SIEMENS

Energy Automation

SIPROTEC 5 – Bay Controller 6MD85, 6MD86

Catalog SIPROTEC 5.03 · Edition 1

Answers for infrastructure and cities.

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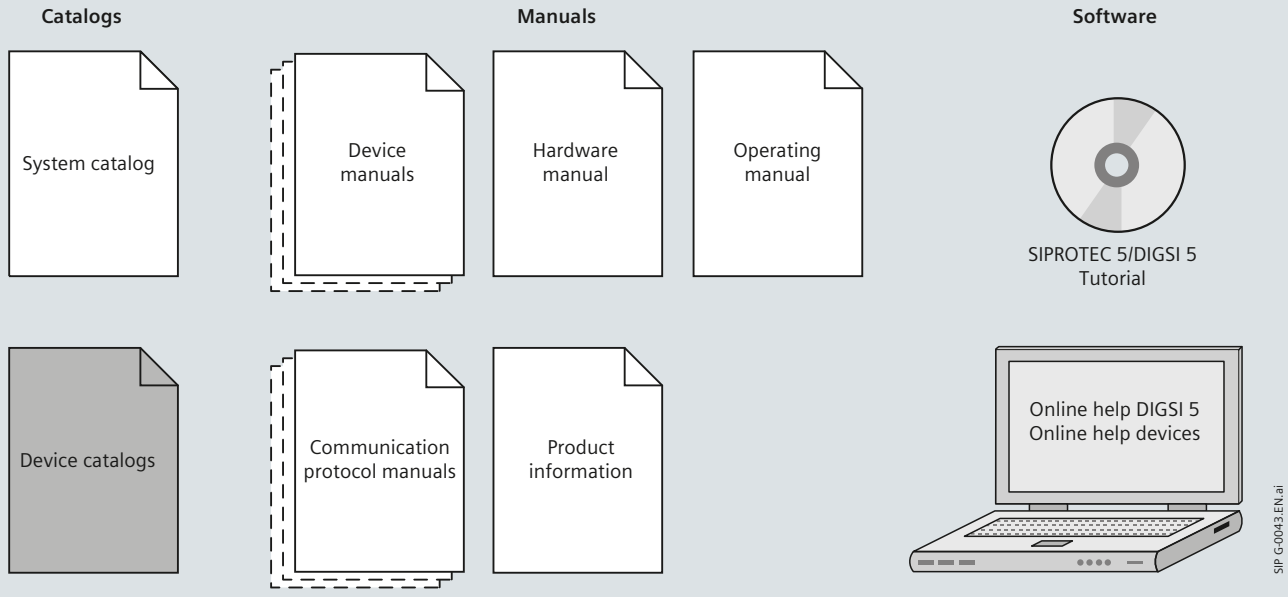

Overview of documentation for the SIPROTEC 5 system

System catalog

The system catalog describes the SIPROTEC 5 system features.

Device catalogs

The device catalogs describe device-specific features such as functional scope, hardware and applications.

Device manuals

The device manuals describe the functions and applications of a specific SIPROTEC 5 device. The printed manual and the online help for the device have the same informational structure.

Hardware manual

The hardware manual describes the hardware components and device combinations of the SIPROTEC 5 device family.

Operating manual

The operating manual describes the basic principles and procedures for operating and assembling the devices of the SIPROTEC 5 device family.

Communication protocol manuals

The communication protocol manuals include a description of specific protocols for communication within the SIPROTEC 5 device family and to higher-level control centers.

Product information

The product information includes general information about device installation, technical data, limiting values for input and output modules, and conditions when preparing for operation. This document is delivered with each SIPROTEC 5 device.

DIGSI 5 online help

The DIGSI 5 online help contains a help package for DIGSI 5 and CFC. The help package for DIGSI 5 includes a description of the basic operation of software, the DIGSI principles and editors. The help package for CFC includes an introduction to CFC programming, basic examples of CFC handling, and a reference chapter with all CFC blocks available for the SIPROTEC 5 device family.

Online help devices

The online help for devices has the same information structure as the device manual.

SIPROTEC 5 / DIGSI 5 Tutorial

The tutorial on the DVD contains brief information about important product features, more detailed information about the individual technical areas, as well as operating sequences with tasks based on practical operation and a brief explanation.

Contents

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ISO 9001
ISO 14001
DNV
Certified Company

OHSAS 18001
DNV
Certified Company

The products and systems described in this catalog are manufactured and sold according to a certified management system (acc. to ISO 9001, ISO 14001 and BS OHSAS 18001).
DNV Certificate No.: 92113-2011-AHSO-GER-TGA and Certificate No.: 87028-2010-AHSO-GER-TGA.

Editorial

SIPROTEC has been a recognized brand leader in digital protection and field devices on the energy market for decades. The Siemens high-performance SIPROTEC devices cover the entire power spectrum and can be implemented in a wide range of fields – from power generation to very high voltage transmission and distribution network applications.

"Smart automation for transmission grids" is the Siemens response to the present and future challenges to achieve a reliable and efficient energy supply. SIPROTEC 5 is an active component of the energy-efficient smart grid and an important building block in the complex distributed energy supply systems and networks solutions.

The next generation of SIPROTEC devices, SIPROTEC 5, is based on the proven features of SIPROTEC 4 to provide you with a new, modern platform including both hardware and software. This platform offers an excellent solution to the challenges associated with evolving grid structures and workflows. The quality, reliability and proven functions of the former system have been preserved. Innovative approaches including holistic workflow, safety and security, and network stability monitoring (PMU functionality) have been added.

