SIEMENS

www.siemens.com/protection

SIPROTEC 5 Application Note

SIP5-APN-002:
Breaker-and-a-half solutions

Answers for infrastructure and cities.

SIPROTEC 5 - Application: SIP5-APN-002 Breaker-and-a-half solutions

Content

1 Breaker-and-a-half application: Description of the concept 3
1.1 Terminology 3
1.2 Introduction 3
1.3 Solution concept with SIPROTEC 5 for two feeders 4
1.4 Description of the individual system concepts 5
1.5 Description of the device hardware configuration 6
1.6 SIPROTEC 5 Function Groups for Breaker-and-a-half 9
1.7 Protection Functions (Optional Control Functions) 10
1.8 Summary 10
1.9 Appendix 11

1 Breaker-and-a-half application: Description of the concept

Summary:

This application describes the requirements for the protection and control ofbreaker-and-a-half systems and introduces an efficient and progressive solution concept with SIPROTEC 5.

1.1 Terminology

The following terminology is used in the context of breaker-and-a-half:

- Breaker-and-a-half:
  This is the term used for the plant configuration shown in the single line diagram below.
- Diameter:
  This is the term used to describe the three circuit breakers and associated equipment in the diagram below. A number of such “diameters” in parallel are applied to the two busbars.
- Stub Protection:
  In this application this is a special protection that covers the zone between the breakers and the line isolator when the line isolator is open.
- Tie-CB:
  The central circuit breaker, between the two feeders, in the breaker-and-a-half configuration is referred to as the Tie-CB.
- Leader/Follower The Leader/Follower logic is associated with the auto re-close function in the breaker-and-a-half configuration. It determines the sequence of re-closing of the two circuit breakers that trip to clear a fault on the OHL.
- Function Group: Within SIPROTEC5 the fixed allocation of particular function with in a set which is referred to as a Function Group. Not all functions are therefore available for all Function Groups.
- Application Template Predefined device configuration in DIGSI (e.g DIS overhead line, grounded systems). The application templates contain the basic configurations, required functions groups and function as well as default settings.

1.2 Introduction

Properties of a breaker-and-a-half application

- Each line is delimited by two circuit breakers and the associated current transformers. These currents have to be supersized and processed.
- Each diameter contains two feeders (two lines or line and transformer). The center circuit breaker is used jointly by both feeders. Only 3 circuit breakers are consequently available for 2 feeders. Hence the designation breaker-and-a-half application.
- Different voltages have to be selected for synchronizing the switching command depending on the switch position.

Requirements for the system solution

- Feeder protection (main protection and backup protection)
- Circuit-breaker failure protection
- AR for each circuit breaker of a feeder
- Controlling the diameter

- Synchronization of each circuit breaker
- Sufficient number of inputs and outputs for controlling and detecting the switching elements and signal

1.3 Solution concept with SIPROTEC 5 for two feeders

- Main protection and backup protection devices for each line
- 1 central control unit for the entire diameter/bay
- All devices of a diameter are connected by means of a diameter bus.
- Distribution of the functions between the devices using the flexibility of SIPROTEC function structure:
  - Control unit: control, synchrocheck
  - Protection devices: protection, tripping, AR, circuit-breaker failure protection
- Flexible expansion of IOs using the modular quantity structure or connected IO units (diameter bus)

