

# SIPROTEC 5 Devices and Fields of Application

## Overcurrent and Feeder Protection – SIPROTEC 7SJ85

### Description

The SIPROTEC 7SJ85 overcurrent protection has been designed specifically for the protection of feeders and lines. With its modular structure, flexibility, and the high-performance DIGSI 5 engineering tool, the SIPROTEC 7SJ85 device offers future-oriented solutions for protection, control, automation, monitoring, and Power Quality – Basic.

Main function	Feeder and overcurrent protection for all voltage levels
Inputs and outputs	5 predefined standard variants with 4 current transformers, 4 voltage transformers, 11 to 59 binary inputs, 9 to 33 binary outputs
Hardware flexibility	Flexibly adjustable and expandable I/O quantity structure within the scope of the modular SIPROTEC 5 system; 1/6 expansion modules can be added, available with large or small display, or without display
Housing width	1/3 × 19 inches to 2/1 × 19 inches

### Benefits

- Safety due to high-performance protection functions
- Purposeful and easy handling of devices and software thanks to a user-friendly design
- Cybersecurity in accordance with NERC CIP and BDEW White-paper requirements
- Highest availability even under extreme environmental conditions by standard coating of the modules
- Full compatibility between IEC 61850 Editions 1, 2.0, and 2.1

### Functions

DIGSI 5 permits all functions to be configured and combined as required and as per the functional scope that has been ordered.

- Directional and non-directional overcurrent protection with additional functions
- Protection of up to 9 feeders with up to 40 analog inputs
- Optimized tripping times due to directional comparison and protection communication
- Detection of ground faults of any type in compensated or isolated electrical power systems using the following functions: 3I0>, V0>, transient ground-fault function,  $\cos \varphi$ ,  $\sin \varphi$ , dir. detection of intermittent ground faults, harmonic detection, and admittance measurement
- Ground fault detection using the pulse detection method
- Detection of intermittent ground faults with automatic blocking of statically measuring functions to avoid message and fault-record flooding
- Fault locator plus for accurate fault location with inhomogeneous line sections and targeted automatic overhead-line section reclosing (AREC)
- Arc protection
- Overvoltage and undervoltage protection
- Power protection, configurable as active or reactive-power protection



[SIP5\_GD\_SS\_W3, 2, --, --]

Figure 2.4/7 SIPROTEC 5 Device with Expansion Module

- Frequency protection and frequency-change protection for load-shedding applications
- Automatic frequency relief for underfrequency load shedding, taking changed infeed conditions due to decentralized power generation into consideration
- Protection functions for capacitor banks, such as overcurrent, overload, current-unbalance, peak overvoltage, or differential protection
- Directional reactive-power undervoltage protection (QU protection)
- Detection of current and voltage signals up to the 50th harmonic with high accuracy for selected protection functions (such as peak overvoltage protection for capacitors) and operational measured values
- PQ – Basic: Voltage unbalance; voltage changes: overvoltage, dip, interruption; TDD, THD, and harmonics
- Point-on-wave switching
- Control, synchrocheck, and switchgear interlocking protection
- Circuit-breaker failure protection
- Circuit-breaker reignition monitoring
- Graphical logic editor to create high-performance automation functions in the device
- Single-line representation in the small or large display
- Fixed integrated electrical Ethernet RJ45 interface for DIGSI 5 and IEC 61850 (reporting and GOOSE)
- 2 slots for optional communication modules, usable for different and redundant protocols (IEC 61850-8-1, IEC 61850-9-2 Client, IEC 60870-5-103, IEC 60870-5-104, Modbus TCP, DNP3 serial and TCP, PROFINET IO, PROFINET IO S2 redundancy)
- Virtual network partitioning (IEEE 802.1Q - VLAN)

# SIPROTEC 5 Devices and Fields of Application

## Overcurrent and Feeder Protection – SIPROTEC 7SJ85

2.4

- Serial protection communication via optical fibers, two-wire connections, and communication networks (IEEE C37.94 and others), including automatic switchover between ring and chain topology
- Reliable data transmission via PRP and HSR redundancy protocols
- Extensive cybersecurity functionality, such as role-based access control (RBAC), logging of security-related events, signed firmware, or authenticated IEEE 802.1X network access.
- Simple, fast, and secure access to the device via a standard Web browser to display all information and diagnostic data, vector diagrams, single-line and device display pages
- Phasor measurement unit (PMU) for synchrophasor measured values and IEEE C37.118 protocol
- Time synchronization using IEEE 1588
- Control of power transformers
- High-performance fault recording (buffer for a max. record time of 80 s at 8 kHz or 320 s at 2 kHz)
- Auxiliary functions for simple tests and commissioning