The pioneering system architecture places you in full control of switchgear communications. A powerful, reliable communication infrastructure, combined with the flexible engineering capabilities serves as the basis for monitoring and controlling of distributed, decentralized systems. Seamless communications is the central component of the SIPROTEC 5 system architecture to provide flexibility, safety and security in the automated distributed network solutions.

With SIPROTEC 5, you are at the beginning of a new generation of intelligent, digital multifunction field devices. The new operating tool DIGSI 5 offers individual support for you – handles your specific workflow requirements, from system design to device selection and testing, covering the entire device lifecycle. The new tool offers cost savings over the entire lifecycle without compromising safety and system availability.

With the new SIPROTEC 5 generation, you are well equipped to meet the growing economic and reliability demands imposed on your networks. The philosophy of SIPROTEC 5 is reflected in the modularity and flexibility of its hardware and software components. Perfectly tailored fit – the custom fit for your switchgear and specifications for the application and standardization of energy automation.

Ingo Erkens

General Manager
Infrastructure and Cities Sector
Smart Grid Division
Energy Automation

SIPROTEC 5 – bay controller

SIPROTEC 5 bay controller is part of the modular system of SIPROTEC 5. It supports all SIPROTEC 5 system features, and can be used individually as well as universally in the framework of system solutions. In the following, the specific properties of the SIPROTEC 5 bay controller is described. The description of the SIPROTEC 5 system features is found in the system catalog.

In the system catalog, the following properties of SIPROTEC 5 are introduced in detail:

- The SIPROTEC 5 system
- Areas of use
- Hardware
- Engineering
- Communication
- IEC 61850 – Simply usable
- Test and diagnostics
- Safety concept
- DIGSI 5.

The system catalog can be ordered free of charge from your Siemens contact partner under order number E50001-K4605-A011-A1-7600.

SIPROTEC 5 bay controller is based on the distance protection and differential protection principles. It protects overhead lines and cables of all voltage levels with the highest possible degree of selectivity and security. A large number of additional protection and automation functions makes use in all areas of line protection possible.

The devices also contain important auxiliary functions that are necessary for safe network operation today. This includes functions for protection, control, measurement and monitoring. The large number of communication interfaces and communication protocols satisfies the requirements of communication-based selective protection, as well as automated operation.

Commissioning and maintenance work can be completed safely, quickly and thus cost-effectively with high-performance test functions. Because of a modular structure design, the SIPROTEC 5 bay controller can always be flexibly adapted to specific requirements.

SIPROTEC 5 system catalog
Order No. E50001-K4605-A011-A1-7600

Overview

Overview of the devices 6MD85 and 6MD86

SIPROTEC 5 bay controller is based on the flexible and powerful SIPROTEC 5 modular system. When ordering, you can choose between various standard variants. Expandability by expansion modules allows for individual adjustment to specific applications.

Function library and application templates

The extensive SIPROTEC function library is also available in the bay controller type 6MD8. Thus, numerous protection functions such as overcurrent protection, overvoltage protection or frequency protection are available. These functions are truly the same for all devices. Once established, configurations can be transferred from device to device. This results in substantially reduced engineering effort.

In this catalog you will find predefined templates for standard applications. These templates already contain basic configurations, required functions and default settings for standard applications.

Device groups

The bay controller is distinguished by the product groups 6MD85 and 6MD86. 6MD85 devices are tailored to applications in distribution systems. 6MD86 devices are designed for applications in transmission systems and can be operated with a maximum variety of additional functions. The hardware design of both device types can be configured flexibly.

Further distinguishing features:

Type	6MD85	6MD86
Circuit-breaker tripping signal	–	Optional
Automatic reclosing	–	Optional
CFC switching sequences	Optional	■
CFC arithmetic	Optional	■
Measured-value processing	Optional	■
Number of switching devices greater than 4	Optional	■
Synchrocheck	Optional	■

Table 1 Overview of different distinguishing features

Common features:

- Numerous protection functions configurable
- Modularly expandable quantity structure
- Optionally usable as Phasor Measurement Unit
- Powerful automation with CFC.

