## Contents

		The state of the s	
Section M:		Resistors and Capacitors	50
Mathematics, Physics, Theory of Circuits,		Colour Marking of Resistors and Capacitors	51
Components	11	Application Groups and Structures	
Symbols in this Book	12	of Capacitors	53
Subscripts and Signs for Formula Symbols in this Book.	13	Semiconductor Resistors	54 55
International Formula Symbols	14	Field Effect Transistors, IGBT	56
Quantities and Units	15		57
Mathematical Symbols	17	Bipolar Transistors	58
Exponents, Unit Prefixes, Logarithms, Calculations According to the Rule of Three.	18	Thyristor Types and Trigger Diodes	59
Logarithmic Unit Decibel	19	Rectifier Terms	60
Angles, Trigonometric Functions, Percentage		Types of Packages for Diodes, Transistors	
Calculation	20	and ICs	61
Relationships Between Trigonometric		Magnetic Field-dependent Components	62
Functions	21	Photoelectronic Components	63
Lengths and Areas	22	Protection Circuits for Diodes and Thyristors .	64
Body and Mass	23	Components for Surge Protection	65
Mass, Force, Pressure, Moment of Force	24	Cooling of Semiconductor Components	66
Motion Rules	25		
Mechanical Work, Mechanical Power, Energy	26		
Transmissions	27	Section TM:	
Pulleys, Wedges, Winches	28	Technical Documentation, Measuring	67
Heat	29		co
Charge, Voltage, Electric Current, Resistance.	30	Graphical Representation of Characteristics.	68
Electric Power, Electric Work	31	General Technical Drawing	69
Electric Field, Capacitor	32	Graphical Representation of Bodies	70
Alternating Quantities, Wavelength	33	Dimension Arrows, Special Representations	71
Power of Alternating Sine-wave Current,		Dimensioning, Hatching	72
Impulse	34	Circuit Diagrams as Functional Documents	74
Magnetic Field, Coil	35	Other Functional Documents	75
Electric and Magnetic Field Strengths	36	Location- and Connection-related Documents	76
Current in the Magnetic Field, Induction	37	Marking in Circuit Diagrams	77
Resistor Circuits	38	Code Letters for Components (Objects)	
Reference Arrows, Kirchhoff's Rules, Voltage Dividers	39	in Circuit Diagrams	78
Potentiometer	40	an Object	79
Equivalent Voltage Source, Equivalent Current		Contact Marking in Circuit Diagrams	80
Source, Matching	41	Circuit Symbols	81
Basic Circuits of Inductances and		General Circuit Symbols	82
Capacitances	42	Additional Circuit Symbols, Switches in	
Switching Capacitors and Coils	43	Energy Plants	83
Series Connection of R, L, C	44	Measuring Instruments and Devices	84
Equivalent Series Connection and Equivalent Parallel Connection	46	Semiconductor Components	85 86
Simple Filters	47	Analog Information Processing, Meters and	
Three-phase Systems (Alternating Current)	48	Tariff Switchgears	88
Unbalanced Load, Star-delta Conversion, Bridge Circuit	49	Audio Converter, Video Converter and Aerial Systems	89