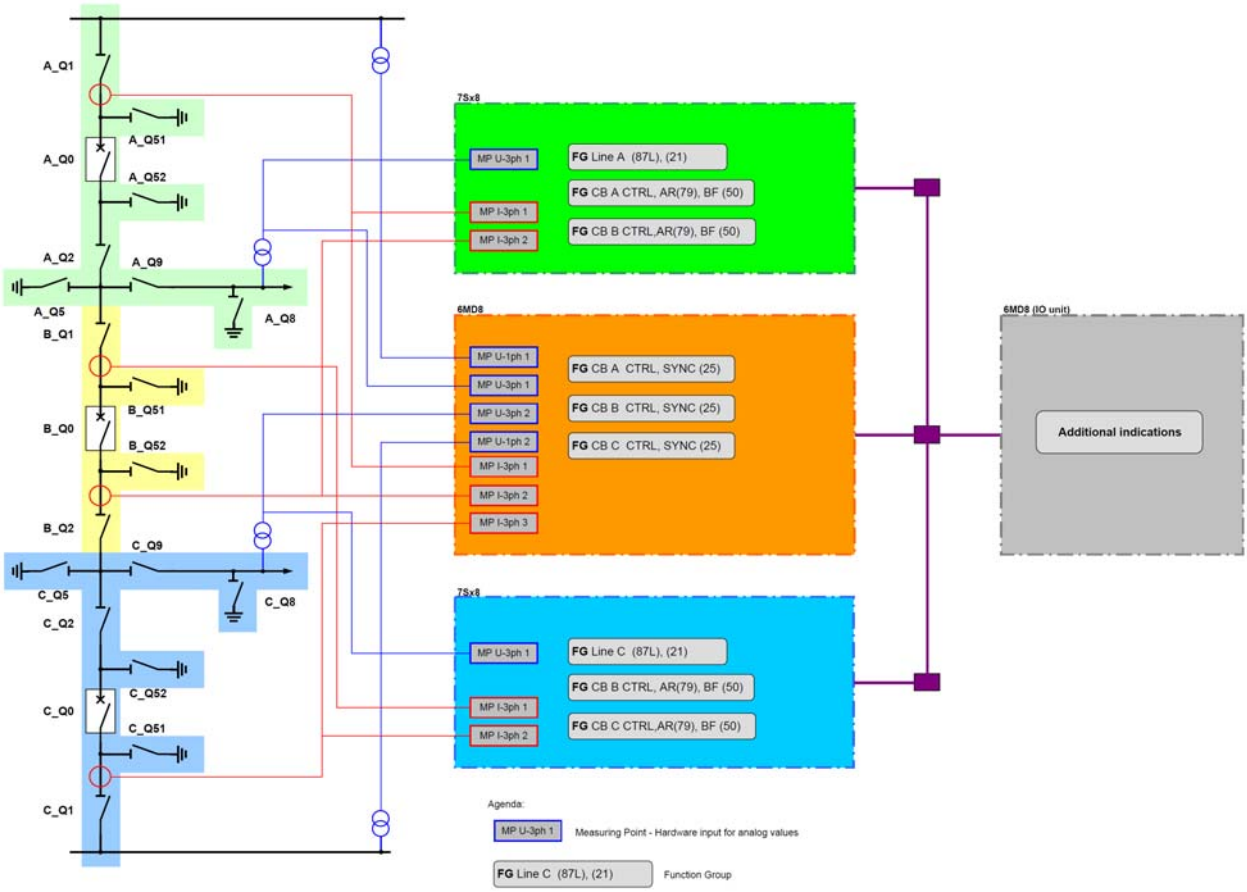


Figure 1: Overall concept for protection and control of breaker-and-a-half systems

1.4 Description of the individual system concepts

Diameter bus

A dedicated diameter bus is implemented for the entire diameter whose only function is to ensure the data exchange of the individual devices of a diameter. This provides the following system benefits:

- fast data exchange between the devices
- isolated signal exchange (optical fiber)
- enhanced security compared to wire connections through monitoring of the signal links
- easy implementation of group indications and additional automation functions via SW (e.g. common start of fault records, coordination of protection functions that run parallel)
- It is possible to implement communication and function redundancies.
- easy integration of redundant devices and additional devices
- reduced wiring and engineering effort
- more flexibility for future modifications
- less space required

Controlling equipment

The equipment, especially the circuit breakers, is operated from a central device.

- clearly arranged operation owing to representation on a central device display
- The diameter bus provides the central device with all the information that is relevant to assume the control task. (e.g. interlocking)
- It is possible to activate backup protection functions in the bay controller if no line backup protection is used.

Synchrocheck

The synchrocheck is implemented centrally in the control unit for the entire diameter. All voltages are applied directly.

- enhanced security and reduced wiring effort because no external coupling relays are needed to select the voltage
- monitoring of all voltage transformers (fuse failure monitor)

Line protection

Protection requirements can be implemented with one device.

