

Preface to the 3rd English edition	4	Protection Circuits for Diodes and Thyristors	64
References	10	Components for Surge Protection	65
Section F: Fundamentals, Physics, Components 11		Cooling of Semiconductor Components	66
Symbols in this Book	12	Section TM: Technical Documentation, Measuring 67	
Subscripts and Signs for Formula Symbols in this Book	13	Graphical Representation of Characteristics	68
Symbols for Rotating Electrical Machines	14	General Technical Drawing	69
Quantities and Units	15	Graphical Representation of Bodies	70
Mathematical Symbols	17	Dimension Arrows, Special Representations	71
Exponents, Unit Prefixes, Logarithms, Calculations According to the Rule of Three	18	Dimensioning	72
Logarithmic Unit Decibel	19	Dimensioning, Hatching	73
Angles, Trigonometric Functions, Percentage Calculation	20	Circuit Diagrams as Function-related Documents	74
Relationships between Trigonometric Functions	21	Other Function-related Documents	75
Lengths and Areas	22	Location- and Connection-related Documents	76
Body and Mass	23	Code letters of Objects (Equipment) in Circuit Diagrams	77
Mass, Force, Pressure, Moment of Force	24	Designation of Components in Circuit Diagrams	78
Rules of Motion	25	Use of Reference Designation acc. to DIN EN IEC 81346 in Plants	80
Mechanical Work, Mechanical Power, Energy	26	Designation of Contacts in Circuit Diagrams	81
Transmissions	27	Circuits and Circuit Symbols	82
Pulleys, Wedges, Winches	28	General Circuit Symbols	83
Heat	29	Additional Circuit Symbols, Switches in Energy Plants	84
Charge, Voltage, Electric Current, Resistance	30	Measuring Instruments and Devices	85
Electric Power, Electric Work	31	Semiconductor Components	86
Electric Field, Capacitor	32	Binary Elements	87
Alternating Quantities, Wavelength	33	Analogue Information Processing, Meters and Tariff Switchgears	89
Power of Alternating Sine-wave Current, Pulse	34	Audio Converter, Video Converter and Aerial Systems	90
Magnetic Field, Coil	35	Circuit Symbols for Installation Circuit Diagrams and Installation Diagrams	91
Current in the Magnetic Field, Induction	36	Installation Circuit Diagrams	93
Resistor Circuits	37	Circuit Symbols for Block Diagrams	94
Reference Arrows, Kirchhoff's Laws, Voltage Dividers	38	Coils, Transformers, Rotating Generators	95
Potentiometer	39	Single-phase AC Motors and Starters	96
Equivalent Voltage Source, Equivalent Current Source, Matching	40	Three-phase Motors and Starters	97
Basic Circuits of Inductances and Capacitances	41	Converter-fed Motors	98
Switching Capacitors and Coils	42	Comparison of Circuit Symbols	99
Series Connection of R, L, C	43	Marks and Symbols on Electrical Equipment (Examples)	101
Parallel Connection of R, L, C	44	Hydraulic and Pneumatic Symbols	102
Equivalent Series Connection and Equivalent Parallel Connection	45	Symbols in Process Engineering	103
Simple Filters	46	Designation for Electropneumatic Controls	104
Three-phase Alternating Current	47	Electropneumatic Basic Circuits	105
Unbalanced Load, Star-delta Conversion, Bridge Circuit	48	Preparing Documentation on Equipment and Plants	106
Unbalanced Similar Loads in Three-phase Alternating Current	49	Structure and Contents of Operating Instructions	107
Resistors and Capacitors	50	Electrical Measuring Instruments and Systems	108
Colour Marking of Resistors and Capacitors	51	Pictograms for Measuring	109
Types of Resistors and Capacitors	52	Measuring Circuits for Resistance Calculation	110
Application Groups and Structures of Capacitors	53	Measuring Range Extension	111
Semiconductor Resistors	54	AC/DC Quantity Gathering	112
Diodes	55	Measurements in Electrical Installations	113
Field Effect Transistors, IGBT	56	Low-voltage Power Meters	116
Bipolar Transistors	57	Electricity Meters, Low-voltage Power Meters	117
Thyristor	58	Electronic kWh Meters (Smart Meters)	118
Thyristor Types and Trigger Diodes	59	Electronic Domestic Meters, Energy Services and SMGw	119
