC.2.4 Disabled side B ... 216
CC.3 Process of energy transfer ... 217
CC.3.1 General ... 217
CC.3.2 Normal startup ... 219
CC.3.3 Normal shutdown or pause after energy transfer ... 225
CC.3.4 Error and emergency handling ... 229
CC.3.5 Pause by EV supply equipment using ISO 15118-2:2014 ... 241
CC.3.6 Renegotiation initiated by EV or EV supply equipment using ISO 15118-2:2014 ... 251
CC.4 Safety related functions ... 255
CC.4.1 Safety measures for side B ... 255
CC.4.2 Vehicle coupler latching function ... 259
CC.4.3 Loss of electrical continuity of the control pilot conductor ... 259
CC.4.4 Loss of electrical continuity of the proximity detection conductor ... 259
CC.4.5 Voltage check at initialization ... 259
CC.4.6 Minimum cross-sectional area of the protective conductor ... 259
CC.4.7 Loss of electrical continuity of the protective conductor ... 259
CC.5 Additional functions ... 260
CC.5.1 Pre-charge ... 260
CC.5.2 Sleep mode and communication session restart methods ... 262
CC.5.3 Configuration EE vehicle connector latch position switch ($S_S3$) activation ... 269
CC.5.4 Configuration EE vehicle connector latch position switch ($S_S3$) verification ... 269
CC.5.5 Handling of operating ranges ... 270
CC.5.6 Compatibility check ... 277
CC.5.7 Considerations for CCM, CVM and CPM (informative) ... 281
CC.6 Specific requirements ... 283
CC.6.1 Requirements for load dump ... 283
CC.6.2 Side B current regulation ... 283
CC.6.3 Measuring current and voltage at side B ... 283
CC.6.4 Overcurrent protection of side B ... 284
CC.7 General test conditions ... 284
CC.7.1 Operating points – Definitions ... 284
CC.7.2 Standard test setup ... 286
CC.7.3 Definition of measured values at side B ... 286
CC.7.4 Exemplary approach to set a test point in CCM ... 286

CC.7.5 Test cases ... 289
Annex DD (informative) Bidirectional power transfer control ... 354
DD.1 General ... 354
DD.2 Forward power transfer (FPT) and reverse power transfer (RPT) ... 354
Annex EE (normative) Test load impedance verification ... 355
EE.1 General ... 355
EE.2 Response curve verification ... 355
EE.3 Test setup for test load verification (informative) ... 358
EE.4 Result ... 359
Annex FF (normative) Multi-side B separated EV supply equipment ... 360
FF.1 General ... 360
FF.2 Classification and use case of multi-side B EV supply equipment ... 360
FF.2.1 System operation ... 360
FF.2.2 Side B system ... 360
FF.2.3 Configuration ... 360
FF.3 Constructional requirements of a side B system ... 363
FF.3.1 Constructional requirements of a side B system according to Annex AA ... 363
FF.3.2 Constructional requirements of a side B system according to Annex BB ... 364
FF.3.3 Constructional requirements of a side B system according to Annex CC ... 364
FF.4 Side B system performance ... 364
FF.4.1 General performance requirements ... 364
FF.4.2 Performance of multi-side B EV supply equipment providing simultaneous operation ... 364
FF.5 Safety requirements ... 364
FF.5.1 General safety requirements ... 364
FF.5.2 Short-circuit protection ... 365
FF.5.3 Overload protection ... 365
FF.5.4 Access to live parts through an unmated vehicle connector during energy transfer ... 365
FF.5.5 Additional safety requirements for multi-side B EV supply equipment providing simultaneous operation ... 366
FF.5.6 Diagnostic check of mechanical disconnection device in the side B system ... 366
FF.5.7 Interconnected side B live parts (DC+/DC–) in multi-side B EV supply equipment ... 366
Annex GG (informative) Communication and energy transfer process between the EV supply equipment and the EV ... 367
GG.1 General ... 367
GG.2 System configuration ... 367
GG.3 Energy transfer control process and state ... 367
GG.3.1 General ... 367
GG.3.2 Description of the initialization stage ... 368
GG.3.3 Description of the energy transfer stage ... 368
GG.3.4 Description of the shutdown stage ... 369
Annex HH (informative) Touch current and touch impulse current ... 370
HH.1 General ... 370
HH.2 Current through the human body ... 375
HH.3 Conditional dependent thresholds ... 376
HH.4 Hazards due to leakage between side B live parts and the protective conductor ... 376