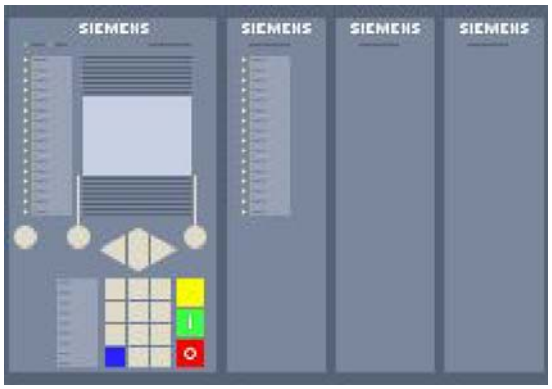
- line differential protection and distance protection possible in one device (7SL8). alternatively distributed on two devices (7SD8 and 7SA8)
- integrated stub protection (87Stub) when line disconnectors are open
- increased sensitivity of the line differential protection through separate transformer acquisition
- additional stability of the direction determination for the distance protection
- saturation detection for each transformer

1.5 Description of the device hardware configuration

For this solution the following devices are selected:

- 7SL8 Line Differential and Distance Protection (Line 1 Main 1)
- 7SL8 Line Differential and Distance (Line 2 Main 1)
- 6MD8 Bay Controller (Control of all switches of the diameter)
- 6MD8 IO-Unit (for additional indications)

2 x 7SL87 for Line 1 and 2: Product code P1C5036



7Sx8	I	U	BI	BO
PS 201			3	2
I/O 202	4	4	8	6
I/O 208	4	4	4	11
I/O 207	-	-	16	8
I/O 207	-	-	16	8
CB 202		optional		
			47	35
used			32	27
spare:			15	8

7Sx8	I	U	BI	BO
PS 201			3	2
I/O 202	4	4	8	6
I/O 208	4	4	4	11
I/O 207	-	-	16	8
I/O 207	-	-	16	8
CB 202		optional		
			47	35
used:			32	27
spare:			15	8

- Housing width: 5/6 x 19"
- Housing type: Flush mounting
- Binary inputs: 47
- Binary outputs: 36 Relays (22 Standard, 14 Fast, 0 High-Speed, 0 Power)
- Current transformers: 8 for protection, 0 for measurement and sensitive ground-current detection
- Voltage transformers: 8
- Modules in 19" row 1: IO202 , PS201 , IO208 , IO207 , IO207
- Number of LEDs: 32
- Display type: Small display
- Power Supply: DC 60 V-250 V, AC 100 V-230 V

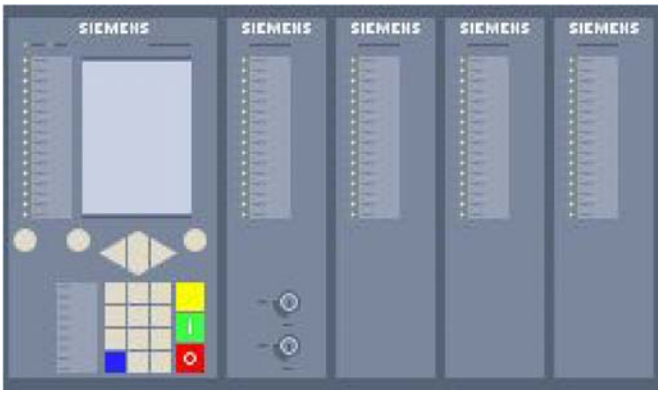
Communication:

- Communications encryption: Normal
- Integrated Ethernet port: for DIGSI 5
- Plug-in module position E:
  USART-AD-1FO: 1 x optic 1.5 km, 820 nm, ST connector, for serial protocols, e.g. IEC60870-5-103, DNP3.0 etc. and protection interface
- Plug-in module position F:
  ETH-BA-2EL: 2 x electric Ethernet, RJ45, applicable for DIGSI, IEC61850, DNP etc.