## Contents

Circuit Symbols for Installation Circuit Diagrams and Installation Diagrams	90	Automatic Switch for Staircase Lighting, Doorbell System with Door Opener	129
Installation Circuit Diagrams	92	Circuits with Latching Relays	130
Circuit Symbols for Overview Diagrams	93	Louvre-control Circuits	131
Coils, Transformers, Rotating Generators	94	Intercom Systems	133
Single-phase A.C. Motors and Starters	95	Two-wire Door Intercom Systems	134
Three-phase Motors and Starters	96	Lamp Circuits with Dimmers	135
Converter-fed Motors with A.C./D.C. Drive		Push-button Dimmer, Types of Dimmers	136
Systems	97	Automatic Controller with Heat Sensor	137
Comparison of Circuit Symbols	98	Automatic Switch with Ultrasonic	
Marks and Symbols on Electrical		Motion Sensor	138
Equipment (Examples)		Electrical Installation with Low-voltage Halogen Lamps	130
Hydraulic and Pneumatic Controls		Field-reducing Electrical Installation	
Symbols in Process Engineering	102	Building Management and Automation	
Preparing Documentation on Equipment	100	Lines and Areas in a KNX-TP System	
and Plant	103	Circuit Symbols for KNX	
Structure and Contents of Operating Instructions	104	Components of KNX-TP Systems	
Electrical Measuring Instruments and		Special Actuators and System Devices	1-7-
Systems	105	for KNX-TP	145
Pictographs for Measuring	106	Sensors for KNX-TP	146
Measuring Circuits for Resistance Calculation	107	Actuators for KNX-TP	147
Measuring Range Extension	108	Installation Bus with FSK Control KNX-PL	148
Measurements in Electrical Installations 1	109	Project Design and Commissioning Based	
Low-voltage Power Meters	112	on KNX	149
Electricity Meters, Kilowatt-hour Meters 1	113	Local Operating Network LON	151
Digital Watt Meters (Smart Meters)	114	LON Components	152
Oscilloscope		Electrical Installations with Wireless Control.	
Measurement with the Oscilloscope		Local Control Network LCN	155
Displacement and Angle Measurement		House Connection with Protective Equipotentional Bonding	156
with Sensors 1	117	Foundation Earth Electrode Installed in	150
Measurement of Force and Pressure		Concrete or Soil	157
with Sensors		Main Power Supply Lines in Residential	
Motion Measurement with Sensors		Buildings	
Temperature Measurement with Sensors	120	Installation of the Meter Cabinet	159
		Minimum Electrical Equipment in Residential	400
		Buildings, Meter Cabinets	
Section El:	•••	Wiring in Residential Buildings	16
Electrical Installations	121	Calculation of Circuit Loading of Lines without Branching	162
Qualifications to Performing Electrotechnical	• • •	Calculation of Circuit Loading of	
Work		Branched Lines	164
Working on Electrical Equipment		Protection of Conductors against Overload	
Workshop Equipment	124		165
Cable Installation, Working on Electrical Conductors	125	Methods of Installation for Permanent Installation	164
On-off Circuits, Series Connection		Ampacity of Cables and Wires	
Three- and Four-way Switch Circuits			169
Practical Installation of Electrical Circuits 1		Ampacity Correction Factor	

## Contents

Minimum Conductor Cross Sections, Ampacity of Power Cables	171	Fault Protection by Automatic Disconnection from the Power Supply	212
Overcurrent Protection Devices		Other Protection Measures	214
(Low-voltage Fuses)	172	Additional Fault Protection in Professionally	
Overcurrent Protection Devices	173	Monitored Systems	215
Bathrooms with Bathtubs or Showers	174	Conductors for Protective Measures	216
Special Rooms and Facilities, Working	175	Initial Testing of Protective Measures	217
Under Voltage		Repetitive Testing	218
Saunas, Swimming Pools, Accessible Pools Electrical Installations in Hazardous	176	Repair, Modification and Testing of Electrical Equipment	219
Locations (Risk of Fire)	177	Transformers and Chokes, Insulation Testing	
Electrical Installations in Agricultural Facilities	179	Calculation of Transformers	222
Electrical Installations in Medical Areas		Additional Operating Parameters of	
Electrical Installations in Teaching Rooms	175	Transformers	
with Experimental Facilities	181	Small Transformers	
Electrical Installations in Hazardous Locations		Types of Power Stations	
(Risk of Explosion)	182	Rotating Generators	226
Power Supply of Workshops and Machine	400	Insulator Classes, Nameplates of Transformers	227
Shops		Transformers for Three-phase Current	
Lighting Engineering		Transformers in Parallel Operation	
Design of Interior Workshop Lighting		Power Mains for Energy Supply	
Maintenance Factors of Workplace Lighting		Overhead Power Lines	
Calculation of Lighting Systems		Overhead Mains	
Lighting and Glare		Sag of Overhead Power Lines	
Fluorescent Lamps for 230 V		Installation of Buried Cables	
Incandescent Lamps, Metal-vapour Lamps		Private Power Generating Systems	
Energy-saving Lamps, Colour Reproduction .		Reimbursement for Renewable Energies	
Induction Lamps and Optical Fibres Electronic Ballasts for Fluorescent Lamps		According to EEG	237
Discharge Lamp Circuits		Wind Power Stations	238
LED Lighting		Photovoltaic Systems	239
LED-Lamps		Photovoltaic Arrays	240
Photometric Data of Light Fixtures		Smart Grids	241
Fluorescent Tube Systems		Fuel Cells	242
Theoreseem rabe bystems	150	$\label{protection} \mbox{Protection of Electrical Equipment, IP Codes} \ .$	243
		Electrochemistry	244
Section SE:		Primary Cells	245
Safety, Energy Supply	199	Accumulators	246
First Aid at the Workplace	200	Charging Methods for Rechargeable Batteries	2/17
Personal Protective Equipment PPE	201	Emergency Power Supply and Emergency	,
Signs for Accident Prevention	202	Lighting	248
Workplace Health and Safety	206	Stand-by Uninterrupted Power Supply	
Types of Contact, Current Hazards,		Systems	
Types of Faults	207	UPS Systems (Uninterrupted Power Supply) .	250
Protective Measures, Protection Classes		Electromagnetic Compatibility EMC	251
Distribution Systems (Network Layouts)	209	Electromagnetic Interferences EMI	252
Protection against Electric Shock	210	Measures against EMI	
Differential Current Devices	211	Internal Lightning Protection	254

