

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Programmable controllers –
Part 9: Single-drop digital communication interface for small sensors and
actuators (SDCI)**

**Automates programmables –
Partie 9: Interface de communication numérique point à point pour petits
capteurs et actionneurs (SDCI)**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2022 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC - webstore.iec.ch/advsearchform

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, ...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 300 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 19 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Programmable controllers –
Part 9: Single-drop digital communication interface for small sensors and
actuators (SDCI)**

**Automates programmables –
Partie 9: Interface de communication numérique point à point pour petits
capteurs et actionneurs (SDCI)**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 25.040.40; 35.240.50

ISBN 978-2-8322-1261-5

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD.....	20
INTRODUCTION.....	22
0.1 General.....	22
0.2 Patent declaration.....	23
1 Scope.....	24
2 Normative references	24
3 Terms, definitions, symbols, abbreviated terms, and conventions	25
3.1 Terms and definitions.....	25
3.2 Symbols and abbreviated terms	29
3.3 Conventions.....	31
3.3.1 General	31
3.3.2 Service parameters.....	32
3.3.3 Service procedures.....	32
3.3.4 Service attributes.....	32
3.3.5 Figures	33
3.3.6 Tables	33
3.3.7 Transmission octet order	33
3.3.8 Behavioral descriptions.....	33
4 Overview of SDCI (IO-Link™)	35
4.1 Purpose of technology	35
4.2 Positioning within the automation hierarchy	35
4.3 Wiring, connectors and power	36
4.4 Communication features of SDCI	36
4.5 Role of a Master	39
4.6 SDCI configuration.....	40
4.7 Mapping to fieldbuses and/or other upper-level systems	40
4.8 Standard structure	40
5 Physical Layer (PL)	41
5.1 General.....	41
5.1.1 Basics	41
5.1.2 Topology	41
5.2 Physical layer services.....	42
5.2.1 Overview	42
5.2.2 PL services.....	43
5.3 Transmitter/Receiver.....	45
5.3.1 Description method.....	45
5.3.2 Electrical requirements	45
5.3.3 Timing requirements	50
5.4 Power supply	54
5.4.1 Power supply options.....	54
5.4.2 Port Class B	55
5.4.3 Power-on requirements.....	56
5.5 Medium.....	56
5.5.1 Connectors	56
5.5.2 Cable.....	57
6 Standard Input and Output (SIO)	58

7	Data link layer (DL).....	59
7.1	General.....	59
7.2	Data link layer services	60
7.2.1	DL-B services	60
7.2.2	DL-A services	71
7.3	Data link layer protocol	75
7.3.1	Overview	75
7.3.2	DL-mode handler	76
7.3.3	Message handler	84
7.3.4	Process Data handler	92
7.3.5	On-request Data handler	95
7.3.6	ISDU handler	98
7.3.7	Command handler	102
7.3.8	Event handler	105
8	Application layer (AL)	108
8.1	General.....	108
8.2	Application layer services	109
8.2.1	AL services within Master and Device	109
8.2.2	AL Services	110
8.3	Application layer protocol.....	118
8.3.1	Overview	118
8.3.2	On-request Data transfer	118
8.3.3	Event processing	124
8.3.4	Process Data cycles	127
9	System Management (SM).....	128
9.1	General.....	128
9.2	System Management of the Master	128
9.2.1	Overview	128
9.2.2	SM Master services	130
9.2.3	SM Master protocol.....	135
9.3	System Management of the Device	143
9.3.1	Overview	143
9.3.2	SM Device services	145
9.3.3	SM Device protocol.....	151
10	Device	158
10.1	Overview.....	158
10.2	Process Data Exchange (PDE)	159
10.3	Parameter Manager (PM).....	159
10.3.1	General	159
10.3.2	Parameter Manager state machine	159
10.3.3	Dynamic parameter	162
10.3.4	Single parameter	162
10.3.5	Block Parameter	163
10.3.6	Concurrent parameterization access.....	166
10.3.7	Command handling	166
10.4	Data Storage (DS)	167
10.4.1	General	167
10.4.2	Data Storage state machine.....	167

10.4.3	DS configuration	169
10.4.4	DS memory space	169
10.4.5	DS Index_List	169
10.4.6	DS parameter availability	170
10.4.7	DS without ISDU	170
10.4.8	DS parameter change indication	170
10.5	Event Dispatcher (ED)	170
10.6	Device features	170
10.6.1	General	170
10.6.2	Device backward compatibility	170
10.6.3	Protocol revision compatibility	171
10.6.4	Visual SDCI indication	171
10.6.5	Parameter access locking	171
10.6.6	Data Storage locking	171
10.6.7	Locking of local parameter entries	171
10.6.8	Locking of local user interface	171
10.6.9	Offset time	171
10.6.10	Data Storage concept	172
10.6.11	Block Parameter	172
10.7	Device reset options	172
10.7.1	Overview	172
10.7.2	Device reset	173
10.7.3	Application reset	173
10.7.4	Restore factory settings	174
10.7.5	Back-to-box	174
10.8	Device design rules and constraints	174
10.8.1	General	174
10.8.2	Process Data	174
10.8.3	Communication loss	175
10.8.4	Direct Parameter	175
10.8.5	ISDU communication channel	175
10.8.6	DeviceID rules related to Device variants	175
10.8.7	Protocol constants	176
10.9	IO Device description (IODD)	176
10.10	Device diagnosis	176
10.10.1	Concepts	176
10.10.2	Events	177
10.10.3	Visual indicators	178
10.11	Device connectivity	179
11	Master	179
11.1	Overview	179
11.1.1	Positioning of Master and Gateway Applications	179
11.1.2	Structure, applications, and services of a Master	180
11.1.3	Object view of a Master and its Ports	181
11.2	Services of the Standardized Master Interface (SMI)	182
11.2.1	Overview	182
11.2.2	Structure of SMI service arguments	183
11.2.3	Concurrency and prioritization of SMI services	184
11.2.4	SMI_MasterIdentification	185