Rectifier Terms	60	Oscilloscopes	120
Types of Packages for Diodes, Transistors and ICs	61	Measurement with the Oscilloscope	121
Magnetic Field-dependent Components	62		
Photoelectronic Components	63		

Displacement and Angle Measurement with Sensors	122	Foundation Earth Electrode Installed in Concrete or Soil	175
Force and Pressure Measurement with Sensors	123	Main Power Supply Lines in Residential Buildings	176
Motion Measurement with Sensors	124	Installation of the Meter Cabinet	177
Temperature Measurement with Sensors	125	Minimum Electrical Equipment in Residential Buildings, Meter Cabinets	178
Optoelectronic Proximity Switches (Light Barriers)	126	Minimum Equipment for Communication Systems in Residential Buildings	179
Proximity Switches (Sensors)	127	Wiring in Residential Buildings	180
Ultrasonic Sensors	128	Calculation of Circuit Loading of Lines without Branching	181
Other Sensors	129	Calculation of Circuit Loading of Branched Lines	183
Connection of Control System Proximity Sensors	130	Length-related Inductance and Voltage Drop	184
Section E1: Electrical Installations	131	Protection of Conductors against Overload and Short-Circuits	185
Qualifications for Performing Electrotechnical Work	132	Maximum Line Lengths After Voltage Drop	186
Working on Electrical Installations	133	Supplement 5	186
Workshop Equipment	134	Methods of Installation for Permanent Installation	187
Cable Installation, Working on Electrical Conductors	135	Ampacity of Cables and Wires at $\vartheta_a = 25^\circ\text{C}$	188
On-off Circuits, Series Connection	136	Ampacity of Cables and Wires at $\vartheta_a = 30^\circ\text{C}$	189
Two-way Switch Circuits and Intermediate Switch Circuits	137	Ampacity of Cables and Wires for Permanent Installation	190
Installing Electrical Circuits in Practice	138	Additional Information on Ampacity	191
Automatic Switch for Staircase Lighting, Doorbell System with Door Opener	139	Ampacity Correction Factors	192
Circuits with Latching Relays	140	Calculation of Circuit Loading with Harmonics	193
Louvre-control Circuits	141	Distributor Circuit with Harmonics	194
Two-wire Door Intercom Systems	143	Minimum Conductor Cross-sections, Ampacity of Power Cables	195
Video Systems for Home Communication	144	Separation Classes of Communication Cabling	196
Door Intercom Systems	145	Overcurrent Protection Devices (Low-voltage Fuses)	197
Dimming of Conventional Lamps	146	Overcurrent Protection Devices for Equipment	200
Conventional Push-button Dimmers, Types of Dimmers	147	Bathrooms with Bathtubs or Showers	201
Dimmers for LED Lamps	148	Special Rooms and Facilities, Live-line Working	202
Light Management with DALI	149	Saunas, Swimming Pools, Accessible Pools	203
Automatic Switch with Heat Sensor	150	Electrical Installations in Hazardous Locations (Risk of Fire)	204
Automatic Switch with Ultrasonic Motion Sensor	151	Electrical Installations in Agricultural Facilities	205
Electrical Installation with Low-voltage Halogen Lamps	152	Electrical Installations in Medical Areas	206
Field-reducing Electrical Installation	153	Electrical Installations in Teaching Rooms with Experimental Facilities	208
Building Management and Automation	154	Electrical Installations in Hazardous Locations (Risk of Explosion)	209
Lines and Areas in a KNX-TP Installation Bus	155	Power Supply of Workshops and Machine Shops	210
Circuit Symbols for KNX	156	Set-up of Switch Cabinets	211
Components of KNX-TP Systems	157	Lighting Engineering	212
Sensors for KNX-TP	158	Design of Interior Workplace Lighting	213
Actuators for KNX-TP	159	Maintenance Factors of Workplace Lighting	214
Installation Bus with FSK Control KNX-PL	160	Calculation of Lighting Systems	215
Configuring a Smart Home System	161	Lighting and Glare	216
Project Design and Commissioning Based on KNX 1	162	Fluorescent Lamps for 230 V	217
Smart Home with Busch-free@home	164	Incandescent Lamps, Gas Discharge Lamps	218