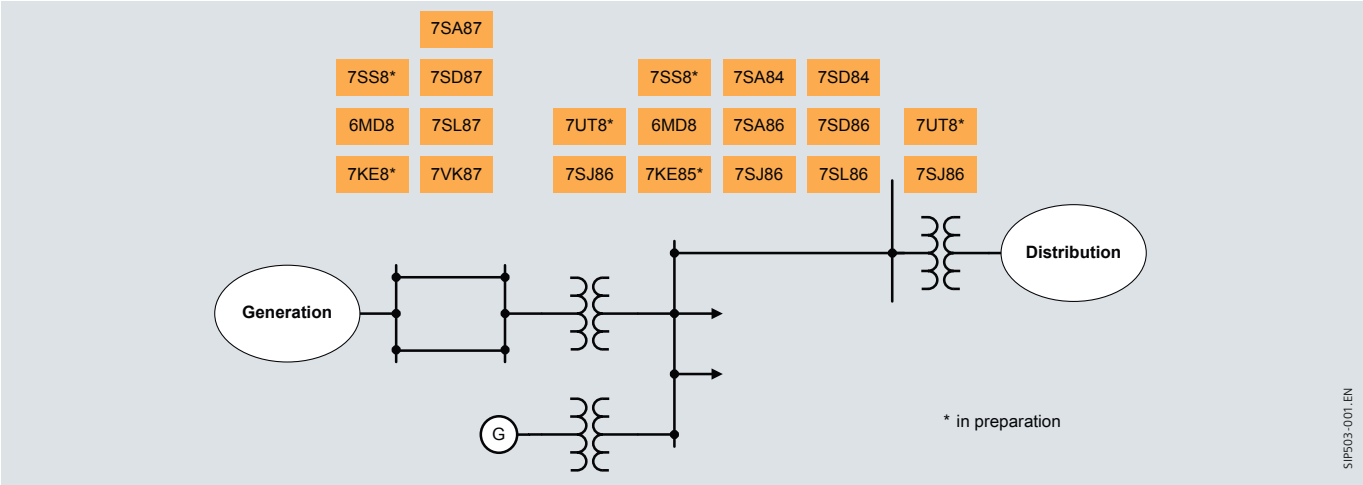


Fig. 1 Applications of SIPROTEC 5 devices in a transmission system

Bay controller 6MD85

Properties – 6MD85

Short description	Bay controller for medium-voltage and high- to extra-high-voltage switchgear with integrated operation and extensive protection functions. Powerful automation, simple configuration with DIGSI 5.
Inputs and outputs Hardware flexibility	5 predefined standard variants with 4 current transformers and 4 voltage transformers, 11 to 75 binary inputs, 9 to 41 binary outputs or flexibly adjusted and expandable I/O quantity structure within the scope of the SIPROTEC 5 modular system
Width of housing	1/3 × 19" to 1/1 × 19"

- Integrated bay controller with versatile protection functions for applications from medium to extra high voltage.
- Control of up to 20 switching devices
- Synchrocheck and switchgear interlocking system
- Supports integration into the station automation system with IEC 61850
- Further communication protocols: IEC 60870-5-103, MODBUS RTU Slave
- Up to four communication modules
- Usable as Phasor Measurement Unit (PMU) for synchrophasor measured values with IEEE C37.118 protocol
- Powerful automation with CFC (Continuous Function Chart)
- Optional overcurrent protection for all voltage levels with 3-pole tripping
- Also used in switchgear with breaker-and-a-half scheme
- Selective protection of overhead lines and cables with single- and multi-ended infeeds for use with protection data communication
- Overcurrent protection also configurable as backup function
- Various additional functions
- Secure serial protection data communication, also over great distances and all available physical media (fiber-optic cable, 2-wire connections and communication networks) *
- Measurement of operational values
- Powerful fault recording
- Consistent monitoring concept
- Auxiliary functions for simple tests and commissioning.

Applications

The bay controller 6MD85 is a universal protection, control and automation device on the basis of the SIPROTEC 5 system. It is especially designed for the protection of lines and therefore it is optimally suitable for reserve or emergency protection for the line protection devices. Due to its high flexibility in using of protection data communication * it is suitable as selective protection equipment for overheadlines and cables with single- and multi-ended infeeds. The device supports all SIPROTEC 5 system characteristics. It enables future-oriented system solutions with high investment security and low operating costs.

Fig. 2 Bay controller 6MD85 (1/3 device with 1/6 expansion module and operation panel for key-operated switch)

Functions

Table 2 on page 9 shows all functions that are available in the 6MD85. Basically, all functions can be configured freely with DIGSI 5. For the application of some of the functions, you require the appropriate number of free function points within the device. The function point calculator in the online configurator provides support in determining the required number of function points for your device.

Application templates

Application templates are available in DIGSI for standard applications. They comprise all basic configurations and default settings. Table 2 on page 9 shows the functional scope and the function point requirement for the application templates described. The following application templates are available:

6MD85 standard

- Double-busbar feeder with switchgear interlocking.

6MD85 extended control

- Additionally to 6MD85 standard, this includes the CFC blocks for switching sequences and arithmetic
- Switching sequence for automatic busbar transfer preconfigured (started by function key).