HH.5 Balanced versus unbalanced voltages at side B live parts (DC+/DC–) ..... 377
HH.6 Insulation monitoring device ..... 378
HH.7 IMD reaction time ..... 379
HH.8 Conclusion ..... 379
Bibliography ..... 380

Figure 101 – Example of a coupling session ..... 27
Figure 102 – Voltage $V_T8$ to apply to simulate short period overvoltage at side B between DC+ and DC– ..... 52
Figure 103 – Typical voltages between side B live parts (DC+/DC–) and protective conductor under normal operation ..... 55
Figure 104 – IMD connection which results in a voltage more than the maximum voltage limits ..... 56
Figure 105 – Examples of a fault between the secondary circuit and the protective conductor ..... 59
Figure 106 – Measurement of the touch leakage current ..... 67
Figure 107 – Touch time – DC voltage under single fault condition (water wet, fingertip to feet) ..... 69
Figure 108 – Insulation barriers ..... 76
Figure 109 – Construction types of vehicle adapters ..... 81
Figure 110 – Apparatus to test the side B cable assembly anchorage ..... 83
Figure 111 – Test setup the side B cable assembly anchorage ..... 84
Figure 112 – Example of a side B cable assembly equipped with handle and a warning label attached to the cable ..... 86
Figure 113 – Example setup of SPD for the protection of the EV supply equipment against transients ..... 91
Figure 114 – Example of an SPD-assembly having one voltage switching type SPD between side B live conductors (DC+/DC–) and protective conductor ..... 93
Figure 115 – Symbol ISO 7000-0434B:2004-01 ..... 107
Figure 116 – Side B voltage tolerances in CVM ..... 110
Figure 117 – Current control delay for an increasing current request ..... 112
Figure 118 – Current control delay for a decreasing current control request ..... 113
Figure 119 – Voltage at side B in CVM operation in steady state with ripple ..... 116
Figure 120 – Setup to measure the maximum side B inductance ..... 117
Figure 121 – Reference device (RD) A_0 ..... 121
Figure 122 – Test arrangement A_0 ..... 122
Figure 123 – Reference device RD A_1 ..... 122
Figure 124 – Test arrangement A_1 ..... 123
Figure 125 – Reference device RD C_0 ..... 124
Figure 126 – Test arrangement C_0 ..... 125
Figure 127 – Reference device RD C_1 ..... 125
Figure 128 – Test arrangement C_1 ..... 126
Figure 129 – General test setup for system A ..... 132
Figure 130 – General test setup for system B ..... 133
Figure 131 – General test setup for system C ..... 134
Figure 132 – Test load example ..... 135