### Applications

- Detection and selective 3-pole tripping of short circuits in electrical equipment of star networks, lines with infeed at 1 or 2 ends, parallel lines, and open-circuited or closed ring systems of all voltage levels up to AC 400 V
- Backup protection for differential protection devices of all kind for lines, transformers, generators, motors, and busbars
- Protection and monitoring of capacitor banks
- Phasor Measurement Unit (PMU)
- Reverse-power protection
- Load shedding applications
- Automatic switchover
- Regulation or control of power transformers (two-winding transformers, three-winding transformers, grid coupling transformers)
- Detection and recording of power-quality data in the medium-voltage and subordinate low-voltage power system

### Application Templates

DIGSI 5 provides application templates for standard applications. They include basic configurations and default settings.

The following application templates are available:

#### Non-directional definite-time overcurrent protection/inverse-time overcurrent protection

- Overcurrent protection (non-directional) for phases and ground
- transformer inrush-current detection

#### Directional definite-time overcurrent protection/inverse-time overcurrent protection – grounded power system

- Overcurrent protection (directional and non-directional) for phases and ground
- transformer inrush-current detection
- Measuring-voltage failure detection

#### Directional definite-time overcurrent protection/inverse-time overcurrent protection – arc-suppression-coil-ground systems/isolated systems

- Overcurrent protection (directional and non-directional) for phases
- Directional sensitive ground-fault detection for static ground faults
- Directional sensitive ground-fault detection for transient and static ground faults
- Transformer inrush-current detection
- Measuring-voltage failure detection

#### Capacitor bank H-bridge + 1 x RLC

- Overcurrent protection for phases and ground
- Capacitor-bank phase unbalance protection
- Peak overvoltage protection
- Overload protection
- Undercurrent protection

#### MSCDN capacitor bank

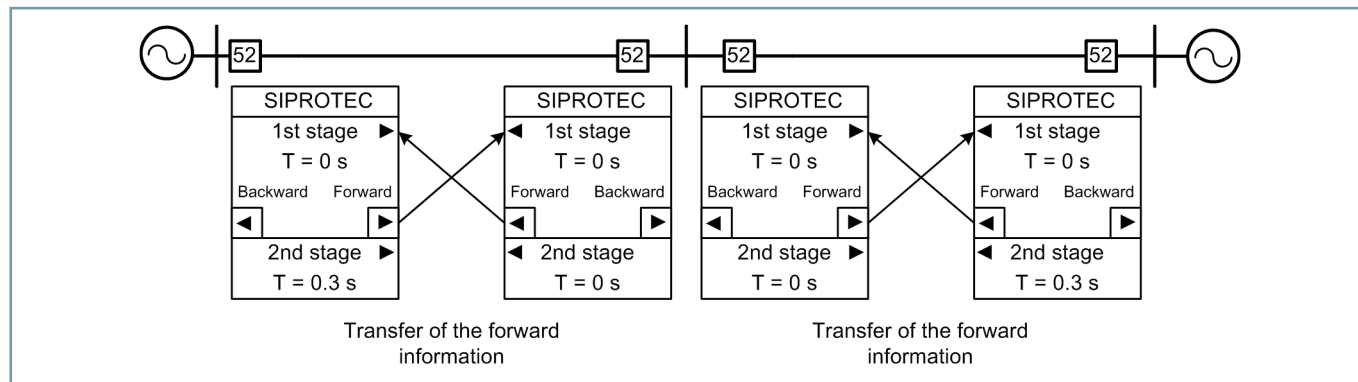
- Overcurrent protection for phases and ground
- Capacitor-bank phase unbalance protection
- Differential protection for capacitor
- Peak overvoltage protection
- Overload protection
- Undercurrent protection

### Application Examples

#### Directional Comparison Protection via Protection Interfaces for Power Line with an Infeed at Both Ends

With the direction determination of the directional overcurrent protection, you can implement directional comparison protection for power line with an infeed at both ends (Figure 2.4/8). Directional comparison protection is used for the selective isolation of a faulty line section (for example, subsections of closed

rings). Sections are isolated quickly, that is, they do not suffer the disadvantage of long grading times. This technique requires that directional information can be exchanged between the individual protection stations. This information exchange can, for example, be implemented via a protection interface. Alternatives for the protection interface are IEC 61850 GOOSE or exchange via pilot wires for signal transmission, with an auxiliary-voltage loop.