11.2.5	SMI_PortConfiguration.....	186
11.2.6	SMI_ReadbackPortConfiguration	187
11.2.7	SMI_PortStatus	189
11.2.8	SMI_DSToParServ	190
11.2.9	SMI_ParServToDS	191
11.2.10	SMI_DeviceWrite	193
11.2.11	SMI_DeviceRead	194
11.2.12	SMI_ParamWriteBatch.....	195
11.2.13	SMI_ParamReadBatch.....	197
11.2.14	SMI_PortPowerOffOn	198
11.2.15	SMI_DeviceEvent	200
11.2.16	SMI_PortEvent	201
11.2.17	SMI_PDIn	201
11.2.18	SMI_PDOut	203
11.2.19	SMI_PDInOut	204
11.2.20	SMI_PDInIQ	205
11.2.21	SMI_PDOutIQ.....	207
11.2.22	SMI_PDRedbackOutIQ	208
11.3	Configuration Manager (CM).....	209
11.3.1	Coordination of Master applications	209
11.3.2	State machine of the Configuration Manager	212
11.4	Data Storage (DS)	217
11.4.1	Overview	217
11.4.2	DS data object.....	217
11.4.3	Backup and Restore	217
11.4.4	DS state machine	217
11.4.5	Parameter selection for Data Storage	224
11.5	On-request Data exchange (ODE).....	224
11.6	Diagnosis Unit (DU)	225
11.6.1	General	225
11.6.2	Device specific Events.....	226
11.6.3	Port specific Events	226
11.6.4	Dynamic diagnosis status	227
11.6.5	Best practice recommendations	227
11.7	PD Exchange (PDE).....	228
11.7.1	General	228
11.7.2	Process Data input mapping	228
11.7.3	Process Data output mapping	229
11.7.4	Process Data invalid/valid qualifier status	230
12	Holistic view on Data Storage	231
12.1	User point of view	231
12.2	Operations and preconditions	232
12.2.1	Purpose and objectives	232
12.2.2	Preconditions for the activation of the Data Storage mechanism	232
12.2.3	Preconditions for the types of Devices to be replaced	232
12.2.4	Preconditions for the parameter sets	232
12.3	Commissioning	233
12.3.1	On-line commissioning.....	233
12.3.2	Off-site commissioning	233

12.4	Backup Levels	234
12.4.1	Purpose	234
12.4.2	Overview	234
12.4.3	Commissioning ("Disable").....	235
12.4.4	Production ("Backup/Restore")	235
12.4.5	Production ("Restore")	236
12.5	Use cases	236
12.5.1	Device replacement ("Backup/Restore")	236
12.5.2	Device replacement ("Restore")	236
12.5.3	Master replacement	236
12.5.4	Project replication	237
13	Integration	237
13.1	Generic Master model for system integration	237
13.2	Role of gateway applications.....	238
13.2.1	Clients	238
13.2.2	Coordination	238
13.3	Security	238
13.4	Special gateway applications	238
13.4.1	Changing Device configuration including Data Storage	238
13.4.2	Parameter server and recipe control	239
13.5	Port and Device Configuration Tool (PDCT)	239
13.5.1	Strategy	239
13.5.2	Accessing Masters via SMI	239
13.5.3	Basic layout examples	239
Annex A (normative)	Codings, timing constraints, and errors	241
A.1	General structure and encoding of M-sequences.....	241
A.1.1	Overview	241
A.1.2	M-sequence control (MC).....	241
A.1.3	Checksum/M-sequence type (CKT).....	242
A.1.4	User data (PD or OD)	242
A.1.5	Checksum/status (CKS).....	243
A.1.6	Calculation of the checksum	244
A.2	M-sequence types.....	245
A.2.1	Overview	245
A.2.2	M-sequence TYPE_0	245
A.2.3	M-sequence TYPE_1_x	245
A.2.4	M-sequence TYPE_2_x	247
A.2.5	M-sequence type 3	249
A.2.6	M-sequence type usage for STARTUP, PREOPERATE and OPERATE modes	249
A.3	Timing constraints.....	251
A.3.1	General	251
A.3.2	Bit time	251
A.3.3	UART frame transmission delay of Master (Ports).....	251
A.3.4	UART frame transmission delay of Devices	251
A.3.5	Response time of Devices	251
A.3.6	M-sequence time	251
A.3.7	Cycle time	252
A.3.8	Idle time	253