Figure 133 – Operating points ..... 137
Figure AA.1 – Overall circuit diagram of system A EV supply equipment and EV ..... 140
Figure AA.2 – Failure detection principle by detection of DC leakage current ..... 144
Figure AA.3 – Example of vehicle connector latch monitoring circuit ..... 148
Figure AA.4 – Example of vehicle inlet with the latch holder covered by a metal plate that inhibits latch holding ..... 149
Figure AA.5 – Flow diagram for forward power transfer ..... 162
Figure AA.6 – Sequence diagram for forward power transfer ..... 163
Figure AA.7 – Representation of the delay between the measurement and the digital communication transmission for system A ..... 169
Figure AA.8 – Acceptable range of the measured current at side B (target current of the EV $I_{EV_trg}$ = 50 A) ..... 170
Figure AA.9 – Change in the target current requested by the EV ..... 171
Figure AA.10 – Side B performance of EV supply equipment ..... 172
Figure AA.11 – Circuit diagram of a system A BPT EV supply equipment and EV ..... 173
Figure AA.12 – Flow diagram for bidirectional power transfer ..... 179
Figure AA.13 – Sequence diagram for bidirectional power transfer ..... 180
Figure AA.14 – Transition of applicable maximum current of the EV supply equipment at side B and target current of the EV during dynamic control ..... 181
Figure BB.1 – System B EV supply equipment circuit diagram ..... 185
Figure BB.2 – Representation of delay between the measures current and voltage at side B and the digital communication transmission for system B ..... 187
Figure BB.3 – FPT control sequence for system B ..... 190
Figure BB.4 – Timing sequence diagram of FPT ..... 200
Figure BB.5 – Operating points and test points for side B current regulation in CCM ..... 201
Figure BB.6 – Operating points and test points for side B voltage regulation in CVM ..... 206
Figure BB.7 – Definition of CCM, CVM and CPM ..... 207
Figure BB.8 – Typical FTP process ..... 208
Figure CC.1 – Circuit diagram for a system C EV supply equipment of configuration EE ..... 211
Figure CC.2 – Circuit diagram of a system C EV supply equipment of configuration FF ..... 214
Figure CC.3 – Equivalent disabled side B of the EV supply equipment ..... 216
Figure CC.4 – Example of a sequence diagram ..... 219
Figure CC.5 – Sequence diagram for normal startup ..... 220
Figure CC.6 – Sequence diagram for normal shutdown or pause after energy transfer by EV or EV supply equipment ..... 226
Figure CC.7 – Sequence diagram for EV supply equipment and EV initiated error shutdown ..... 230
Figure CC.8 – Sequence diagram for EV initiated error shutdown based on DIN SPEC 70121 during energy transfer ..... 233
Figure CC.9 – Sequence diagram for an emergency shutdown executed by the EV ..... 236
Figure CC.10 – Sequence diagram for an emergency shutdown executed by the EV supply equipment ..... 239
Figure CC.11 – Sequence diagram for pause before cable-check phase by EV supply equipment using ISO 15118-2:2014 ..... 242
Figure CC.12 – Sequence diagram for pause after pre-charge phase and before energy transfer stage by the EV supply equipment using ISO 15118-2:2014 ..... 246

Figure CC.13 – Sequence diagram for renegotiation initiated by EV or EV supply equipment using ISO 15118-2:2014 ... 252
Figure CC.14 – Worst case equivalent circuit during pre-charge ... 260
Figure CC.15 – Restart methods sequence for the EV supply equipment ... 263
Figure CC.16 – Restart method verification on the EV supply equipment ... 264
Figure CC.17 – Example of a B1 – B2 transition ... 265
Figure CC.18 – Example of a B1 – E – B1 – B2 transition ... 266
Figure CC.19 – Example of a B1 – F – B1 – B2 transition ... 266
Figure CC.20 – Restart methods sequence for the EV ... 268
Figure CC.21 – Example of a B – C – B toggle ... 269
Figure CC.22 – Operating points ... 285
Figure CC.23 – Approaching a single test point TP in CCM (example 1) ... 288
Figure CC.24 – Approaching multiple test points $TP_n$ CCM (example 2) ... 289
Figure CC.25 – Test points $TP_n$ ... 298
Figure CC.26 – Voltage at the vehicle connector ... 306
Figure CC.27 – Test points $TP_n$ for the load dump test ... 309
Figure CC.28 – Test point matrix for side B current regulation in CCM including static deviation and ripple ... 314
Figure CC.29 – Test point sequence for side B current regulation in CCM ... 317
Figure CC.30 – Test point matrix for 0 A mode during energy transfer ... 318
Figure CC.31 – Test point matrix for side B voltage regulation in CVM during pre-charge ... 321
Figure CC.32 – Test point matrix for control delay of charging current in CCM ... 327
Figure CC.33 – Test point sequence ... 329
Figure CC.34 – Test points for voltage measurement during welding detection ... 344
Figure CC.35 – Test setup for IMD measurement connections ... 351
Figure EE.1 – Magnitude of the impedance of the test load between DC+ and DC– for system A and system B ... 356
Figure EE.2 – Magnitude of the impedance of the test load between DC+ and DC– for system A for current ripple measurements ... 357
Figure EE.3 – Magnitude of the impedance of the test load between DC+ and DC– for system C ... 357
Figure EE.4 – Test setup for test load verification ... 358
Figure FF.1 – Example of a multi-side B EV supply equipment with a single PEC ... 362
Figure FF.2 – Example of a multi-side B EV supply equipment with multiple PECs ... 363
Figure HH.1 – EV and EV supply equipment equivalent circuit ... 370
Figure HH.2 – Circuit diagram simplification of the circuit in Figure HH.1 ... 373
Figure HH.3 –Thevenin equivalent circuit diagram of the circuit in Figure HH.1 ... 373
Figure HH.4 – Leakage current and impulse current in relation to limits in IEC 60479 series ... 374
Figure HH.5 – Examples of circuits with equivalent impulse current and leakage current through a human body ... 375