[dw\_DwDOCP07, 1, en\_US]

Figure 2.4/8 Application Example: Principle of Directional Comparison Protection for Power Line with an Infeed at Both Ends

The application example for SIPROTEC 7SJ82 (Figure 2.4/6) shows the functional scope and the basic configuration for this application.

#### Protection and Control at a Double Busbar

In the Figure 2.4/9, a double-busbar feeder is protected and additionally controlled by a SIPROTEC 7SJ85 device. This example is based on the application template **Directional definite-time overcurrent protection/inverse-time overcurrent protection – grounded power system**. In addition to the appli-

cation template, the functions Circuit-breaker failure protection, Automatic reclosing, and Synchrocheck in the circuit-breaker function group are required and configured. These functions can easily be added via **drag and drop** from the DIGSI 5 function library. Operational measured values and energy metered values are calculated in the **Voltage-current 3ph** function group. They are available for the output on the display, the transmission to the substation automation technology, and the processing in the CFC. A switching sequence stored in the CFC that is activated via a function key starts an automatically running busbar switchover process.

# SIPROTEC 5 Devices and Fields of Application

## Overcurrent and Feeder Protection – SIPROTEC 7SJ85

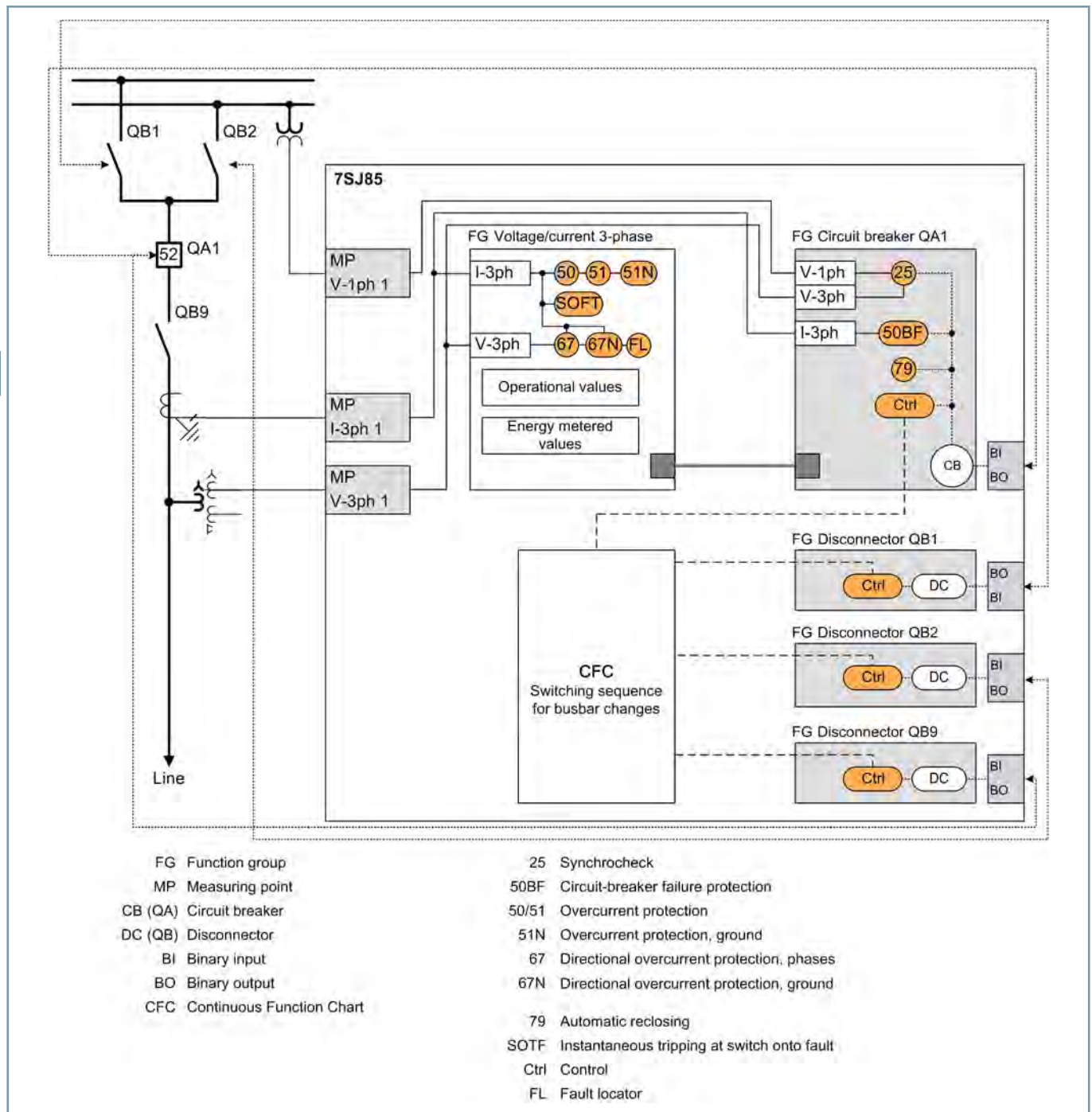


Figure 2.4/9 Application Example: Overcurrent Protection 7SJ85 at a Double-Busbar Feeder

### Protection of a Capacitor Bank

Figure 2.4/10 shows the protection of an H-bridge capacitor bank. For this application, the device provides special functions for the protection of capacitor banks. Thanks to the modular structure and performance of SIPROTEC 5, the complete application can be protected with one single device.

### Properties:

- Short-circuit protection (ANSI 50, 50N) for phase and ground faults
- Peak overvoltage protection (ANSI 59C) to protect the dielectric medium of the bank against dangerous peak overvoltage, in particular caused by the harmonic components with consideration up to the 50th harmonic component. The peak

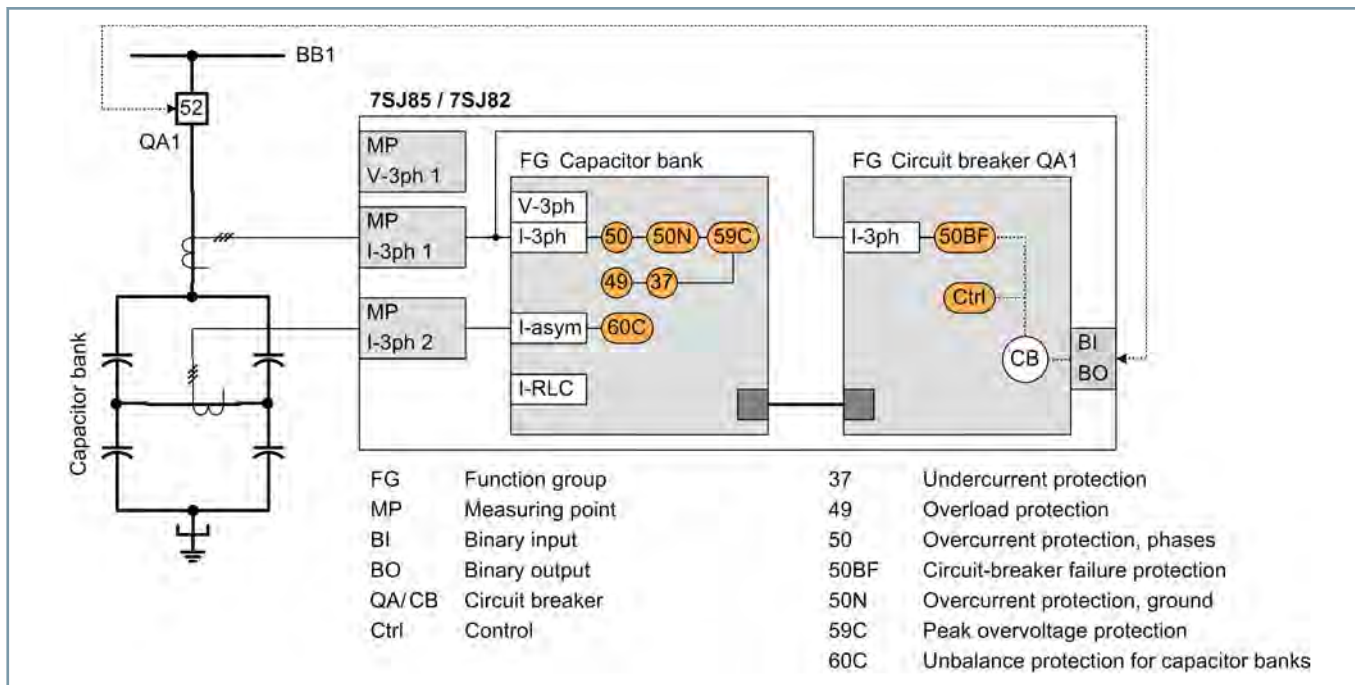
# SIPROTEC 5 Devices and Fields of Application

## Overcurrent and Feeder Protection – SIPROTEC 7SJ85

voltage is calculated from the current by calculating the integral.