A.3.9	Recovery time	253
A.4	Errors and remedies	253
A.4.1	UART errors	253
A.4.2	Wake-up errors.....	253
A.4.3	Transmission errors.....	253
A.4.4	Protocol errors.....	254
A.5	General structure and encoding of ISDUs	254
A.5.1	Overview	254
A.5.2	I-Service.....	254
A.5.3	Extended length (ExtLength).....	255
A.5.4	Index and Subindex	256
A.5.5	Data	256
A.5.6	Check ISDU (CHKPDU).....	256
A.5.7	ISDU examples.....	257
A.6	General structure and encoding of Events.....	259
A.6.1	General	259
A.6.2	StatusCode type 1 (no details).....	259
A.6.3	StatusCode type 2 (with details)	260
A.6.4	EventQualifier.....	261
A.6.5	EventCode.....	262
Annex B (normative)	Parameters and commands.....	263
B.1	Direct Parameter pages 1 and 2.....	263
B.1.1	Overview	263
B.1.2	MasterCommand	264
B.1.3	MasterCycleTime and MinCycleTime	265
B.1.4	M-sequenceCapability	266
B.1.5	RevisionID (RID).....	267
B.1.6	ProcessDataIn	267
B.1.7	ProcessDataOut	268
B.1.8	VendorID (VID).....	268
B.1.9	DeviceID (DID)	268
B.1.10	FunctionID (FID).....	268
B.1.11	SystemCommand	269
B.1.12	Device specific Direct Parameter page 2	269
B.2	Predefined Device parameters	269
B.2.1	Overview	269
B.2.2	SystemCommand	272
B.2.3	DataStorageIndex.....	273
B.2.4	DeviceAccessLocks	274
B.2.5	ProfileCharacteristic	276
B.2.6	PDInputDescriptor	276
B.2.7	PDOutputDescriptor.....	276
B.2.8	VendorName	276
B.2.9	VendorText.....	276
B.2.10	ProductName.....	276
B.2.11	ProductID	276
B.2.12	ProductText.....	276
B.2.13	SerialNumber.....	277
B.2.14	HardwareRevision	277

B.2.15	FirmwareRevision	277
B.2.16	ApplicationSpecificTag	277
B.2.17	FunctionTag	277
B.2.18	LocationTag.....	277
B.2.19	ErrorCount.....	277
B.2.20	DeviceStatus	277
B.2.21	DetailedDeviceStatus	278
B.2.22	ProcessDataInput	279
B.2.23	ProcessDataOutput	279
B.2.24	OffsetTime.....	279
B.2.25	Profile parameter (reserved).....	280
B.2.26	Preferred Index.....	280
B.2.27	Extended Index.....	280
B.2.28	Profile specific Index (reserved).....	280
Annex C (normative)	ErrorTypes (ISDU errors)	281
C.1	General.....	281
C.2	Application related ErrorTypes	281
C.2.1	Overview	281
C.2.2	Device application error – no details	282
C.2.3	Index not available	282
C.2.4	Subindex not available.....	282
C.2.5	Service temporarily not available	282
C.2.6	Service temporarily not available – local control	282
C.2.7	Service temporarily not available – device control.....	282
C.2.8	Access denied	282
C.2.9	Parameter value out of range.....	282
C.2.10	Parameter value above limit	282
C.2.11	Parameter value below limit.....	282
C.2.12	Parameter length overrun	283
C.2.13	Parameter length underrun	283
C.2.14	Function not available.....	283
C.2.15	Function temporarily unavailable	283
C.2.16	Invalid parameter set	283
C.2.17	Inconsistent parameter set.....	283
C.2.18	Application not ready	283
C.2.19	Vendor specific.....	283
C.3	Derived ErrorTypes	283
C.3.1	Overview	283
C.3.2	Master – Communication error.....	284
C.3.3	Master – ISDU timeout.....	284
C.3.4	Device Event – ISDU error.....	284
C.3.5	Device Event – ISDU illegal service primitive	284
C.3.6	Master – ISDU checksum error	284
C.3.7	Master – ISDU illegal service primitive.....	284
C.3.8	Device Event – ISDU buffer overflow	284
C.4	SMI related ErrorTypes	285
C.4.1	Overview	285
C.4.2	ArgBlock unknown	285
C.4.3	Incorrect ArgBlock content type	285

C.4.4	Device not communicating	285
C.4.5	Service unknown	285
C.4.6	Process Data not accessible	285
C.4.7	Insufficient memory	285
C.4.8	Incorrect Port number	285
C.4.9	Incorrect ArgBlock length	286
C.4.10	Master busy	286
C.4.11	Inconsistent DS data	286
C.4.12	Device or Master error	286
Annex D (normative)	EventCodes (diagnosis information)	287
D.1	General	287
D.2	EventCodes for Devices	287
D.3	EventCodes for Ports	289
Annex E (normative)	Coding of ArgBlocks	291
E.1	General	291
E.2	MasterIdent	292
E.3	PortConfigList	293
E.4	PortStatusList	295
E.5	On-request_Data	297
E.6	DS_Data	298
E.7	DeviceParBatch	298
E.8	IndexList	299
E.9	PortPowerOffOn	299
E.10	PDIn	299
E.11	PDOut	300
E.12	PDInOut	300
E.13	PDInIQ	301
E.14	PDOutIQ	301
E.15	DeviceEvent	302
E.16	PortEvent	302
E.17	VoidBlock	302
E.18	JobError	303
Annex F (normative)	Data types	304
F.1	General	304
F.2	Basic data types	304
F.2.1	General	304
F.2.2	BooleanT	304
F.2.3	UIntegerT	304
F.2.4	IntegerT	305
F.2.5	Float32T	307
F.2.6	StringT	308
F.2.7	OctetStringT	308
F.2.8	TimeT	309
F.2.9	TimeSpanT	310
F.3	Composite data types	311
F.3.1	General	311
F.3.2	ArrayT	311
F.3.3	RecordT	311
Annex G (normative)	Structure of the Data Storage data object	315