Table 101 – Verification criterion ... 43
Table 102 – Data/message for the compatibility check test ... 47

Table 103 – Voltage threshold for emergency shutdown reaction for system B and system C ..... 49
Table 104 – EV supply equipment reaction depending on the present voltage at side B condition ..... 49
Table 105 – Compliance tests for protection against overvoltage at side B between DC+ and DC– ..... 50
Table 106 – Test load setup for protection against overvoltage test ..... 50
Table 107 – Data/messages for protection against overvoltage test ..... 51
Table 108 – Overvoltage condition and verification criterion ..... 51
Table 109 – Control circuit supply integrity test ..... 52
Table 110 – Touch voltage under normal operation ..... 69
Table 111 – Touch voltage under single fault conditions ..... 69
Table 112 – Safety provisions for protection against electric shock for EV supply equipment at side B ..... 72
Table 113 – Minimum protective measures ..... 77
Table 114 – Pull force and torque test values for side B cable assembly anchorage ..... 85
Table 115 – Touch current limits ..... 88
Table 116 – Sizes of conductors of power supply cord ..... 96
Table 117 – Cord strain relief pull force ..... 98
Table 118 – Current ripple limit of the EV supply equipment ..... 115
Table 119 – Test parameter values ..... 126
Table 120 – Recommended circuit parameters of the test load ..... 136
Table AA.1 – Definition of symbols of the overall circuit diagram of a system A EV supply equipment ..... 141
Table AA.2 – Parameters and values of the circuit diagram for a system A EV supply equipment ..... 142
Table AA.3 – Principle of fault protection ..... 143
Table AA.4 – Requirements for earth leakage current fault monitoring ..... 145
Table AA.5 – Error shutdown times and criteria ..... 150
Table AA.6 – Action and message parameter for error shutdown triggered by the EV supply equipment ..... 152
Table AA.7 – Action and message parameter for error shutdown triggered by the EV ..... 152
Table AA.8 – Emergency shutdown times and criteria ..... 153
Table AA.9 – Actions and criteria for emergency shutdown ..... 154
Table AA.10 – System A setup of the test load for regulation of the present current at side B in CCM ..... 155
Table AA.11 – System A recommended steps for regulation of the present current at side B in CCM ..... 155
Table AA.12 – Specification of measuring instrument ..... 157
Table AA.13 – Voltage threshold for emergency shutdown ..... 157
Table AA.14 – Maximum boost current for system A EV supply equipment ..... 159
Table AA.15 – FPT states of the FPT EV supply equipment ..... 160
Table AA.16 – FPT control process and states of the FPT EV supply equipment ..... 161
Table AA.17 – Test scenarios ..... 165
Table AA.18 – Normal shutdown times and criteria ..... 166
Table AA.19 – Actions and message parameters for normal shutdown ..... 166