- Overload protection (ANSI 49) to protect the bank against thermal overload
- Highly sensitive current-unbalance protection (ANSI 60C) to detect the failure of individual capacitor elements as monitoring and protection function; manual and automatic adjustment in the bay. The automatic adjustment permits dynamic unbalances (caused by temperature influence, for example) to be considered.

- Undercurrent protection (ANSI 37) to trip the local circuit breaker when the infeed is disconnected providing protection against hazardous voltage at the non-discharged bank, for example, in phase opposition
- Circuit-breaker failure protection (ANSI 50BF)



[dw\_CapBank\_SLE\_Normal, 1, en\_US]

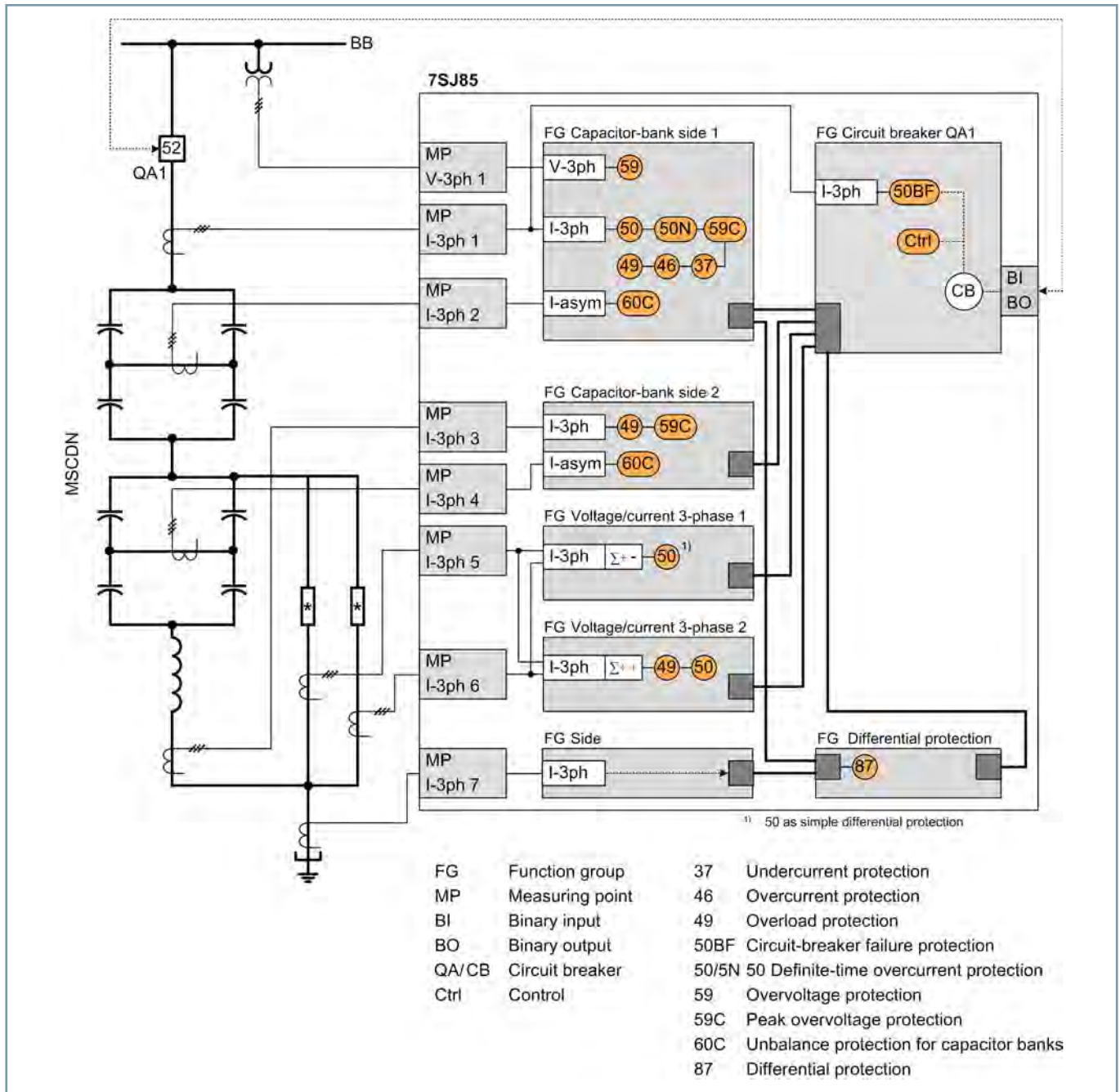
Figure 2.4/10 Application Example: Protection of an H-Bridge Capacitor Bank