Annex H (normative) Master and Device conformity	316
H.1 Electromagnetic compatibility (EMC) requirements	316
H.1.1 General	316
H.1.2 Operating conditions	316
H.1.3 Performance criteria	316
H.1.4 Required immunity tests	317
H.1.5 Required emission tests	318
H.1.6 Test configurations for Master	318
H.1.7 Test configurations for Devices	320
H.2 Test strategies for conformity	321
H.2.1 Test of a Device	321
H.2.2 Test of a Master	322
Annex I (informative) Residual error probabilities	323
I.1 Residual error probability of the SDCI data integrity mechanism	323
I.2 Derivation of EMC test conditions	323
Annex J (informative) Example sequence of an ISDU transmission	325
Annex K (informative) Recommended methods for detecting parameter changes	327
K.1 CRC signature	327
K.2 Revision counter	327
Bibliography	328
Figure 1 – Example of a confirmed service	33
Figure 2 – Memory storage and transmission order for WORD based data types	33
Figure 3 – Example of a nested state	34
Figure 4 – SDCI compatibility with IEC 61131-2	35
Figure 5 – Domain of the SDCI technology within the automation hierarchy	35
Figure 6 – Generic Device model for SDCI (Master's view)	37
Figure 7 – Relationship between nature of data and transmission types	38
Figure 8 – Object transfer at the application layer level (AL)	39
Figure 9 – Logical structure of Master and Device	40
Figure 10 – Three wire connection system	41
Figure 11 – Topology of SDCI	42
Figure 12 – Physical layer (Master)	42
Figure 13 – Physical layer (Device)	43
Figure 14 – Line driver reference schematics	45
Figure 15 – Receiver reference schematics	45
Figure 16 – Reference schematics for SDCI 3-wire connection system	46
Figure 17 – Voltage level definitions	46
Figure 18 – Switching thresholds	47
Figure 19 – Inrush current and charge (example)	48
Figure 20 – Power-on timing for Power 1	50
Figure 21 – Format of an SDCI UART frame	50
Figure 22 – Eye diagram for the 'H' and 'L' detection	51
Figure 23 – Eye diagram for the correct detection of a UART frame	52
Figure 24 – Wake-up request	54

Figure 25 – Class A and B Port definitions	55
Figure 26 – Pin layout front view	57
Figure 27 – Reference schematics for effective line capacitance and loop resistance	58
Figure 28 – Structure and services of the data link layer (Master)	59
Figure 29 – Structure and services of the data link layer (Device)	60
Figure 30 – State machines of the data link layer	76
Figure 31 – Example of an attempt to establish communication	76
Figure 32 – Failed attempt to establish communication	77
Figure 33 – Retry strategy to establish communication	78
Figure 34 – Fallback procedure	79
Figure 35 – State machine of the Master DL-mode handler	80
Figure 36 – Submachine 1 to establish communication	80
Figure 37 – State machine of the Device DL-mode handler	83
Figure 38 – SDCI message sequences	85
Figure 39 – Overview of M-sequence types	86
Figure 40 – State machine of the Master message handler	87
Figure 41 – Submachine "Response 3" of the message handler	88
Figure 42 – Submachine "Response 8" of the message handler	88
Figure 43 – Submachine "Response 15" of the message handler	88
Figure 44 – State machine of the Device message handler	91
Figure 45 – Interleave mode for the segmented transmission of Process Data	93
Figure 46 – State machine of the Master Process Data handler	93
Figure 47 – State machine of the Device Process Data handler	94
Figure 48 – State machine of the Master On-request Data handler	96
Figure 49 – State machine of the Device On-request Data handler	97
Figure 50 – Structure of the ISDU	98
Figure 51 – State machine of the Master ISDU handler	100
Figure 52 – State machine of the Device ISDU handler	101
Figure 53 – State machine of the Master command handler	103
Figure 54 – State machine of the Device command handler	104
Figure 55 – State machine of the Master Event handler	106
Figure 56 – State machine of the Device Event handler	107
Figure 57 – Structure and services of the application layer (Master)	109
Figure 58 – Structure and services of the application layer (Device)	109
Figure 59 – OD state machine of the Master AL	119
Figure 60 – OD state machine of the Device AL	121
Figure 61 – Sequence diagram for the transmission of On-request Data	122
Figure 62 – Sequence diagram for On-request Data in case of errors	123
Figure 63 – Sequence diagram for On-request Data in case of timeout	123
Figure 64 – Event state machine of the Master AL	124
Figure 65 – Event state machine of the Device AL	125
Figure 66 – Single Event scheduling	126
Figure 67 – Sequence diagram for output Process Data	127