Table AA.20 – Recommended specification of target current of the EV ..... 171
Table AA.21 – Requirements for the side B performance of EV supply equipment ..... 171
Table AA.22 – Setup of test load for protection against under-voltage at the vehicle connector ..... 176
Table AA.23 – BPT states of BPT EV supply equipment ..... 176
Table AA.24 – BPT control process of BPT EV supply equipment ..... 178
Table AA.25 – Selection of protection measures against over-temperature ..... 183
Table AA.26 – Protection measures against over-temperature ..... 183
Table BB.1 – Parameters values of the control circuit for FPT ..... 186
Table BB.2 – Error shutdown times and criteria ..... 192
Table BB.3 – Emergency shutdown times and criteria ..... 192
Table BB.4 – EV simulator voltage ranges emergency shutdown reaction test ..... 196
Table BB.5 – Setup of the test load for side B current regulation in CCM ..... 201
Table BB.6 – Recommended steps for minimum side B current regulation in CCM ..... 202
Table BB.7 – Recommended steps for side B voltage regulation in CVM ..... 204
Table CC.1 – Vehicle couplers for system C ..... 210
Table CC.2 – Component values and tolerances for configuration EE ..... 212
Table CC.3 – Proximity pilot voltages ..... 213
Table CC.4 – Component values and tolerances for configuration FF ..... 215
Table CC.5 – Component limits for the disabled side B of the EV supply equipment ..... 217
Table CC.6 – Message code mapping for sequence diagram ..... 218
Table CC.7 – Example of a sequence description ..... 219
Table CC.8 – Sequence description for normal startup ..... 221
Table CC.9 – Sequence description for normal shutdown or pause after energy transfer by EV or EV supply equipment ..... 227
Table CC.10 – Overview of error and emergency shutdown cases ..... 229
Table CC.11 – Sequence description for EV supply equipment and EV initiated error shutdown ..... 231
Table CC.12 – Sequence description for EV initiated error shutdown based on DIN SPEC 70121 during energy transfer ..... 234
Table CC.13 – Sequence diagram an emergency shutdown executed by the EV ..... 237
Table CC.14 – Sequence diagram an emergency shutdown executed by the EV supply equipment ..... 240
Table CC.15 – Sequence description for pause before cable-check phase by EV supply equipment using ISO 15118-2:2014 ..... 243
Table CC.16 – Sequence description for pause after pre-charge phase and before energy transfer stage by the EV supply equipment using ISO 15118-2:2014 ..... 247
Table CC.17 – Sequence description for renegotiation initiated by EV or EV supply equipment using ISO 15118-2:2014 ..... 253
Table CC.18 – Insulation states and EV supply equipment reaction based on the insulation resistance ..... 258
Table CC.19 – Values to design the EV supply equipment during pre-charge based on Figure CC.14 ..... 261
Table CC.20 – Energy transfer control modes at different communication session stage/phase ..... 282
Table CC.21 – EV simulator target current and voltage ..... 301

Table CC.22 – Current ripple limits ..... 301
Table CC.23 – Component valued for the inrush current limit test ..... 311
Table CC.24 – Current ripple limits ..... 318
Table CC.25 – Test setup values to measure side B voltage regulation in CVM during pre-charge ..... 323
Table CC.26 – Current ripple limits ..... 332
Table CC.27 – EV simulator characteristics ..... 342
Table CC.28 – Test cases for the functional check of the IMD ..... 352
Table EE.1 – Test load parameters ..... 356
Table FF.1 – Possible combinations for multi-side B EV supply equipment ..... 361
Table HH.1 – Key(s) and exemplary values for design verification ..... 371

INTERNATIONAL ELECTROTECHNICAL COMMISSION

# ELECTRIC VEHICLE CONDUCTIVE CHARGING SYSTEM –

## Part 23: DC electric vehicle supply equipment

## FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 61851-23 has been prepared by IEC technical committee 69: Electric power/energy transfer systems for electrically propelled road vehicles and industrial trucks. It is an International Standard.

This second edition cancels and replaces the first edition published in 2014. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) the structure has been rearranged according to IEC 61851-1:2017;
b) electrical safety requirements in Clause 8 and Clause 12 have been revised based on the requirements in IEC 62477-1 and inspired by the hazard based safety approach of IEC 62368-1;

c) test methods for checking conformity to the stated requirements have been mostly added; general provisions for compliance tests have been specified in Clause 102;

d) specific requirements and/or information for the following functions have been added: energy transfer with thermal management system (101.2), bi-directional power transfer control (Annex DD), multi- side B separated EV supply equipment (Annex FF), and communication and energy transfer process (Annex GG);

e) Annex AA (system A), Annex BB (system B) and Annex CC (system C) have been updated including additions in conjunction with b) and c). This document has been limited to be applicable to system A, system B and system C;

f) the former Annex DD and Annex EE have been deleted. A new Annex EE, with the requirements for the artificial test load, has been added.

g) a new informative annex for the touch current and the touch impulse current (Annex HH) has been added.

The text of this International Standard is based on the following documents:

| Draft | Report on voting |
|---|---|
| 69/907/FDIS | 69/925/RVD |

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

This document is to be read in conjunction with IEC 61851-1:2017.