Functions:

- Function points class: Base + 425 function points

1 x 6MD86 for Control of all switches of the diameter: Product code P1G475



6MD8	I	U	BI	BO
PS 201			3	2
I/O 202	4	4	8	6
I/O 202	4	4	8	6
I/O 208	4	4	4	11
I/O 207	-	-	16	8
I/O 207	-	-	16	8
			55	41
used:			47	36
spare:			8	5

- Housing width: 6/6 x 19"
- Housing type: Flush mounting
- Binary inputs: 55
- Binary outputs: 42 Relays (22 Standard, 20 Fast, 0 High-Speed, 0 Power)
- Current transformers: 8 for protection, 4 for measurement and sensitive ground-current detection
- Voltage transformers: 12
- Modules in 19" row 1: IO202 , PS201 , IO202 , IO208 , IO207 , IO207

- Number of LEDs: 80
- Key switch: With
- Display type: Large display
- Power Supply: DC 60 V-250 V, AC 100 V-230 V

Communication:

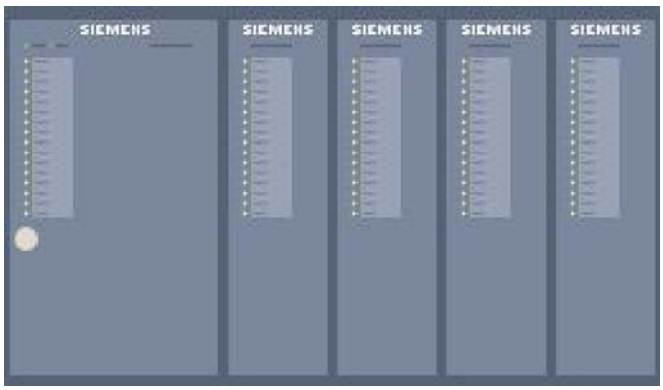
Communications encryption: Normal
Integrated Ethernet port: for DIGSI 5

- Plug-in module position E:
  USART-AD-1FO: 1 x optic 1.5 km, 820 nm, ST connector, for serial protocols, e.g. IEC60870-5-103, DNP3.0 etc. and protection interface
- Plug-in module position F:
  ETH-BA-2EL: 2 x electric Ethernet, RJ45, applicable for DIGSI, IEC61850, DNP, etc.

Functions:

- Function points class: Base + 75 function points

1 x 6MD85 IO-Unit (for additional indications): Product code P1G499



6MD8	I	U	BI	BO
PS 201			3	2
I/O 202	4	4	8	6
I/O 207	-	-	16	8
I/O 207	-	-	16	8
I/O 207	-	-	16	8
I/O 207	-	-	16	8
			75	40
used for additional indications:				
e.g. MCB trip:			75	40

- Housing width: 6/6 x 19"
- Housing type: Flush mounting
- Binary inputs: 75
- Binary outputs: 41 Relays (35 Standard, 6 Fast, 0 High-Speed, 0 Power)

- Current transformers: 0 for protection, 4 for measurement and sensitive ground-current detection
- Voltage transformers: 4
- Modules in 19" row 1: IO202 , PS201 , IO207 , IO207 , IO207 , IO207
- Number of LEDs: 80
- Power Supply: DC 60 V-250 V, AC 100 V-230 V

Communication:

- Communications encryption: Normal
- Integrated Ethernet port: for DIGSI 5
- Plug-in module position E:
  Port is available but not assembled
- Plug-in module position F:
  ETH-BA-2EL: 2 x electric Ethernet, RJ45, applicable for DIGSI, IEC61850, DNP, etc.

Functions:

- Function points class: Base

1.6 SIPROTEC 5 Function Groups for Breaker-and-a-half

The protection functions (including sync check and auto re-close) are assigned to Function Groups. The grouping of functions in this manner provides a clear interface and separation of tasks between the various functions in a complex application. The following example shows the allocation for the Main 1 Protection of the OHL and Transformer to Function Groups:

Distribution of Protection Functions in the Function Groups:

Function	Protection Devices FG CB QA/B/C	Controller Device FG CB QA/B/C	Protection Devices FG Line
Distance Protection			X
Feeder Differential			X
Over Current			X
Over Voltage			X
Auto Re-Close	X		
Sync Check		X	
Breaker Fail	X		

Figure 2: Functional allocation

1.7 Protection Functions (Optional Control Functions)

In the Diameter there are a number of protection functions that in combination cover all fault scenarios. The following list shows a typical arrangement/allocation of these functions to the various protection devices:

Function	Function Group	Description	Protection IED	Detailed App Instr.
OHL protection	Line	Distance, differential and earth fault protection etc. cover all faults on the OHL	7SA86, 7SA87, 7SD86, 7SD87, 7SL86 and 7SL87	SIP5-APN0016
Stub protection	Line	Protection to cover the zone between circuit breakers and line isolator	7SA86, 7SA87, 7SD86, 7SD87, 7SL86 and 7SL87	SIP5-APN017
Bus protection		Protection to the busbar and zone between CB and Busbar		In preparation
Breaker fail protection	Circuit Breaker	Local back-up protection for breaker fail scenarios after a protection trip	7SA86, 7SA87, 7SD86, 7SD87, 7SL86 and 7SL87	See device manual
Auto re-close Incl leader follower function	Circuit Breaker	Together with the OHL protection provides for re-close of CB after OHL fault clearance	7SA86, 7SA87, 7SD86, 7SD87, 7SL86 7SL87, 7VK86 7VK87 and 6MD8x	SIP5-APN-019
Sync Check	Circuit Breaker	Provides sync check prior to closing of CB (after AR or control command)	7SA86, 7SA87, 7SD86, 7SD87, 7SL86 and 7SL87	SIP5-APN-004

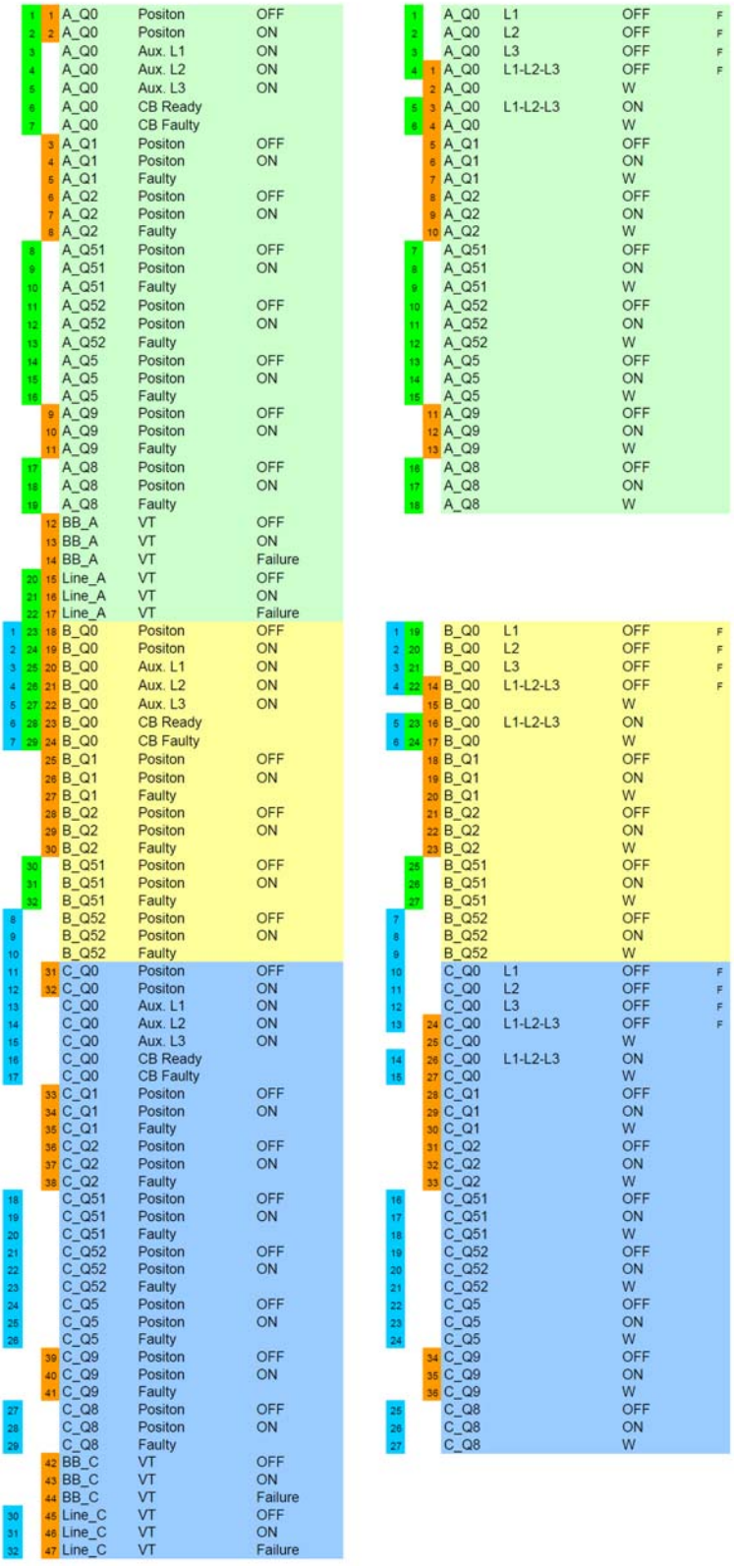
Figure 3: Function overview

1.8 Summary

The solution concept introduced above uses the variable features of the SIPROTEC 5 series. It is based on a distributed system solution approach whose components are merged to a total solution using highly efficient and reliable communication options. The individual functions can be adjusted flexibly to customer requirements and to the individual device within the overall solution.

1.9 Appendix

In the appendix you find an exemplary engineering of binary inputs and outputs for a breaker-and-a-half application.



1	1	A_Q0	Positon	OFF
2	2	A_Q0	Positon	ON
3		A_Q0	Aux. L1	ON
4		A_Q0	Aux. L2	ON