Contents
----------

	Conte	1113
External Lightning Protection	255	Microcomputers
Lightning Arrester Systems	257	Visual Display Units, Monitors 300
Quality of Power Supply	258	PC Ports and Connectors 301
Harmonics	259	Interface Connections, Interface Converters 302
Compensation, Power Factor Correction	260	Operating System Windows 303
Compensation of Reactive Power	261	Elements of Windows User Interfaces 304
Monitoring of Final Circuits	263	IT Networks
Alarm and Monitoring Systems	264	Components of Data Networks 306
Safety and Security Systems in Buildings	265	Communication via Ethernet 308
Smoke Alarms	266	Installation of an Ethernet 309
Arc Fault Detection Device AFDD or		Industrial Ethernet
Arc Fault Circuit Interrupter AFCI		Signal Transmission
Alarm Systems		Wireless Data Transmission 312
Intrusion or Burglar Alarm System	269	Wireless LAN
Closed-circuit Television CCTV	270	Identification Systems
Temperatures Relevant to Heat Demand Calculations	271	AS-Interface Bus System
Energy Conservation Directive		Safe Communication across Different
Heating Energy Consumption and	212	Field Busses
Energy Index of a Single-family House	274	PROFIBUS, Process Field Bus
Room Heating	275	Remote Control Systems
Underfloor and Ceiling Panel Heating	276	for Remote Control Systems
Air Conditioning	277	Programmable Measuring Transducers
Electric Cookers	278	for Remote Control Systems
Water Heaters	279	Connection to the Telephone Network 321
Household Appliances	280	Telecommunication via ISDN
CE Marking	281	ISDN and Voice over IP (VoIP) 323
Energy Efficiency Classes	282	Internet Access
Energy-saving Potentials	284	Internet Applications
Heat Pumps	285	Backing up and Protecting Data 326
Electricity Tariffs	286	Aerials, Electrical Equipment for Aerial Systems
		Satellite Reception
Section IC:		Satellite Equipment
Information and Communication Technology		Aerial Systems for Satellite Receivers 330
Systems	287	Broadcasting of Digital Terrestrial Television
Binary Numbers and Codes	288	(DBV-T)
Hexadecimal and Octal Numbers		Master Aerial Systems
ASCII Code in Unicode	290	Installation and Safety of Aerial Systems 333
Binary Operations	291	Broadband Communication Systems 334
Boolean Algebra		
Development of Combinational Circuits		Section AC:
Code Converters	294	Automation, Drive and Control Systems 335
Comparators and Flip-flops	295	Base Circuits of Amplifiers
Digital Counters and Shift Registers		Fundamental Principles of the Operational
D/A Converters and A/D Converters		Amplifier
Modulation and Demodulation	298	Circuits with Operational Amplifiers 338