The clauses of particular requirements in this document supplement or modify the corresponding clauses in IEC 61851-1:2017. Where the text of subsequent clauses indicates an "addition" to or a "replacement" of the relevant requirement, test specification or explanation of IEC 61851-1:2017, these changes are made to the relevant text of IEC 61851-1:2017, which then becomes part of this document. Where no change is necessary, the words "This clause of IEC 61851-1:2017 is applicable" are used. The new clauses which are not included in IEC 61851-1:2017 have a clause number starting from 101, for example 3.101, 101.1, etc. The annexes of this document are numbered using double-alphabet, for example Annex AA, to avoid confusion with the annexes in IEC 61851-1:2017.

In this document, the following print types are used:

– *test specifications: italic type*.

– notes: smaller roman type.

Figures in this document use L1 and N to represent the connection of the side A of the EV supply equipment to the AC supply network or DC supply network. This is only to simplify the figures and not to impose requirements.

A list of all parts in the IEC 61851 series, published under the general title *Electric vehicle conductive charging system*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

**IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**

# ELECTRIC VEHICLE CONDUCTIVE CHARGING SYSTEM –

## Part 23: DC electric vehicle supply equipment

## 1 Scope

This part of IEC 61851 applies to the EV supply equipment to provide energy transfer between the supply network and electric vehicles (EVs), with a rated maximum voltage at side A of up to 1 000 V AC or up to 1 500 V DC and a rated maximum voltage at side B up to 1 500 V DC.

This document specifies the EV supply equipment of system A, system B and system C as defined in Annex AA, Annex BB and Annex CC. Other systems are under consideration.

This document provides the requirements for bidirectional power transfer (BPT) EV supply equipment for system A, with a rated maximum voltage at side A up to 1 000 V AC or 1 500 V DC. The requirements for reverse power transfer (RPT) and BPT for system B and system C are under consideration and are not specified in this document.

Annex DD provides information about BPT.

This document does not cover all safety aspects related to maintenance.

Requirements for systems not providing simple separation or protective separation between side A and side B are under consideration.

The requirements for digital communication between EV supply equipment and the EV to control energy transfer are defined in IEC 61851-24.

Requirements for energy transfer with an automated connection device are given in IEC 61851-23-1[1].

Specific requirements for EV supply equipment with multiple vehicle connectors are provided in Annex FF.

General information about energy transfer control, signalling and digital communication is provided in Annex GG.

General information on the touch current and touch impulse current is provided in Annex HH.

Requirements for EV supply equipment without current, voltage and/or power control are under consideration.

EV supply equipment in compliance with this document are not intended to provide energy transfer to a single EV with

– multiple vehicle connectors of the same EV supply equipment, or
– multiple EV supply equipment.

Requirements for such use case are under consideration.

[1] Under preparation. Stage at the time of publication: IEC AFDIS 61851-23-1:2023.

NOTE Requirements for EVs mated to an EV supply equipment are specified in ISO 17409:2020. ISO 17409 will be revised to the ISO 5474 series[2].

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60038:2009, *IEC standard voltages*

IEC 60068-2-75:2014, *Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests*

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60227-1:2007, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 1: General requirements*

IEC 60245-1:2003, *Rubber insulated cables – Rated voltages up to and including 450/750 V – Part 1: General requirements*
IEC 60245-1:2003/AMD1:2007

IEC 60320-1, *Appliance couplers for household and similar general purposes – Part 1: General requirements*

IEC 60364-4-43:2008, *Low-voltage electrical installations – Part 4-43: Protection for safety – Protection against overcurrent*

IEC 60364-5-53:2019, *Low-voltage electrical installations – Part 5-53: Selection and erection of electrical equipment – Devices for protection for safety, isolation, switching, control and monitoring*

IEC 60364-5-54:2011, *Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors*
IEC 60364-5-54:2011/AMD1:2021

IEC 60384-14, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC 60479-1:2018, *Effects of current on human beings and livestock – Part 1: General aspects*

IEC 60479-2:2019, *Effects of current on human beings and livestock – Part 2: Special aspects*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements and tests*

IEC 60811-501, *Electric and optical fibre cables – Test methods for non-metallic materials – Part 501: Mechanical tests – Tests for determining the mechanical properties of insulating and sheathing compounds*

---

2 Under preparation.

IEC 60812:2018, *Failure modes and effects analysis (FMEA and FMECA)*

IEC 60990:2016, *Methods of measurement of touch current and protective conductor current*

IEC 61008-1:2010, *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) – Part 1: General rules*
IEC 61008-1:2010/AMD1:2012
IEC 61008-1:2010/AMD2:2013