5		A_Q0	Aux. L3	ON
6		A_Q0	CB Ready	
7		A_Q0	CB Faulty	
	3	A_Q1	Positon	OFF
	4	A_Q1	Positon	ON
	5	A_Q1	Faulty	
	6	A_Q2	Positon	OFF
	7	A_Q2	Positon	ON
	8	A_Q2	Faulty	
8		A_Q51	Positon	OFF
9		A_Q51	Positon	ON
10		A_Q51	Faulty	
11		A_Q52	Positon	OFF
12		A_Q52	Positon	ON
13		A_Q52	Faulty	
14		A_Q5	Positon	OFF
15		A_Q5	Positon	ON
16		A_Q5	Faulty	
	9	A_Q9	Positon	OFF
	10	A_Q9	Positon	ON
	11	A_Q9	Faulty	
17		A_Q8	Positon	OFF
18		A_Q8	Positon	ON
19		A_Q8	Faulty	
	12	BB_A	VT	OFF
	13	BB_A	VT	ON
	14	BB_A	VT	Failure
20	15	Line_A	VT	OFF
21	16	Line_A	VT	ON
22	17	Line_A	VT	Failure
1	23	18	B_Q0	Positon	OFF
2	24	19	B_Q0	Positon	ON
3	25	20	B_Q0	Aux. L1	ON
4	26	21	B_Q0	Aux. L2	ON
5	27	22	B_Q0	Aux. L3	ON
6	28	23	B_Q0	CB Ready	
7	29	24	B_Q0	CB Faulty	
		25	B_Q1	Positon	OFF
		26	B_Q1	Positon	ON
		27	B_Q1	Faulty	
		28	B_Q2	Positon	OFF
		29	B_Q2	Positon	ON
		30	B_Q2	Faulty	
	30		B_Q51	Positon	OFF
	31		B_Q51	Positon	ON
	32		B_Q51	Faulty	
8			B_Q52	Positon	OFF
9			B_Q52	Positon	ON
10			B_Q52	Faulty	
11		31	C_Q0	Positon	OFF
12		32	C_Q0	Positon	ON
13			C_Q0	Aux. L1	ON
14			C_Q0	Aux. L2	ON
15			C_Q0	Aux. L3	ON
16			C_Q0	CB Ready	
17			C_Q0	CB Faulty	
		33	C_Q1	Positon	OFF
		34	C_Q1	Positon	ON
		35	C_Q1	Faulty	
		36	C_Q2	Positon	OFF
		37	C_Q2	Positon	ON
		38	C_Q2	Faulty	
18			C_Q51	Positon	OFF
19			C_Q51	Positon	ON
20			C_Q51	Faulty	
21			C_Q52	Positon	OFF
22			C_Q52	Positon	ON
23			C_Q52	Faulty	
24			C_Q5	Positon	OFF
25			C_Q5	Positon	ON
26			C_Q5	Faulty	
		39	C_Q9	Positon	OFF
		40	C_Q9	Positon	ON
		41	C_Q9	Faulty	
27			C_Q8	Positon	OFF
28			C_Q8	Positon	ON
29			C_Q8	Faulty	
		42	BB_C	VT	OFF
		43	BB_C	VT	ON
		44	BB_C	VT	Failure
30		45	Line_C	VT	OFF
31		46	Line_C	VT	ON
32		47	Line_C	VT	Failure