* in preparation

Application example: Bay controller 6MD85

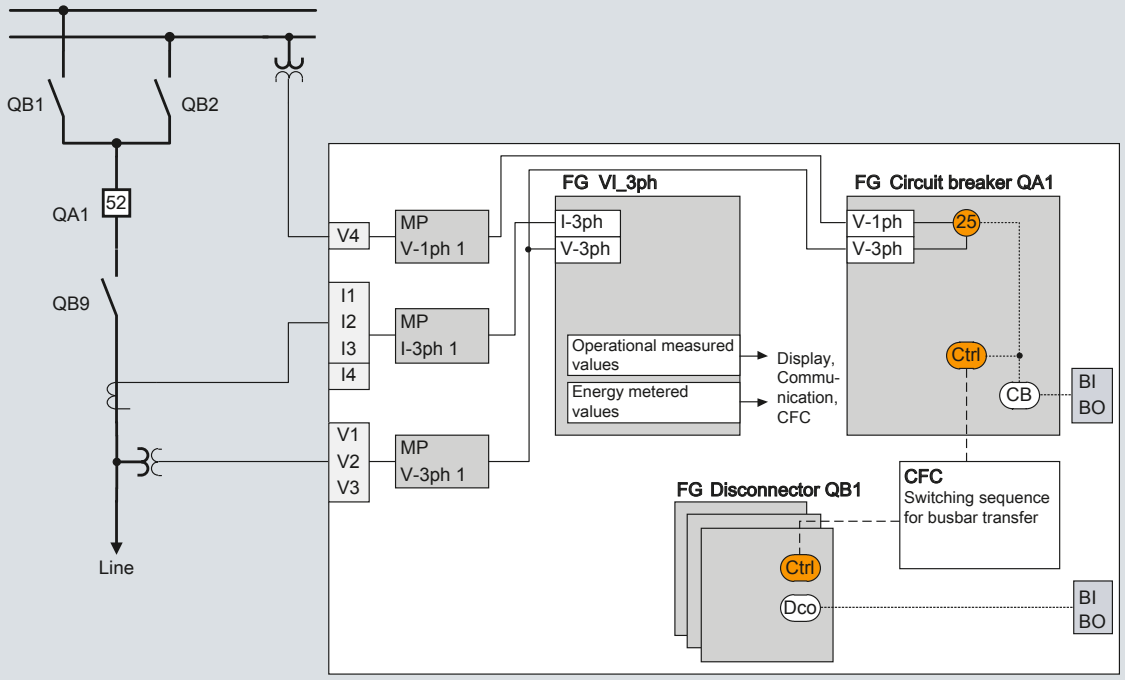


Fig. 3 Application example: Bay controller 6MD85 for double busbar with switching sequence for busbar transfer

6MD85 functions, application templates

ANSI	Function	Abbr.	Application templates: Available in 6MD85	Points for 6MD85	6MD85 standard	6MD85 expanded
25	Synchrocheck, synchronizing function	Sync	■	50 2)		
50BF	Circuit-breaker failure protection	CBFP	–	–		
79	Automatic reclosing	AR	–	–		
PMU	Synchrophasor measurement	PMU	■	40		
	Operational measured values, standard		■	0	■	■
	Measured values, extended: Min, Max, Avg		■	3 1)2)		6 x
	Switching-statistic counters		■	0	■	■
	CFC standard		■	0	■	■
	CFC arithmetic		■	40 2)		
	CFC switching sequences		■	40 2)		■
	Control for 4 switching devices		■	0	■	■
	Control for more than 4 switching devices		■	3 2)3)		
	Protection interface *		■	0		
50/51	Overcurrent protection, phases	I>, I_P>	■	10		
50N/51N	Overcurrent protection, ground	I_N>, I_{NP}	■	10		
67	Directional overcurrent protection *, phase	I>,$I_P \angle$ (V,I)	■	15		
50HS	High speed instantaneous overcurrent protection	I>>>	■	0		
59	Overvoltage protection, 3-phase	V>	■	5		
59	Overvoltage protection, positive-sequence system	V1>	■	5		
59	Overvoltage protection, negative-sequence system *	V2>	■	5		
59N	Overvoltage protection, zero-sequence system *	V0>	■	5		
59	Overvoltage protection, 1-phase, *Vx*	Vx>	■	5		
27	Undervoltage protection, 3-phase *	V<	■	5		
27	Undervoltage protection, positive-sequence system *	V1<	■	5		
27	Undervoltage protection, 1-phase, *Vx* *	Vx<	■	5		
81O	Overfrequency protection	f>	■	5		
81U	Underfrequency protection	f<	■	5		
32, 37	Power protection active/reactive power *	P<>, Q<>	■	10		
	Inrush-current detection		■	0		
	Monitoring and supervision		■	0	■	■
46	Negative-sequence system overcurrent protection	I2>, I2/I1>	■	15		
49	Thermal overload protection	θ, I^2t	■	0		
	External trip initiation		■	10		
74TC	Trip-circuit supervision	TCS	■	0		
	Function points				0	75

* in preparation

Table 2 6MD85 functions, application templates

1) Per measured value and min., max. or mean value for 6MD85 (e.g., only max. values for current = 1 x 3 points)
2) Functions already included in basic scope of 6MD86
3) 3 points per switching device from the 5th switching device for 6MD85

Bay controller 6MD86

Properties – 6MD86

Short description	Bay controller for medium-voltage and high- to extra-high-voltage switchgear with integrated operation and extensive protection functions. Powerful automation, simple configuration with DIGSI 5.
Inputs and outputs Hardware flexibility	6 predefined standard variants with up to 8 current transformers and 8 voltage transformers, 11 to 75 binary inputs, 9 to 41 binary outputs or flexibly adjusted and expandable I/O quantity structure within the scope of the SIPROTEC 5 modular system
Width of housing	1/3 × 19" to 1/1 × 19"

- Integrated bay controller with versatile protection functions for applications from medium to extra high voltage.
- Control of up to 20 switching devices
- Synchrocheck, switchgear interlocking system and protection functions related to the switching device, such as circuit-breaker tripping signal and automatic reclosing
- Supports integration into the station automation system with IEC 61850
- Further communication protocols: IEC 60870-5-103, DNP3 over IP
- Up to four communication modules
- Usable as Phasor Measurement Unit (PMU) for synchrophasor measured values with IEEE C37.118 protocol
- Powerful automation with CFC (Continuous Function Chart)
- Optional overcurrent protection for all voltage levels with 3-pole tripping
- Also used in switchgear with breaker-and-a-half scheme
- Selective protection of overhead lines and cables with single- and multi-ended infeeds for use with protection data communication
- Overcurrent protection also configurable as backup function
- Various additional functions
- Secure serial protection data communication, also over great distances and all available physical media (fiber-optic cable, 2-wire connections and communication networks) *
- Measurement of operational values
- Powerful fault recording
- Consistent monitoring concept
- Auxiliary functions for simple tests and commissioning.