Busch-free@home Components	165	Energy-saving Lamps, Colour Rendering	219
LON	166	Induction Lamps and Optical Fibres	220
LON Components	167	Electronic Ballasts for Fluorescent Lamps	221
LCN	168	LED Lighting	222
Electrical Installations with Wireless Control	169	LED Lamps	223
Components for Radio Control	171	LED Light Tubes, LED Modules	224
Building Automation via Existing Power Lines	172	Photometric Data of Light Fixtures	225
House Connection with Protective Equipotential Bonding	173	Fluorescent Tube Replacement	226
House Connection and Splitting of the PEN conductor	174	Illuminated Advertising Systems with Low Voltage	227
		Fluorescent Tube Systems	228

Section SE: Safety, Energy Supply	229
Personal Protective Equipment (PPE), Safety Colours	230
Signs for Accident Prevention	231
Workplace Health and Safety	235
Types of Contact, Current Hazards,	
Types of Faults	236
Other Current Hazards	237
Protective Measures, Protection Classes	238
Distribution Systems	239
Protection against Electric Shock	240
Residual Current Devices RCD, RCM	241
Fault Protection by Automatic Disconnection from the Power Supply	242
Other Protective Measures	244
Coordination of Electrical Devices	245
Residual Currents and RCDs in Converter Circuits	246
Additional Fault Protection in Professionally Monitored Systems	247
Conductors for Protective Measures	248
Tests acc. to DIN VDE 0100 Part 600	249
Testing of Protective Measures	250
Repetitive Testing	252
Repair, Modification and Testing of Electrical Equipment	253
Testing of Electrical Equipment after Repair or Modification	256
Testing of Electrical Machines and Systems	257
Transformers and Chokes, Insulation Testing	258
Calculation of Transformers	259
Additional Operating Parameters of Transformers	260
Small Transformers	261
Insulator Classes, Nameplates of Transformers	262
Transformers for Three-phase Current	263
Transformers in Parallel Operation	264
Power Mains for Energy Supply	265
Overhead Power Lines	266
Overhead Mains	267
Cables for Power Distribution	268
High-voltage Direct Current Transmission HVDC	269
Installation of Buried Cables	270
Types of Power Stations	271
Rotating Generators	272
Private Power Generating Systems	273
Wind Power Stations	275
Photovoltaic Systems	276
Photovoltaic Arrays	277
Smart Grids	278
Energy Monitoring in Smart Grids	279
Electricity Trading	281
Fuel Cells	282
Types of Protection for Electrical Equipment, ENEC Mark	283
Explosion Protection, ATEX Marking	284
IK Code, IC Code	285
Electrochemistry	286
Primary Cells (Batteries)	287
Accumulators (Secondary Cells)	288
Charging Methods for Rechargeable Batteries	289
Harvesting Energy for Sensors and Actuators	290
Emergency Power Supply and Emergency Lighting	291
Stand-by Uninterrupted Power Supply Systems	292
UPS Systems (Uninterrupted Power Supply)	293
Power Supply for Construction Sites	294
Charging Stations for Electric Vehicles	295
Electric and Magnetic Field Strengths	296
Electromagnetic Compatibility EMC	297
Electromagnetic Interferences EMI	298
Measures against EMI	299
Internal Lightning Protection	300
External Lightning Protection	301
Lightning Arrester Systems	303
Quality of Power Supply	304
Harmonics	305
Measurement of Harmonics	306
THD Values of Harmonics	307
Controlling the Mains Voltage	308
Controlling the Mains Frequency	309
Compensation, Power Factor Correction	310
Compensation of Reactive Power	311
Monitoring of Final Circuits	313
Alarm and Monitoring Systems	314
Safety and Security Systems in Buildings	315
Smoke Detectors	316
Arc Fault Detection Device AFDD	317
Fire Protection	318
Fire Protection Requirements for Line Systems	319
Fire Alarm Systems	320
Alarm Systems	321
Burglar Alarm System	322
Video Surveillance	323
Room Heating	324
Underfloor and Ceiling Panel Heating	325
Air Conditioning	326
Air Conditioning of Switch Cabinets	327
Cooking Plates for Electric Cookers	328
Water Heaters	329
Household Appliances	330
CE Marking	331