Contents
----------

Tasks of Power Converters	Special Types of Contactors 380
Identification Codes for Converter	Identification and Actuation of Contactors 381
Connections	Othisation Categories and Test Conditions
Circuits for Rectifiers and Power Converters . 34	, -
Bidirectional Connection,	Contactor Circuits
Control Characteristics	Contactor circuits with Control Devices 303
Operating Quadrants for Drives, Linear Motors	Motor Protection
Semi-controlled Power Converters	Electronic Motor Protection
Fully Controlled Power Converters	Control via Motor Switches
Inverters	Optoelectronic Proximity Switches
D.C. Choppers, Voltage Source Inverters (VSI) . 34	(Eight Barriers)
Voltage Source Inverters VSI 34	Troximity divitories (Berisols)
Triggering Circuits for Semiconductors 35	
Smoothing and Voltage Stabilisation 35	Additional Control Engineering
Fundamentals of Switch-mode	Digital Control Elements for Continuous
Power Supplies	2 Automatic Control
Switch-mode Power Supplies 35	Analog Control Elements for Continuous
Switching Transistors and Multivibrators 35	
Solid-state Relays SSR and Safety Relays 35 $$	5 Automatic Digital Control
Control Engineering 35	6 Setting of Control Loops
Small Controller EASY 35	
Small Controller LOGO!	8 Limits of Machines
Structograms and Program Flowcharts 35	9 Efficiency of Electrical Drives 400
Programmable Logic Controller PLC, Stored-program Control SPC	Converter-fed Motors for Three-phase A.C. Supply401
Signal Coupling for PLCs and	Surface-cooled Squirrel Cage Motors
Microcomputers	(Standard Motors)
Control Statements for PLCs 36	Operating Data of Squirrel Cage Motors 403
Program Examples for PLCs	Types of Construction of Rotating Electrical Machines
Counters and Timers in PLCs	
Programming Languages SCL	Motors
(Structured Control Language) and	Conventional D.C. Drives 406
SFC (Sequential Function Chart)	Namenlates of Rotating Electrical Machines 407
Program Structure for PLC S7	Three-phase Motors 408
Word Processing with PLCs	Pole-changing Motors
Charts GRAFCET	g Troubleshooting on Three-phase
Alphanumeric Identification of Connections 37	Asynchronous Motors
Electronic Control of Electrical Consumers 37	Single-phase A.C. Motors 411
Limit Values for Loads Connected to the	D.C. Motors
National Grid	
Auxiliary Circuits	
Safety-Related Parts of Control Systems 37	
Architectures of Control Systems 37	
EC Machinery Directive	
Electrical Low-voltage Equipment	Linear Drives
of Machines	
Contactors	9 Testing on Electrical Machines 420

_		
CiO	nte	nts

Drive Systems	422	Section CE: The Company and its Environment, Environmental Technology, Annex	459
Starting of Squirrel Cage Motors  Design of Automation Systems		Organisational Structures of Companies 4	460
Design of Automation Systems	424	Organisation of Work	
		Job Planning, Network Planning	
Section MC:		Teamwork4	
Materials, Connecting, Joining and Bonding	425	Conflict Management	
Periodic Table, Chemical Bond	426	Analysing and Designing Processes 4	
Specific Material Values		Preparing a Presentation	
Steel Standardisation		Presentation of a Project	
Conducting Materials in Electrical Engineering		•	
(Nonferrous Metals)		Diagrams and Charts for Presentations 4 Realising Projects	
Magnetisation Characteristics (B-H Curves)	430	- · ·	
Magnetic Materials	431	Systematic Marketing	
Solders, Thermal Bimetals, Carbon Brushes .		Communication with Customers	
Contact Materials, Overhead Power Lines		Customer Training	+/2
Insulators	434	Constituents of a Collective Labour Agreement	473
Synthetic Materials Used as Insulators	436	Legal Transactions of the Company 4	
Other Insulators		Costs and Key Figures	
Auxiliary Materials		Cost Accounting	
Cables and Wires	439	Preparing a Quotation	
Insulated Power Cables and Cords	440	Design-of-work and Scope-of-work	
Power Cables and Cords	441	Specifications4	478
Other Cables for Permanent Installation	442	Computer-aided Planning of Electrical	
Cables for the Connection of Mobile		Installations	479
Equipment	443	Certification and Auditing 4	480
Cables and Wires for Alarm and Signalling		Hazardous Substances	481
Systems		Hazard Statements (H-Statements) for	
Cables and Wires in Data Networks		Hazardous Substances	182
Wires for ELV Lighting		Precautionary Statements (P-Statements) for Hazardous Materials	483
Codes for Colour Marking of Power Cables		Handling of Electronic Waste Products 4	
Cables for Power Distribution		Standards & Codes	
Connectors in Power Engineering		Important Standards	
Connectors		Important VDE Regulations 4	
RJ45 and RJ11 Connectors		Parts of DIN VDE 01004	
Solderless Connection Technology		Glossary	
Cable Conduits		Overcurrent Protection Devices	
Plugs and Anchors.		for Equipment	197
Nomenclature and Samples of Screws,	.00	Shortcuts of Technical Terms 4	198
Bolts and Nuts	456	Subject Index 5	506
Metric ISO Threads	457	Supporting Companies and Organisations 5	524
ISO System of Limits and Fits	458	List of Picture Sources	527