1		A_Q0	L1	OFF	F
2		A_Q0	L2	OFF	F
3		A_Q0	L3	OFF	F
4	1	A_Q0	L1-L2-L3	OFF	F
	2	A_Q0		W	
5	3	A_Q0	L1-L2-L3	ON	
6	4	A_Q0		W	
	5	A_Q1		OFF	
	6	A_Q1		ON	
	7	A_Q1		W	
	8	A_Q2		OFF	
	9	A_Q2		ON	
	10	A_Q2		W	
7		A_Q51		OFF	
8		A_Q51		ON	
9		A_Q51		W	
10		A_Q52		OFF	
11		A_Q52		ON	
12		A_Q52		W	
13		A_Q5		OFF	
14		A_Q5		ON	
15		A_Q5		W	
	11	A_Q9		OFF	
	12	A_Q9		ON	
	13	A_Q9		W	
16		A_Q8		OFF	
17		A_Q8		ON	
18		A_Q8		W	
1	19	B_Q0	L1	OFF	F
2	20	B_Q0	L2	OFF	F
3	21	B_Q0	L3	OFF	F
4	22	14	B_Q0	L1-L2-L3	OFF	F
		15	B_Q0		W	
5	23	16	B_Q0	L1-L2-L3	ON	
6	24	17	B_Q0		W	
		18	B_Q1		OFF	
		19	B_Q1		ON	
		20	B_Q1		W	
		21	B_Q2		OFF	
		22	B_Q2		ON	
		23	B_Q2		W	
	25		B_Q51		OFF	
	26		B_Q51		ON	
	27		B_Q51		W	
7			B_Q52		OFF	
8			B_Q52		ON	
9			B_Q52		W	
10			C_Q0	L1	OFF	F
11			C_Q0	L2	OFF	F
12			C_Q0	L3	OFF	F
13		24	C_Q0	L1-L2-L3	OFF	F
		25	C_Q0		W	
14		26	C_Q0	L1-L2-L3	ON	
15		27	C_Q0		W	
		28	C_Q1		OFF	
		29	C_Q1		ON	
		30	C_Q1		W	
		31	C_Q2		OFF	
		32	C_Q2		ON	
		33	C_Q2		W	
16			C_Q51		OFF	
17			C_Q51		ON	
18			C_Q51		W	
19			C_Q52		OFF	
20			C_Q52		ON	
21			C_Q52		W	
22			C_Q5		OFF	
23			C_Q5		ON	
24			C_Q5		W	
		34	C_Q9		OFF	
		35	C_Q9		ON	
		36	C_Q9		W	
25			C_Q8		OFF	
26			C_Q8		ON	
27			C_Q8		W	

Published by and copyright © 2013:

Siemens AG

Infrastructure & Cities Sector

Smart Grid Division

Humboldtstr. 59

90459 Nuremberg, Germany

Siemens AG

Infrastructure & Cities Sector

Smart Grid Division

Energy Automation

Humboldtstr. 59

90459 Nuremberg, Germany

www.siemens.com/protection

Printed on elementary chlorine-free bleached paper.

If not stated otherwise on the individual pages of this catalog, we reserve the right to include modifications, especially regarding the stated values, dimensions and weights. Drawings are not binding.

If not stated otherwise, all dimensions in this catalog are given in mm.

For more information, please contact
our Customer Support Center.
Tel.: +49 180 524 8437
Fax: +49 180 524 24 71
(Charges depending on provider)
E-mail: support.ic@siemens.com