IEC 61009-1:2009, *Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs) – Part 1: General rules*
IEC 61009-1:2009/AMD1:2012
IEC 61009-1:2009/AMD2:2013

IEC 60947-2:2016, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*
IEC 60947-2:2016/AMD1:2019

IEC 61140:2016, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61439-1:2020, *Low-voltage switchgear and controlgear assemblies – Part 1: General rules*

IEC 61439-7:2022, *Low-voltage switchgear and controlgear assemblies – Part 7: Assemblies for specific applications such as marinas, camping sites, market squares, electric vehicle charging stations*

IEC 61540:1997, *Electrical accessories – Portable residual current devices without integral overcurrent protection for household and similar use (PRCDs)*
IEC 61540:1997/AMD1:1998

IEC 61557-8:2014, *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V DC – Equipment for testing, measuring or monitoring of protective measures – Part 8: Insulation monitoring devices for IT systems*

IEC 61558-1:2017, *Safety of transformers, reactors, power supply units and combinations thereof – Part 1: General requirements and tests*

IEC 61558-2-4:2021, *Safety of transformers, reactors, power supply units and combinations thereof – Part 2-4: Particular requirements and tests for isolating transformers and power supply units incorporating isolating transformers for general applications*

IEC 61643 (all parts), *Low-voltage surge protective devices*

IEC 61643-11, *Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems – Requirements and test methods*

IEC 61643-21, *Low voltage surge protective devices – Part 21: Surge protective devices connected to telecommunications and signalling networks – Performance requirements and testing methods*

IEC 61851-1:2017, *Electric vehicle conductive charging system – Part 1: General requirements*

IEC 61851-21-2:2018, *Electric vehicle conductive charging system – Part 21-2: Electric vehicle requirements for conductive connection to an AC/DC supply – EMC requirements for off-board electric vehicle charging systems*

IEC 61851-24:2023, *Electric vehicle conductive charging system – Part 24: Digital communication between a DC EV charging station and an electric vehicle for control of DC charging*

IEC 62196-1:2022, *Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles – Part 1: General requirements*

IEC 62196-3:2022, *Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles – Part 3: Dimensional compatibility and interchangeability requirements for DC and AC/DC pin and contact-tube vehicle couplers*

IEC TS 62196-3-1:2020, *Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles – Part 3-1: Vehicle connector, vehicle inlet and cable assembly for DC charging intended to be used with a thermal management system*

IEC 62368-1:2023, *Audio/video, information and communication technology equipment – Part 1: Safety requirements*

IEC 62423:2009, *Type F and type B residual current operated circuit-breakers with and without integral overcurrent protection for household and similar uses*

IEC 62262, *Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)*

IEC 62477-1:2022*, Safety requirements for power electronic converter systems and equipment – Part 1: General*

IEC 62893-4-1:2020, *Charging cables for electric vehicles of rated voltages up to and including 0,6/1 kV – Part 4-1: Cables for DC charging according to mode 4 of IEC 61851-1 – DC charging without use of a thermal management system*

IEC Guide 115, *Application of measurement uncertainty to conformity assessment activities in the electrotechnical sector*

ISO 2719:2016, *Determination of flash point – Pensky-Martens closed cup method*

ISO 6469-3:2018 [3], *Electrically propelled road vehicles – Safety specifications – Part 3: Electrical safety*

ISO 7000, *Graphical symbols for use on equipment*, available at http://www.graphical-symbols.info/equipment

ISO 7010, *Graphical symbols – Safety colours and safety signs – Registered safety signs*, available at https://www.iso.org/obp

ISO 15118-2:2014, *Road vehicles – Vehicle-to-grid communication interface – Part 2: Network and application protocol requirements*

ISO 15118-3, *Road vehicles – Vehicle to grid communication interface – Part 3: Physical and data link layer requirements*

ISO 17409:2020, *Electrically propelled road vehicles – Conductive power transfer – Safety requirements*

---

[3] This publication has been withdrawn. A new edition of ISO 6469-3 (4th edition) came out in 2021.

DIN SPEC 70121:2014, *Electromobility – Digital communication between a DC EV charging station and an electric vehicle for control of DC charging in the combined charging system*

OECD 301 B, *OECD Guideline for testing of chemicals*