2.4

# SIPROTEC 5 Devices and Fields of Application

## Overcurrent and Feeder Protection – SIPROTEC 7SJ85

2.4



[dw\_CapBank\_MSCDN, 1, en\_US]

Figure 2.4/11 Application Example: MSCDN Capacitor Bank

### Protection of an MSCDN Capacitor Bank (MSCDN = Mechanically Switched Circuit Breaker with Damping Network)

In [Figure 2.4/11](#), the SIPROTEC 7SJ85 device protects the capacitor bank in H-bridge connection as well as the associated damping network. Thanks to the modular structure and performance of SIPROTEC 5, the complete application can be protected with a single device.

#### Properties:

- Acquisition of up to nine 3-phase current measuring points
- Short-circuit protection (ANSI 50, 50N) for phase and ground faults

# SIPROTEC 5 Devices and Fields of Application

## Overcurrent and Feeder Protection – SIPROTEC 7SJ85

- Peak overvoltage protection (ANSI 59C) to protect the dielectric medium of the bank against dangerous peak overvoltage, in particular caused by the harmonic components, with consideration up to the 50th harmonic component. The peak voltage is calculated from the current by calculating the integral.
- Overload protection (ANSI 49) to protect the bank against thermal overload
- Highly sensitive current-unbalance protection (ANSI 60C) to detect the failure of individual capacitor elements as monitoring and protection function; manual and automatic adjustment in the bay. The automatic adjustment permits dynamic unbalances (caused by temperature influence, for example) to be considered.
- Differential protection (87C) over the entire capacitor bank to protect against short circuits inside the entire installation
- Overload and overcurrent protection via the 2 resistors and a simple differential protection to detect a failure of one of the 2 resistors. For this purpose, current sum and current difference are determined with the current measuring points in the R branches, at the inputs of the V/I 3-phase function groups.
- Undercurrent protection (ANSI 37) to trip the local circuit breaker when the infeed is disconnected, providing protection against hazardous voltage at the non-discharged bank, for example, in phase opposition
- Circuit-breaker failure protection (ANSI 50BF)

# SIPROTEC 5 Devices and Fields of Application

## Overcurrent and Feeder Protection – SIPROTEC 7SJ85

ANSI	Function	Abbr.	Available	Application Templates				
				1	2	3	4	5
	Protection functions for 3-pole tripping	3-pole	■	■	■	■	■	■
	Expandable hardware quantity structure	I/O	■	■	■	■	■	■
	Process bus client protocol (hint: PB client requires a separate ETH-BD-2FO plug-in module, from V8.0)	PB client	■					
	IEC61850-9-2 Merging Unit Stream (hint: Each stream requires a separate ETH-BD-2FO plug-in module, from V8.0)	MU	■					
	IEC61850-9-2 Merging Unit Stream 7SS85 CU (hint: Only for communication with a 7SS85 CU. A separate ETH-BD-2FO plug-in module is required starting with V8.40)	MU	■					
24	Overexcitation protection	V/f	■					
25	Synchrocheck, synchronization function	Sync	■					
25	Synchrocheck, synchronization function with adjusting commands (from V7.82)	Sync	■					
27	Undervoltage protection: "3-phase" or "positive-sequence system V1" or "universal Vx"	V<	■					
27R, 59R	Voltage change protection (starting with V8.30)	dV/dt	■					
	Undervoltage-controlled reactive power protection	Q>/V<	■					
32, 37	Power protection active/reactive power	P<>, Q<>	■					
32R	Reverse-power protection	- P<	■					
37	Undercurrent	I<	■				■	■
38	Temperature supervision	θ>	■					
46	Negative-sequence system overcurrent protection	I2>	■				■	■
46	Unbalanced-load protection (thermal)	I2² t>	■					
46	Negative-sequence system and overcurrent protection with direction	I2>, ∠(V2, I2)	■					
47	Overvoltage protection, negative-sequence system	V2>	■					
49	Thermal overload protection	θ, I²t	■				■	■
49	Thermal overload protection, user-defined characteristic curve	θ, I²t	■					
49	Overload protection for RLC filter circuit elements of a capacitor bank	θ, I²t	■				■	
50/51 TD	Overcurrent protection, phases	I>	■	■	■	■	■	■
	Instantaneous tripping at switch onto fault	SOTF	■					
50HS	Instantaneous high-current tripping	I>>>	■					
50/51 TD	Overcurrent protection with positive-sequence current I1 (from V7.9)	I1>	■					
50N/ 51N TD	Overcurrent protection, ground	IN>	■	■	■		■	■
50N/ 51N TD	Overcurrent protection, 1-phase	IN>	■					
50 Ns/ 51Ns	Sensitive ground-fault detection for grounded arc suppression coils and isolated power systems including a) 3I0> b) admittance Y0>, c) 3I0-harm> (from V7.8)	INs>	■					
	Sensitive ground-fault detection via pulse detection; hint: this stage also requires the function 50Ns/51Ns or 67Ns "sensitive ground-fault detection for grounded arc suppression coils and isolated power systems"	IN pulse	■					
	Intermittent ground-fault protection	IIE>	■					
50/51 TD	Overcurrent protection for RLC filter circuit elements of a capacitor bank	I>	■					