Applications

The bay controller 6MD86 is a universal protection, control and automation device on the basis of the SIPROTEC 5 system. It is especially designed for the protection of lines and therefore it is optimally suitable for reserve or emergency protection for the line protection devices. Due to its high flexibility in using of protection data communication * it is suitable as selective protection equipment for overhead lines and cables with single- and multi-ended infeeds. The device supports all SIPROTEC 5 system characteristics. It enables future-oriented system solutions with high investment security and low operating costs.

Fig. 4 Bay controller 6MD86 (1/3 device with 1/6 expansion module and operation panel for key-operated switch)

Functions

Table 3 on page 12 shows all functions that are available in the 6MD86. Basically, all functions can be configured freely with DIGSI 5. For the application of some of the functions, you require the appropriate number of free function points within the device. The function point calculator in the online configurator provides support in determining the required number of function points for your device.

Application templates

Application templates are available in DIGSI for standard applications. They comprise all basic configurations and default settings. Table 3 on page 12 shows the functional scope and the function point requirement for the application templates described. The following application templates are available:

6MD86 standard double busbar

- Double-busbar feeder with switchgear interlocking system
- Synchrocheck for circuit-breaker
- Switching sequence for automatic busbar transfer preconfigured (tripped by function key).

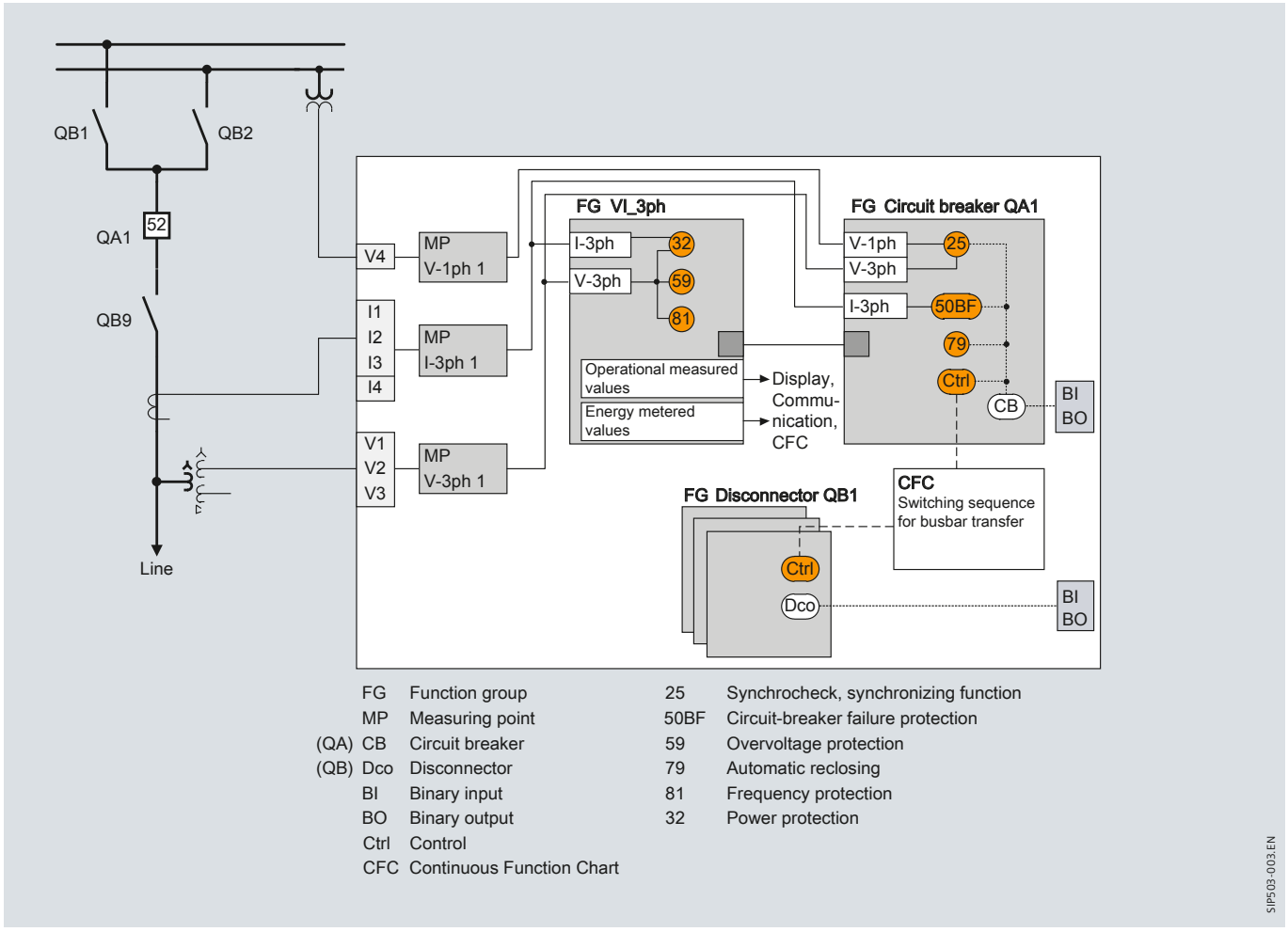
6MD86 1.5 circuit-breaker type 1

- Control of a breaker-and-a-half diameter (3 circuit-breakers, 14 disconnectors)
- Synchrocheck for the three circuit-breakers with dynamic measuring point changeover.

6MD86 1.5 circuit-breaker type 2

- Control of a part of breaker-and-a-half diameter
- Supports concepts with several bay controller per bay
- Circuit-breaker failure protection and automatic reclosing.