Energy Efficiency	332
Calculation of Heating Energy Consumption of Buildings	333
Energy Efficiency Class of Devices	334
Energy Saving Potential	336
Heat Pumps	337
Electricity Tariffs	338
Section IC: Information and Communication Technology	339
Digitisation (Industry 4.0)	340
Internet of Things (IIoT and IoT)	341
Binary Numbers and Codes	342
Hexadecimal and Octal Numbers	343
ASCII Code and Unicode	344
Binary Operations	345
Boolean Algebra	346
Development of Combinational Circuits	347
Code Converters	348
Comparators and Bistable Flip-flops	349
Digital Counters and Shift Registers	350
DA Converters and AD Converters	351
Microcomputers	352
Visual Display Units, Monitors	353
3D Printers	354
PC Ports and Connectors	355

Interface Connections, Interface Converters	356	Fundamentals of Switch-mode Power Supplies ..	411
Operating Systems	357	Switch-mode Power Supplies	412
Windows Keyboard Shortcuts	358	Switching Transistors and Multivibrators	413
Creating Charts in Excel	359	Solid-state Relays and Safety Relays	414
IT Networks	360	Control Engineering	415
Network Communication	361	LOGO! Small Controller	416
Components of Data Networks	362	LOGO! 8 with Ethernet Interface	417
Cables in Data Networks	363	Programmable Logic Controller (PLC)	418
Communication Networks with Fibre-optic Cables	364	Structograms and Program Flowcharts	419
Communication via Ethernet	365	Signal Coupling for PLCs and Microcomputers ..	420
Installation of an Ethernet	366	Control Statements for PLCs	421
Power over Ethernet (PoE)	367	Programming Rules for PLC	422
Industrial Ethernet	368	PLC Programming acc. to DIN EN 61131-3	423
Signal Transmission	369	Counters and Timers in PLCs	424
Modulation and Demodulation	370	Structured Control Language SCL and Sequential Function Chart SFC	425
Wireless Data Transmission	371	Program Structure for PLC	426
Wireless LAN	372	Word Processing with PLCs	427
Interferences of Radio Transmission in Workshops	373	Library-compatible PLC Modules	428
Identification Systems	374	PLC Programming in the TIA Portal	429
AS-i Bus System	375	Sequential Control with GRAFCET	430
Communication across Field Buses	376	Safety-related Parts of Control Systems	432
PROFIBUS	377	Architectures of Control Systems	433
M-Bus and Smart Metering	378	Functional Safety acc. to SIL	434
Remote Control Systems	379	Safety Functions for Drives	435
Remote Control, Remote Maintenance via Text Messages	380	EC Machinery Directive	436
Connection to the Telephone Network	381	Electrical Low-voltage Equipment of Machines ..	437
Internet Telephony (VoIP)	382	Limit Switches, Command Devices	438
Internet Access	383	Electronic Limit Switches	439
Internet Applications	384	Contactors	440
Backing Up and Protecting Data	385	Special Types of Contactors	441
Aerials, Electrical Equipment for Aerial Systems	386	Identification and Actuation of Contactors	442
Satellite Systems	387	Utilisation Categories and Test Conditions Applying to Contactors	443
Satellite Aerial Systems	388	Contactor Circuits	444
Broadcasting of Digital Terrestrial Television (DVB-T2)	389	Contactor Circuits with Control Devices	446
Master Aerial Television Systems (MATV)	390	Motor Protection	447
Installation of Aerial Systems	391	Electronic Motor Protection	448
Broadband Communication Systems	392	Control via Motor Switches	449
Section AC: Automation, Drives and Control Systems	393	Automatic Control Engineering	450
Basic Circuits of Amplifiers	394	Discontinuous Control Elements	451
Fundamental Principles of the Operational Amplifier	395	Digital Continuous Control Elements	452
Circuits with Operational Amplifiers	396	Analogue Continuous Control Element	453
Tasks of Power Converters	398	Automatic Digital Control	454
Identification Codes for Converter Circuits	399	Setting of Control Loops	455
Circuits for Rectifiers and Power Converters	400	Operating Modes and Temperature Rise Limits of Machines	458