2.4



# SIPROTEC 5 Devices and Fields of Application

## Overcurrent and Feeder Protection – SIPROTEC 7SJ85

ANSI	Function	Abbr.	Available	Application Templates				
				1	2	3	4	5
50BF	Circuit-breaker failure protection, 3-pole	CBFP	■					■
50EF	End-fault protection (hint: For use only in decentralized busbar protection with a 7SS85 CU starting with V8.40)		■					
50RS	Circuit breaker restrrike monitoring	CBRM	■					
51V	Voltage-controlled overcurrent protection	t=f(I, V)	■					
59, 59N	Overvoltage protection: "3-phase" or "zero-sequence system V0" or "positive-sequence system V1" or "universal Vx"	V>	■					■
59C	Peak overvoltage protection, 3-phase, for capacitors	V> cap.	■				■	■
60C	Current-unbalance protection for capacitor banks	Iunbal>	■				■	■
60	Voltage-comparison supervision	ΔV>	■					
67	Directional overcurrent protection, phases	I>, <(V, I)	■		■	■		
67N	Directional overcurrent protection, ground	IN>, <(V, I)	■		■			
67 Ns	Sensitive ground-fault detection for grounded arc suppression coils and isolated power systems including a) 3I0> b) V0>, c) cos/sine Phi, d) transient ground fault, e) Phi(V, I), f) admittance		■			■		
	Directional tripping stage with one harmonic; hint: this stage also requires the function "67Ns sensitive ground-fault detection for grounded arc suppression coils and isolated power systems"	<(V0h, I0h)	■					
	Directional Intermittent Ground-Fault Protection	IIEdir>	■					
74TC	Trip-circuit supervision		■					
74CC	Single circuit monitoring (from V7.9)		■					
79	Automatic reclosing, 3-pole	AREC	■					
81	Frequency protection: "f>" or "f<" or "df/dt"	f<>; df/dt<>	■					
81U	Underfrequency load shedding	f<(ULS)	■					
	Vector-jump protection	Δφ>	■					
86	Lockout		■	■	■	■	■	■
87N T	Restricted ground-fault protection	ΔIN	■					
87C	Differential protection for capacitor banks	ΔI	■					■
87V	Voltage differential protection for capacitor banks	ΔV	■					
90 V	Voltage controller for two-winding transformer		■					
90 V	Voltage controller for two-winding transformer with parallel control		■					
	Number of two-winding transformers with parallel control (hint: only together with the function "voltage controller for two-winding transformer with parallel control")		■					
90 V	Voltage controller for three-winding transformer		■					
90 V	Voltage controller for grid coupling transformer		■					
FL	Fault Locator, single-side	FL-one	■					
FL	Fault Locator Plus (from V7.9)	FL plus	■					
PMU	Synchrophasor measurement	PMU	■					
AFD	Arc protection (only with plug-in module ARC-CD-3FO)		■					
	Measured values, standard		■	■	■	■	■	■
	Measured values, extended: Min, max, average		■					
	Switching statistics counter		■					
	PQ – Basic measured values: THD (Total Harmonic Distortion) and harmonic component (starting with V8.01) and THD voltage average values (starting with V8.40)		■					