* in preparation



	FG	Function group	25	Synchrocheck, synchronizing function
	MP	Measuring point	50BF	Circuit-breaker failure protection
(QA)	CB	Circuit breaker	59	Overvoltage protection
(QB)	Dco	Disconnector	79	Automatic reclosing
	BI	Binary input	81	Frequency protection
	BO	Binary output	32	Power protection
	Ctrl	Control		
	CFC	Continuous Function Chart		

Fig. 5 Application example: Bay controller 6MD86 for double busbar with protection functions

Bay Controller 6MD85/6MD86

6MD86 functions, application templates

ANSI	Function	Abbr.	Available in 6MD86	Points for 6MD86	Application templates: 6MD86 standard double busbar	6MD86 breaker-and-a half type 1	6MD86 breaker-and-a half type 2
25	Synchrocheck, synchronizing function	Sync	■	0	■	■	■
50BF	Circuit-breaker failure protection	CBFP	■	15			■
79	Automatic reclosing	AR	■	45			■
PMU	Synchrophasor measurement	PMU	■	40			
	Operational measured values, standard		■	0	■	■	■
	Measured values, extended: Min, Max, Avg		■	0			
	Switching-statistic counters		■	0	■	■	■
	CFC standard		■	0	■	■	■
	CFC arithmetic		■	0			
	CFC switching sequences		■	0	■		
	Control for 4 switching devices		■	0	■	■	■
	Control for more than 4 switching devices		■	0		■	■
	Protection interface *		■	0			
50/51	Overcurrent protection, phases	I>, I_P>	■	10			
50N/51N	Overcurrent protection, ground	I_N>, I_{NP}	■	10			
67	Directional overcurrent protection *, phase	I>,$I_P \angle$ (V,I)	■	15			
50HS	High speed instantaneous overcurrent protection	I>>>	■	0			
59	Overvoltage protection, 3-phase	V>	■	5			
59	Overvoltage protection, positive-sequence system	V1>	■	5			
59	Overvoltage protection, negative-sequence system *	V2>	■	5			
59N	Overvoltage protection, zero-sequence system *	V0>	■	5			
59	Overvoltage protection, 1-phase, *Vx*	Vx>	■	5			
27	Undervoltage protection, 3-phase *	V<	■	5			
27	Undervoltage protection, positive-sequence system *	V1<	■	5			
27	Undervoltage protection, 1-phase, *Vx* *	Vx<	■	5			
81O	Overfrequency protection	f>	■	5			
81U	Underfrequency protection	f<	■	5			
32, 37	Power protection active/reactive power *	P<>, Q<>	■	10			
	Inrush-current detection		■	0			
	Monitoring and supervision		■	0	■	■	■
46	Negative-sequence system overcurrent protection	I2>, I2/I1>	■	15			
49	Thermal overload protection	θ, I^2t	■	0			
	External trip initiation		■	10			
74TC	Trip-circuit supervision	TCS	■	0			
	Function points				0	0	75

* in preparation

Table 3 6MD86 functions, application templates

Application example with 6MD85

Fig. 6 shows a simple application example with a 6MD85 on a double busbar. The circuit-breaker function group contains the synchrocheck. The disconnectors are also controlled by one function group each. Operational measured values and energy measured values are calculated in the function group VI_3-phase, and are available for output on the display, transmission to the station automation system and processing in the CFC. A switching sequence stored in the CFC which is triggered via a function key causes an automatic busbar transfer.