Figure 68 – Sequence diagram for input Process Data.....	128
Figure 69 – Structure and services of the Master System Management.....	129
Figure 70 – Sequence chart of the use case "Port x setup"	130
Figure 71 – Main state machine of the Master System Management	136
Figure 72 – SM Master submachine CheckCompatibility_1	138
Figure 73 – Activity for state "CheckVxy"	140
Figure 74 – Activity for state "CheckCompV10"	140
Figure 75 – Activity for state "CheckComp"	141
Figure 76 – Activity (write parameter) in state "RestartDevice"	141
Figure 77 – SM Master submachine checkSerNum_3.....	142
Figure 78 – Activity (check SerialNumber) for state CheckSerNum_31.....	143
Figure 79 – Structure and services of the System Management (Device)	144
Figure 80 – Sequence chart of the use case "INACTIVE – SIO – SDCI – SIO"	145
Figure 81 – State machine of the Device System Management	152
Figure 82 – Sequence chart of a regular Device startup.....	155
Figure 83 – Sequence chart of a Device startup in compatibility mode	156
Figure 84 – Sequence chart of a Device startup when compatibility fails.....	157
Figure 85 – Structure and services of a Device	158
Figure 86 – Parameter Manager (PM) state machine	160
Figure 87 – Positive and negative parameter checking result	162
Figure 88 – Positive Block Parameter download with Data Storage request	164
Figure 89 – Negative Block Parameter download	165
Figure 90 – Data Storage (DS) state machine	167
Figure 91 – Data Storage request message sequence	169
Figure 92 – Cycle timing	172
Figure 93 – Event flow in case of successive errors	178
Figure 94 – Device LED indicator timing	179
Figure 95 – Generic relationship of SDCI and automation technology	180
Figure 96 – Structure, applications and services of a Master.....	181
Figure 97 – Object model of Master and Ports	182
Figure 98 – SMI services	182
Figure 99 – Coordination of Master applications	210
Figure 100 – Sequence diagram of start-up via Configuration Manager.....	212
Figure 101 – State machine of the Configuration Manager	213
Figure 102 – Activity for state "CheckPortMode_0"	216
Figure 103 – Main state machine of the Data Storage mechanism	218
Figure 104 – Submachine "UpDownload_2" of the Data Storage mechanism	219
Figure 105 – Data Storage submachine "Upload_7"	220
Figure 106 – Data Storage upload sequence diagram	220
Figure 107 – Data Storage submachine "Download_10".....	221
Figure 108 – Data Storage download sequence diagram.....	221
Figure 109 – State machine of the On-request Data Exchange	225
Figure 110 – DeviceEvent flow control	226

Figure 111 – Port Event flow control	226
Figure 112 – SDCI diagnosis information propagation via Events	227
Figure 113 – Principles of Process Data Input mapping	228
Figure 114 – Port Qualifier Information (PQI)	229
Figure 115 – Principles of Process Data Output mapping	230
Figure 116 – Propagation of PD qualifier status between Master and Device	231
Figure 117 – Active and backup parameter	233
Figure 118 – Off-site commissioning	233
Figure 119 – Generic Master model for system integration	238
Figure 120 – PDCT via gateway application	239
Figure 121 – Example 1 of a PDCT display layout	240
Figure 122 – Example 2 of a PDCT display layout	240
Figure A.1 – M-sequence control	241
Figure A.2 – Checksum/M-sequence type octet	242
Figure A.3 – Checksum/status octet	243
Figure A.4 – Principle of the checksum calculation and compression	244
Figure A.5 – M-sequence TYPE_0	245
Figure A.6 – M-sequence TYPE_1_1	245
Figure A.7 – M-sequence TYPE_1_2	246
Figure A.8 – M-sequence TYPE_1_V	246
Figure A.9 – M-sequence TYPE_2_1	247
Figure A.10 – M-sequence TYPE_2_2	247
Figure A.11 – M-sequence TYPE_2_3	248
Figure A.12 – M-sequence TYPE_2_4	248
Figure A.13 – M-sequence TYPE_2_5	248
Figure A.14 – M-sequence TYPE_2_V	249
Figure A.15 – M-sequence timing	252
Figure A.16 – I-Service octet	254
Figure A.17 – Check of ISDU integrity via CHKPDU	257
Figure A.18 – Examples of request formats for ISDUs	257
Figure A.19 – Examples of response ISDUs	258
Figure A.20 – Examples of read and write request ISDUs	259
Figure A.21 – Structure of StatusCode type 1	259
Figure A.22 – Structure of StatusCode type 2	260
Figure A.23 – Indication of activated Events	261
Figure A.24 – Structure of the EventQualifier	261
Figure B.1 – Classification and mapping of Direct Parameters	263
Figure B.2 – MinCycleTime	265
Figure B.3 – M-sequenceCapability	266
Figure B.4 – RevisionID	267
Figure B.5 – ProcessDataIn	267
Figure B.6 – Index space for ISDU data objects	269
Figure B.7 – Structure of the OffsetTime	279