# SIPROTEC 5 Devices and Fields of Application

## Overcurrent and Feeder Protection – SIPROTEC 7SJ85






ANSI	Function	Abbr.	Available	Application Templates				
				1	2	3	4	5
	PQ – Basic measured values: Voltage unbalance (starting with V8.40)		■					
	PQ – Basic measured values: Voltage changes – monitoring of voltage dips, overvoltages and voltage interruptions (starting with V8.40)		■					
	PQ – Basic measured values: TDD - Total Demand Distortion (starting with V8.40)		■					
	CFC (standard, control)		■	■	■	■	■	■
	CFC arithmetic		■					
	Circuit-breaker wear monitoring	$\Sigma I_x, I^2t, 2P$	■					
	Switching sequence function		■					
	Inrush-current detection		■	■	■	■		
	External trip initiation		■					
	Control		■	■	■	■	■	■
PoW	Point-on-wave switching (starting with V7.90)	PoW	■					
	Circuit breaker		■	■	■	■	■	■
	Disconnectors/grounding conductor		■	■	■	■	■	■
	Fault recording of analog and binary signals		■	■	■	■	■	■
	Monitoring		■	■	■	■	■	■
	Protection interface, serial		■					
	Frequency group tracking (from V7.8)		■					
	Cyber security: Role-Based Access Control (from V7.8)		■					
	Temperature recording via communication protocol		■					
	Cyber security: Authenticated network access using IEEE 802.1X (starting from V8.3)		■					
Function point class:				0	30	50	100	300
The configuration and function point class for your application can be determined in the SIPROTEC 5 order configurator at <a href="http://www.siemens.com/siprotec">www.siemens.com/siprotec</a> .								

**Table 2.4/5** SIPROTEC 7SJ85 – Functions, Application Templates

- (1) Non-directional definite-time overcurrent protection/inverse-time overcurrent protection (4\*1, 4\*V)
- (2) Directional definite-time overcurrent protection/inverse-time overcurrent protection – grounded power system
- (3) Directional definite-time overcurrent protection/inverse-time overcurrent protection - grounded arc suppression coils/isolated power systems
- (4) Capacitor bank: H-bridge + 1\*RLC
- (5) Capacitor bank: MSCDN

# SIPROTEC 5 Devices and Fields of Application

## Overcurrent and Feeder Protection – SIPROTEC 7SJ85

Standard Variants for SIPROTEC 7SJ85		
S1	1/3, 11 BI, 9 BO, 4 I, 4 V Housing width 1/3 x 19" 11 binary inputs 9 binary outputs (1 life contact, 2 standard, 6 fast) 4 current-transformer inputs 4 voltage-transformer inputs Contains the following modules: base module with PS201 and IO202	
S2	1/2, 17 BI, 16 BO, 4 I, 4 V Housing width 1/2 x 19" 17 binary inputs 16 binary outputs (1 life contact, 9 standard, 6 fast) 4 current-transformer inputs 4 voltage-transformer inputs Contains the following modules: base module with PS201 and IO202 Expansion modules IO206	
S3	1/2, 27 BI, 17 BO, 4 I, 4 V Housing width 1/2 x 19" 27 binary inputs 17 binary outputs (1 life contact, 10 standard, 6 fast) 4 current-transformer inputs 4 voltage-transformer inputs Contains the following modules: base module with PS201 and IO202 Expansion modules IO207	
S4	2/3, 43 BI, 25 BO, 4 I, 4 V Housing width 2/3 x 19" 43 binary inputs 25 binary outputs (1 life contact, 18 standard, 6 fast) 4 current-transformer inputs 4 voltage-transformer inputs Contains the following modules: base module with PS201 and IO202 Expansion modules 2x IO207	
S5	5/6, 59 BI, 33 BO, 4 I, 4 V Housing width 5/6 x 19" 59 binary inputs 33 binary outputs (1 life contact, 26 standard, 6 fast) 4 current-transformer inputs 4 voltage-transformer inputs Contains the following modules: base module with PS201 and IO202 Expansion modules 3x IO207	

**Table 2.4/6** Standard Variants for SIPROTEC 7SJ85

You can find the technical data of the devices in the manual  
[www.siemens.com/siprotec](http://www.siemens.com/siprotec).