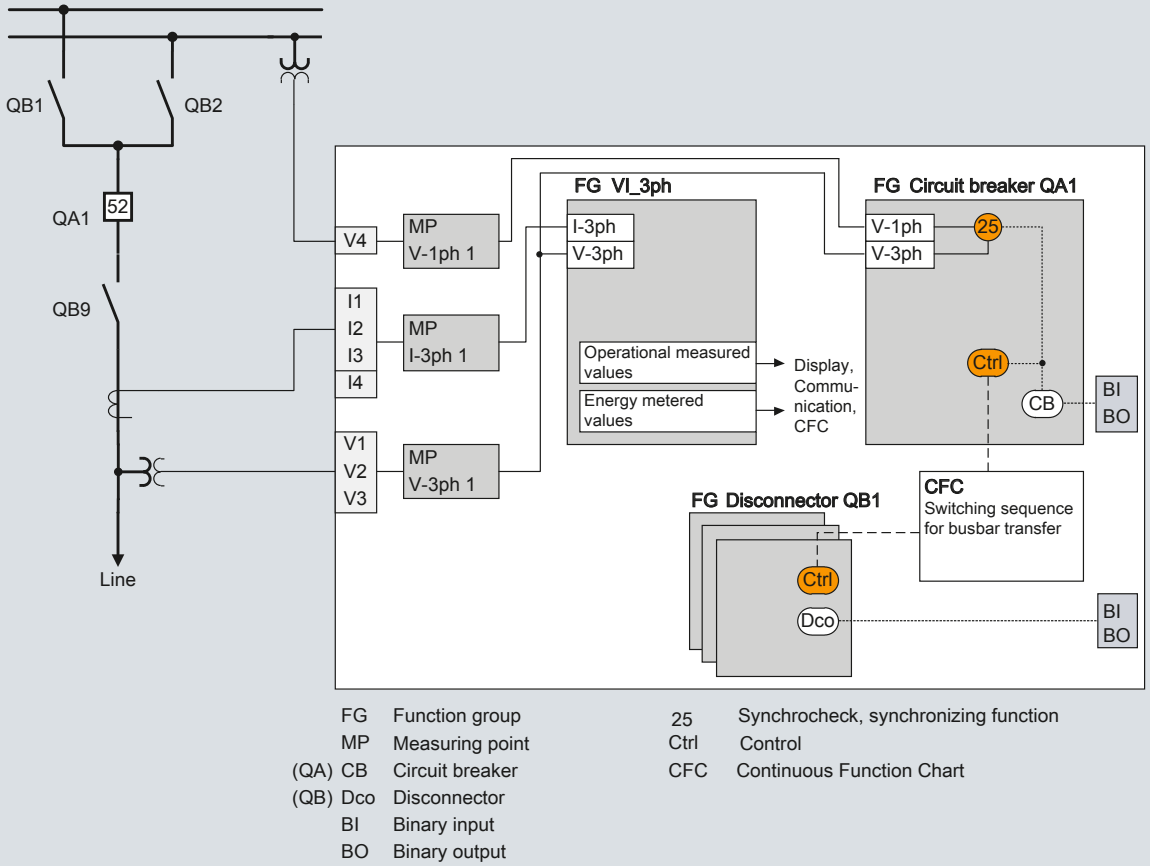


Fig. 6 Application example: Bay controller 6MD85 for double busbar with switching sequence for busbar transfer

Double busbar with protection functions (6MD86)

Application example with 6MD86

In Fig. 8, the double-busbar feeder is controlled by a 6MD85 and additionally protected. For this purpose, the circuit-breaker failure protection and automatic reclosing are activated in the circuit-breaker function group. Function group VI_3-phase contains the protection functions overvoltage protection, frequency protection and power protection. Different to Fig. 6 it is therefore connected to the circuit-breaker in order to provide a destination for the resulting tripping signals. Such connections can be configured easily and flexibly in the DIGSI editor "Function group connections" (Fig. 7).

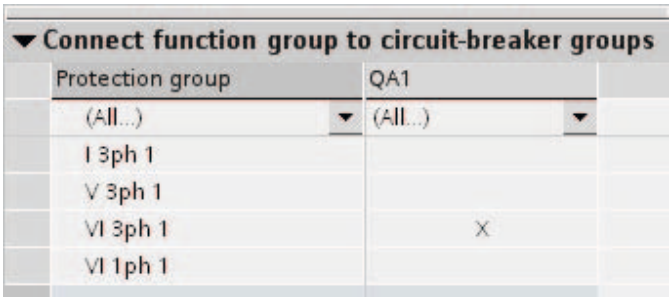


Fig. 7 Assignment of the function group with protection functions to the circuit-breaker (protection object)