Figure E.1 – Assignment of ArgBlock identifiers	291
Figure F.1 – Coding example of small UIntegerT	305
Figure F.2 – Coding example of large UIntegerT	305
Figure F.3 – Coding examples of IntegerT	307
Figure F.4 – Singular access of StringT	308
Figure F.5 – Coding example of OctetStringT.....	309
Figure F.6 – Definition of TimeT.....	309
Figure F.7 – Example of an ArrayT data structure	311
Figure F.8 – Example 2 of a RecordT structure	313
Figure F.9 – Example 3 of a RecordT structure	313
Figure F.10 – Write requests for Example 3	314
Figure H.1 – Test setup for electrostatic discharge (Master)	319
Figure H.2 – Test setup for RF electromagnetic field (Master).....	319
Figure H.3 – Test setup for fast transients (Master)	319
Figure H.4 – Test setup for RF common mode (Master)	320
Figure H.5 – Test setup for electrostatic discharges (Device).....	320
Figure H.6 – Test setup for RF electromagnetic field (Device).....	321
Figure H.7 – Test setup for fast transients (Device)	321
Figure H.8 – Test setup for RF common mode (Device)	321
Figure I.1 – Residual error probability for the SDCl data integrity mechanism	323
Figure J.1 – Example for ISDU transmissions	325
Table 1 – Service assignments of Master and Device	43
Table 2 – PL_SetMode	43
Table 3 – PL_WakeUp	44
Table 4 – PL_Transfer	44
Table 5 – Electrical characteristics of a receiver	47
Table 6 – Electrical characteristics of a Master Port.....	48
Table 7 – Electrical characteristics of a Device	49
Table 8 – Power-on timing	50
Table 9 – Dynamic characteristics of the transmission	52
Table 10 – Wake-up request characteristics.....	54
Table 11 – Electrical characteristics of a Master Port Class B.....	55
Table 12 – Master pin assignments.....	56
Table 13 – Device pin assignments.....	57
Table 14 – Cable characteristics	58
Table 15 – Cable conductor assignments.....	58
Table 16 – Service assignments within Master and Device	61
Table 17 – DL_ReadParam.....	61
Table 18 – DL_WriteParam.....	62
Table 19 – DL_Read	63
Table 20 – DL_Write	63
Table 21 – DL_ISDUTransport	64

Table 22 – DL_ISDUAbort.....	65
Table 23 – DL_PDOutputUpdate.....	65
Table 24 – DL_PDOutputTransport.....	66
Table 25 – DL_PDInputUpdate.....	66
Table 26 – DL_PDInputTransport.....	67
Table 27 – DL_PDCycle.....	67
Table 28 – DL_SetMode.....	68
Table 29 – DL_Mode.....	69
Table 30 – DL_Event.....	69
Table 31 – DL_EventConf.....	70
Table 32 – DL_EventTrigger.....	70
Table 33 – DL_Control.....	70
Table 34 – DL-A services within Master and Device.....	71
Table 35 – OD.....	72
Table 36 – PD.....	73
Table 37 – EventFlag.....	74
Table 38 – PDInStatus.....	74
Table 39 – MHInfo.....	74
Table 40 – ODTrig.....	75
Table 41 – PDTrig.....	75
Table 42 – Wake-up procedure and retry characteristics.....	78
Table 43 – Fallback timing characteristics.....	79
Table 44 – State transition table of the Master DL-mode handler.....	81
Table 45 – State transition table of the Device DL-mode handler.....	83
Table 46 – State transition table of the Master message handler.....	89
Table 47 – State transition table of the Device message handler.....	92
Table 48 – State transition table of the Master Process Data handler.....	94
Table 49 – State transition table of the Device Process Data handler.....	95
Table 50 – State transition table of the Master On-request Data handler.....	96
Table 51 – State transition table of the Device On-request Data handler.....	97
Table 52 – FlowCTRL definitions.....	99
Table 53 – State transition table of the Master ISDU handler.....	100
Table 54 – State transition table of the Device ISDU handler.....	102
Table 55 – Control codes.....	103
Table 56 – State transition table of the Master command handler.....	103
Table 57 – State transition table of the Device command handler.....	105
Table 58 – Event memory.....	105
Table 59 – State transition table of the Master Event handler.....	107
Table 60 – State transition table of the Device Event handler.....	108
Table 61 – AL services within Master and Device.....	110
Table 62 – AL_Read.....	110
Table 63 – AL_Write.....	111
Table 64 – AL_Abort.....	112

Table 65 – AL_GetInput	113
Table 66 – AL_NewInput	114
Table 67 – AL_SetInput	114
Table 68 – AL_PDCycle	114
Table 69 – AL_GetOutput	115
Table 70 – AL_NewOutput	115
Table 71 – AL_SetOutput	116
Table 72 – AL_Event	117
Table 73 – AL_Control	118
Table 74 – States and transitions for the OD state machine of the Master AL	119
Table 75 – States and transitions for the OD state machine of the Device AL	121
Table 76 – State and transitions of the Event state machine of the Master AL	124
Table 77 – State and transitions of the Event state machine of the Device AL	125
Table 78 – SM services within the Master	131
Table 79 – SM_SetPortConfig	131
Table 80 – Definition of the InspectionLevel (IL)	132
Table 81 – Definitions of the Target Modes	132
Table 82 – SM_GetPortConfig	133
Table 83 – SM_PortMode	134
Table 84 – SM_Operate	135
Table 85 – State transition table of the Master System Management	137
Table 86 – State transition table of the Master submachine CheckCompatibility_1	139
Table 87 – State transition table of the Master submachine checkSerNum_3	142
Table 88 – SM services within the Device	146
Table 89 – SM_SetDeviceCom	146
Table 90 – SM_GetDeviceCom	147
Table 91 – SM_SetDeviceIdent	148
Table 92 – SM_GetDeviceIdent	149
Table 93 – SM_SetDeviceMode	150
Table 94 – SM_DeviceMode	150
Table 95 – State transition table of the Device System Management	153
Table 96 – State transition table of the PM state machine	160
Table 97 – Sequence of parameter checks	163
Table 98 – Steps and rules for Block Parameter checking	165
Table 99 – Prioritized ISDU responses on command parameters	166
Table 100 – State transition table of the Data Storage state machine	168
Table 101 – Overview on reset options and their impact on Devices	173
Table 102 – Overview of the protocol constants for Devices	176
Table 103 – Classification of Device diagnosis incidents	177
Table 104 – Timing for LED indicators	179
Table 105 – SMI services	183
Table 106 – SMI_MasterIdentification	185
Table 107 – SMI_PortConfiguration	186