Bidirectional Connections, Control Characteristics	401	Efficiency of Electrical Drives	459
Quadrants of Operation for Drives, Linear Motors	402	Converter-fed Motors for Three-phase AC Supply ..	460
Semi-controlled Converters	403	Surface-cooled Squirrel-Cage Motors (Standard Motors)	461
Fully-controlled Converters	404	Operating Data of Squirrel-Cage Motors	462
Inverters	405	Types of Rotating Electrical Machines	463
DC Choppers, Voltage Source Inverters (VSI)	406	Alphanumeric Identification of Connections	464
Voltage Source Inverters with DC Link	407	Electronic Control of Electrical Consumers	465
Selection and Configuration of Frequency Converters	408	Limit Values for Loads Connected to the National Grid	466
Triggering Circuits for Semiconductors	409	Auxiliary Circuits	467
Smoothing and Voltage Stabilisation	410	Calculation Formulas for Rotating Electrical Motors	468
		Conventional DC Drives	469
		Nameplates of Rotating Electrical Machines ..	470
		Three-phase Motors	471

Pole-changing Motors	472	Section CE: The Company and its Environment ..	521
Troubleshooting on Three-phase		Organisational Structures of Companies	522
Asynchronous Motors	473	Organisation of Work	523
Single-phase AC Motors	474	Computer-aided Planning of Electrical	
DC Motors	475	Installations	524
Servomotors	476	Job Planning, Precedence Diagram Method	525
Activation of Servomotors	477	Teamwork	526
Stepper Motors	478	Conflict Management	527
Micromotors	479	Business Etiquette	528
Data of Microdrives, Gears of Micromotors	480	Analysing and Designing Processes	529
Linear Drives	481	Preparing a Presentation	530
Piezo Actuators and Piezo Drives	482	Presentation of a Project	531
Testing of Electrical Machines	483	Diagrams for Presentations	532
Drive Systems	484	Realising Projects	533
Selection of a Suitable Drive Motor	485	Design-of-work and Scope-of-work	
Starting of Squirrel-Cage Motors	486	Specifications	534
Soft Starter	487	Systematic Marketing	535
Design of Automation Systems	488	Communication with Customers	536
Section MC: Materials, Connecting, Joining and Bonding	489	Customer Training	537
Periodic Table, Chemical Bond	490	Constituents of a Collective Labour Agreement	538
Specific Material Values	491	Legal Transactions of the Company	539
Steel Standardisation	492	Costs and Key Figures	540
Conducting Materials in Electrical Engineering (Non-ferrous Metals)	493	Cost Accounting	541
Magnetisation Characteristics	494	Preparing a Quotation	542
Magnetic Materials	495	Terms Used in Quality Management	543
Solders, Thermal Bimetals, Carbon Brushes	496	Certification and Auditing	544
Contact Materials, Overhead Power Lines	497	Statistical Evaluation in Quality Management	545
Insulators	498	Hazardous Substances	546
Synthetic Materials Used as Insulators	500	Hazard Statements (H-Statements) for Hazardous Substances	547
Other Insulators	501	Precautionary Statements (P-Statements) for Hazardous Substances	548
Auxiliary Materials	502	Environmental and Waste Management	549
Cables and Wires	503		
Insulated Power Lines and Cables	504		
Power Lines and Cables	505		
Other Cables for Permanent Installation	506		
Cables for the Connection of Mobile Equipment	507		
Cables and Wires for Alarm and Signalling Systems	508		
Wires for Extra Low-voltage Lighting	509		
Multimedia Cabling in Private Homes	510		
Codes for Colour Marking of Power Cables	511		
Connectors in Power Engineering	512		
Connectors	513		
RJ45 and CAT 7 Connectors	514		
Solderless Connection Technology	515		
Cable Conduits	516		
Plugs and Anchors	517		
Nomenclature and Samples of Screws, Bolts and Nuts	518		
Metric ISO Threads	519		
Tolerances and Fits	520		
Appendix	550		
Standards	550		
Important Standards	551		
VDE Standards	554		
Glossary	557		
Abbreviations of Technical Terms	562		
Supporting Companies and Organisations	584		
List of Image Sources	587		
First Aid in the Workplace	588		
Learning Fields, Main Sections of the Book, Examination Sections	589		