Table 108 – SMI_ReadbackPortConfiguration	188
Table 109 – SMI_PortStatus	189
Table 110 – SMI_DSToParServ	190
Table 111 – SMI_ParServToDS	192
Table 112 – SMI_DeviceWrite	193
Table 113 – SMI_DeviceRead	194
Table 114 – SMI_ParamWriteBatch	196
Table 115 – SMI_ParamReadBatch	197
Table 116 – SMI_PortPowerOffOn	199
Table 117 – SMI_DeviceEvent	200
Table 118 – SMI_PortEvent	201
Table 119 – SMI_PDIn	202
Table 120 – SMI_PDOut	203
Table 121 – SMI_PDInOut	204
Table 122 – SMI_PDInIQ	206
Table 123 – SMI_PDOutIQ	207
Table 124 – SMI_PDReadbackOutIQ	208
Table 125 – Internal variables and Events controlling Master applications	210
Table 126 – State transition table of the Configuration Manager	213
Table 127 – States and transitions of the Data Storage state machines	222
Table 128 – State transition table of the ODE state machine	225
Table 129 – Recommended Data Storage Backup Levels	234
Table 130 – Criteria for backing up parameters ("Backup/Restore")	235
Table 131 – Criteria for backing up parameters ("Restore")	236
Table A.1 – Values of communication channel	241
Table A.2 – Values of R/W	242
Table A.3 – Values of M-sequence types	242
Table A.4 – Data types for user data	243
Table A.5 – Values of PD status	243
Table A.6 – Values of the Event flag	244
Table A.7 – M-sequence types for the STARTUP mode	249
Table A.8 – M-sequence types for the PREOPERATE mode	249
Table A.9 – M-sequence types for the OPERATE mode (legacy protocol)	250
Table A.10 – M-sequence types for the OPERATE mode	250
Table A.11 – Recommended MinCycleTimes	252
Table A.12 – Definition of the nibble "I-Service"	255
Table A.13 – ISDU syntax	255
Table A.14 – Definition of nibble Length and octet ExtLength	256
Table A.15 – Use of Index formats	256
Table A.16 – Mapping of EventCodes (type 1)	260
Table A.17 – Values of INSTANCE	261
Table A.18 – Values of SOURCE	262
Table A.19 – Values of TYPE	262

Table A.20 – Values of MODE	262
Table B.1 – Direct Parameter pages 1 and 2.....	264
Table B.2 – Types of MasterCommands.....	265
Table B.3 – Possible values of MasterCycleTime and MinCycleTime	266
Table B.4 – Values of ISDU	266
Table B.5 – Values of SIO.....	268
Table B.6 – Permitted combinations of BYTE and Length	268
Table B.7 – Implementation rules for parameters and commands.....	270
Table B.8 – Index assignment of data objects (Device parameter)	270
Table B.9 – Coding of SystemCommand (ISDU)	272
Table B.10 – DataStorageIndex assignments.....	273
Table B.11 – Structure of Index_List	274
Table B.12 – Device locking possibilities.....	275
Table B.13 – DeviceStatus parameter	278
Table B.14 – DetailedDeviceStatus (Index 0x0025).....	279
Table B.15 – Time base coding and values of OffsetTime	280
Table C.1 – ErrorTypes.....	281
Table C.2 – Derived ErrorTypes.....	284
Table C.3 – SMI related ErrorTypes	285
Table D.1 – EventCodes for Devices.....	287
Table D.2 – EventCodes for Ports	289
Table E.1 – ArgBlock types and their ArgBlockIDs	292
Table E.2 – MasterIdent.....	293
Table E.3 – PortConfigList	294
Table E.4 – PortStatusList	296
Table E.5 – On-request_Data.....	297
Table E.6 – DS_Data	298
Table E.7 – DeviceParBatch	298
Table E.8 – IndexList	299
Table E.9 – PortPowerOffOn.....	299
Table E.10 – PDIn	300
Table E.11 – PDOut.....	300
Table E.12 – PDInOut.....	301
Table E.13 – PDInIQ	301
Table E.14 – PDOutIQ	302
Table E.15 – DeviceEvent.....	302
Table E.16 – PortEvent.....	302
Table E.17 – VoidBlock.....	303
Table E.18 – JobError.....	303
Table F.1 – BooleanT	304
Table F.2 – BooleanT coding	304
Table F.3 – UIntegerT	305
Table F.4 – IntegerT	305

Table F.5 – IntegerT coding (8 octets)	306
Table F.6 – IntegerT coding (4 octets)	306
Table F.7 – IntegerT coding (2 octets)	306
Table F.8 – IntegerT coding (1 octet)	306
Table F.9 – Float32T	307
Table F.10 – Coding of Float32T	307
Table F.11 – StringT	308
Table F.12 – OctetStringT	308
Table F.13 – TimeT	309
Table F.14 – Coding of TimeT	310
Table F.15 – TimeSpanT	310
Table F.16 – Coding of TimeSpanT	310
Table F.17 – Structuring rules for ArrayT	311
Table F.18 – Example for the access of an ArrayT	311
Table F.19 – Structuring rules for RecordT	312
Table F.20 – Example 1 for the access of a RecordT	312
Table F.21 – Example 2 for the access of a RecordT	312
Table F.22 – Example 3 for the access of a RecordT	313
Table G.1 – Structure of the stored DS data object	315
Table G.2 – Associated header information for stored DS data objects	315
Table H.1 – EMC test conditions for SDCI	317
Table H.2 – EMC test levels	317
Table K.1 – Proper CRC generator polynomials	327

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PROGRAMMABLE CONTROLLERS –**Part 9: Single-drop digital communication interface
for small sensors and actuators (SDCI)****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) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 61131-9 has been prepared by subcommittee 65B: Measurement and control devices, of IEC technical committee 65: Industrial-process measurement, control and automation. It is an International Standard.

This second edition cancels and replaces the first edition published in 2013. This edition constitutes a technical revision.

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

- a) requirements for Port Class B have been refined;
- b) best practice patterns for Data Storage (backup of Device parameters) and Device reset functions have been introduced;
- c) a new Standardized Master Interface (SMI) for PLC, IT, and an engineering tool access have been added.

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

Draft	Report on voting
65B/1218/FDIS	65B/1219/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/standardsdev/publications.

A list of all parts in the IEC 61131 series, published under the general title *Programmable controllers*, 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,
- replaced by a revised edition, or
- amended.

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.

INTRODUCTION

0.1 General

IEC 61131-9 is part of a series of standards on programmable controllers and the associated peripherals and should be read in conjunction with the other parts of the series.

Where a conflict exists between this and other IEC standards (except basic safety standards), the provisions of this document should be considered to govern in the area of programmable controllers and their associated peripherals.

The increased use of micro-controllers embedded in low-cost sensors and actuators has provided opportunities for adding diagnosis and configuration data to support increasing application requirements.

The driving force for the SDCI (IO-Link™¹) technology is the need of these low-cost sensors and actuators to exchange this diagnosis and configuration data with a controller (PC or PLC) using a low-cost, digital communication technology while maintaining backward compatibility with the current DI/DO signals.

In fieldbus concepts, the SDCI technology defines a generic interface for connecting sensors and actuators to a Master unit, which can be combined with gateway capabilities to become a fieldbus remote I/O node.

Any SDCI compliant Device can be attached to any available interface Port of the Master. SDCI compliant Devices perform physical to digital conversion in the Device, and then communicate the result directly in a standard format using "coded switching" of the 24 V I/O signalling line, thus removing the need for different DI, DO, AI, AO modules and a variety of cables.

Physical topology is point-to-point from each Device to the Master using three wires over distances up to 20 m. The SDCI physical interface is backward compatible with the usual 24 V I/O signalling specified in IEC 61131-2. Transmission rates of 4,8 kbit/s, 38,4 kbit/s and 230,4 kbit/s are supported.

The Master of the SDCI interface detects, identifies, and manages Devices plugged into its Ports.

Tools allow the association of Devices with their corresponding electronic I/O Device Descriptions (IODD) and their subsequent configuration to match the application requirements.

The SDCI technology specifies three different levels of diagnostic capabilities: for immediate response by automated needs during the production phase, for medium term response by operator intervention, or for longer term commissioning and maintenance via extended diagnosis information.

The structure of this document is described in 4.8.

Conformity with IEC 61131-9 cannot be claimed unless the requirements of Annex H are met.

¹ IO-Link™ is a trade name of the "IO-Link Community". This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the trade name holder or any of its products. Compliance with this document does not require use of the registered logos for IO-Link™. Use of the registered logos for IO-Link™ requires permission of the "IO-Link Community".

Terms of general use are defined in IEC 61131-1 or in the IEC 60050 series [1]². More specific terms are defined in this document.

0.2 Patent declaration

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent. IEC takes no position concerning the evidence, validity, and scope of this patent right.

The holder of this patent right has assured IEC that s/he is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with IEC. Information may be obtained from the patent database available at <http://patents.iec.ch>.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights other than those in the patent database. IEC shall not be held responsible for identifying any or all such patent rights.

² Numbers in square brackets refer to the Bibliography.

PROGRAMMABLE CONTROLLERS –

Part 9: Single-drop digital communication interface for small sensors and actuators (SDCI)

1 Scope

This part of IEC 61131 specifies a single-drop digital communication interface technology for small sensors and actuators SDCI (commonly known as IO-Link™³), which extends the traditional digital input and digital output interfaces as defined in IEC 61131-2 towards a point-to-point communication link for the exchange of complex data in both directions. This technology also enables the transfer of parameters to Devices and the delivery of identification and diagnostic information from the Devices to the automation system.

This technology is mainly intended for use with simple sensors and actuators in factory automation, which include small and cost-effective microcontrollers.

This document specifies the SDCI communication services and protocol (physical layer, data link layer and application layer in accordance with the ISO/OSI reference model) for both SDCI Masters and Devices.

This document also includes EMC test requirements.

This document does not cover communication interfaces or systems incorporating multiple point or multiple drop linkages, or integration of SDCI into higher level systems such as fieldbuses.

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 60664 (all parts), *Insulation coordination for equipment within low-voltage supply systems*

IEC 60947-5-2, *Low-voltage switchgear and controlgear – Part 5-2: Control circuit devices and switching elements – Proximity switches*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3 : Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

³ IO-Link™ is a trade name of the "IO-Link Community". This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the trade name holder or any of its products. Compliance with this document does not require use of the registered logos for IO-Link™. Use of the registered logos for IO-Link™ requires permission of the "IO-Link Community".