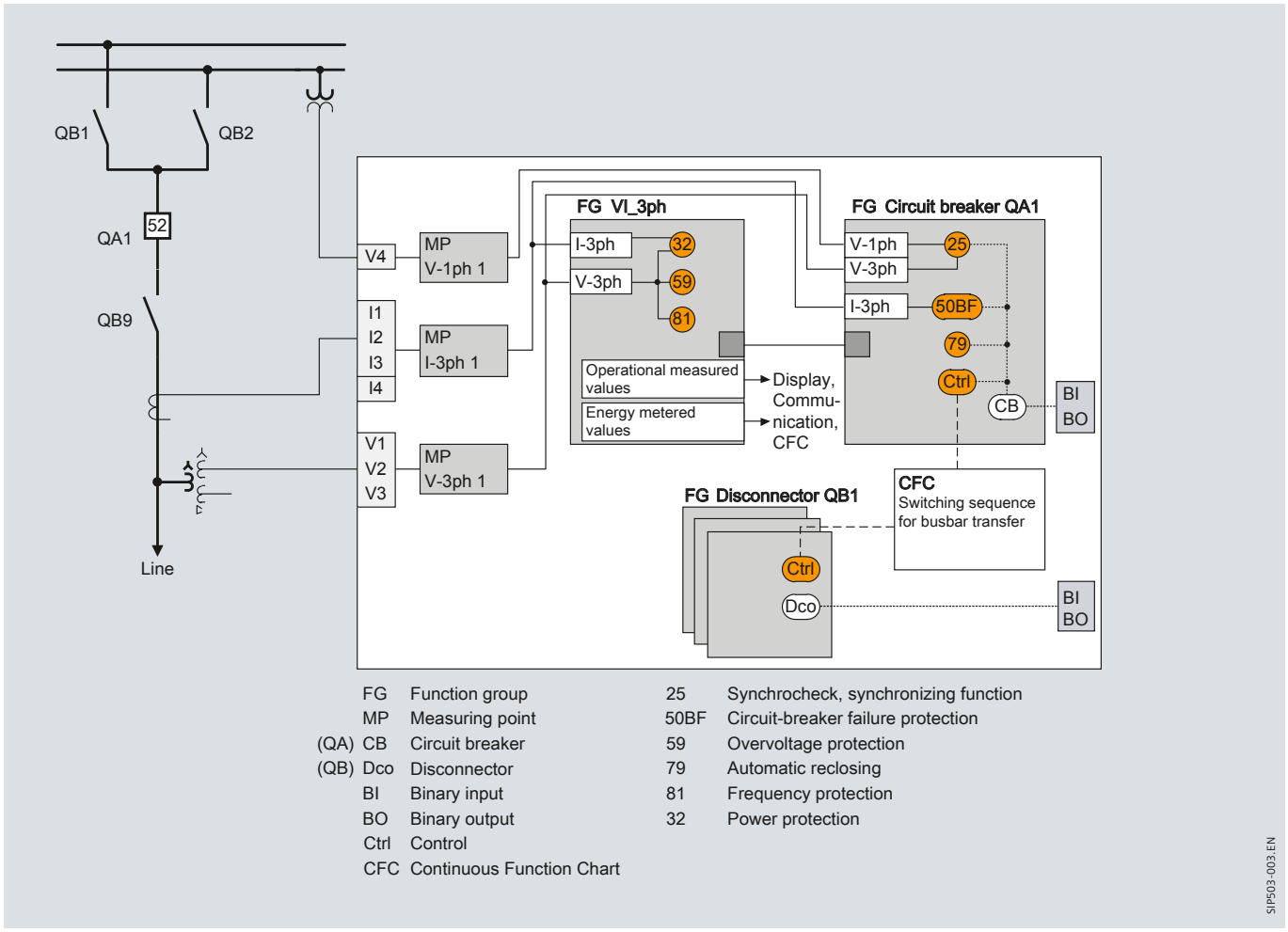


Fig. 8 Application example: Bay controller 6MD86 for double busbar with protection functions

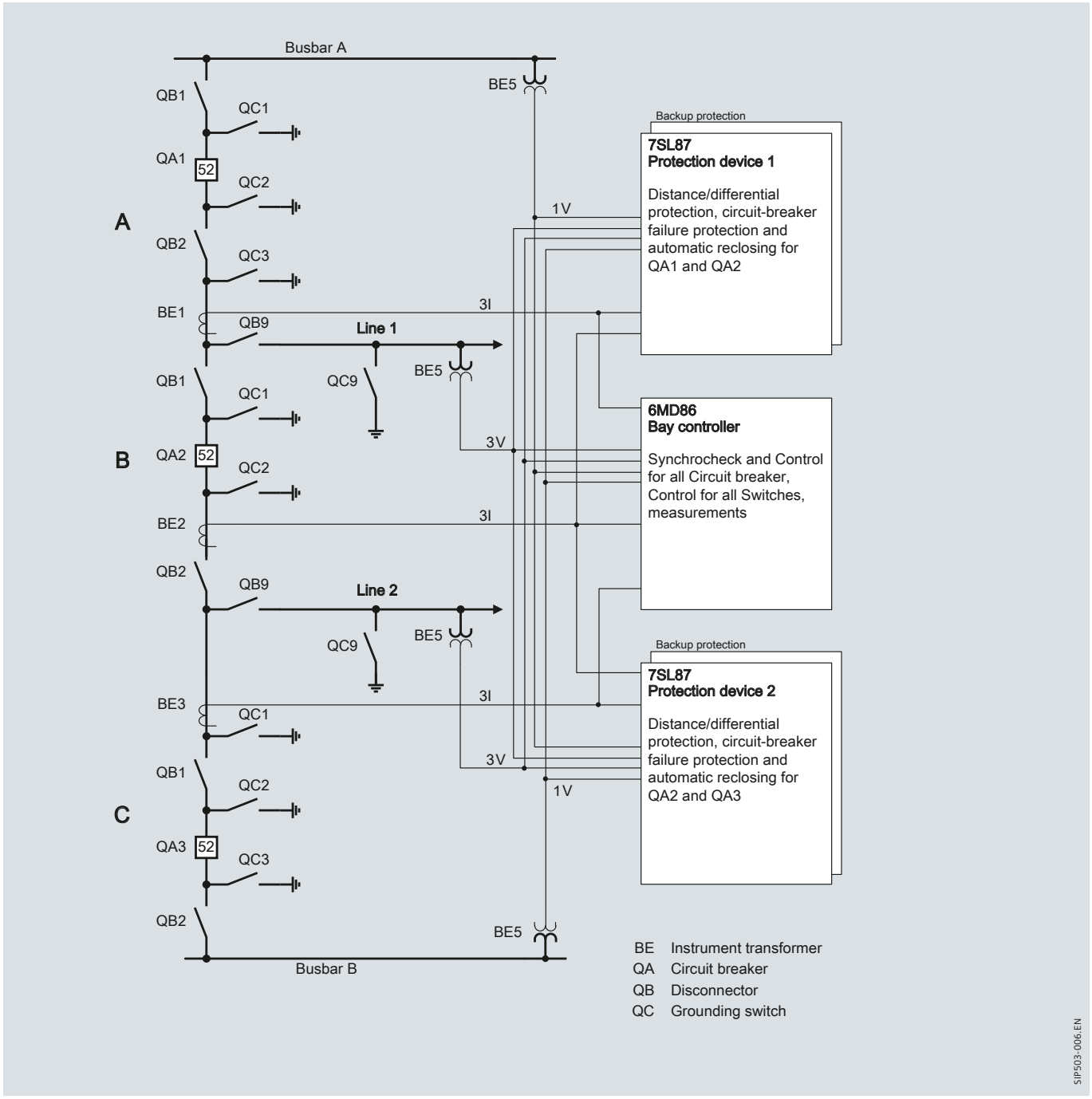


Fig. 9 Application example: Breaker-and-a-half layout with one bay controller and two line protection devices (overview)

Fig. 9 shows a breaker-and-a-half diameter with protection and control system. Protection is ensured by two line protection devices 7SL87 which also include circuit-breaker failure protection and automatic reclosing of the three circuit-breakers.

All switching devices and the synchrocheck of the circuit-breakers are controlled by the bay controller 6MD86. Fig. 10 shows the functions of 6MD86.

Breaker-and-a-half diameter with protection and control (6MD86)

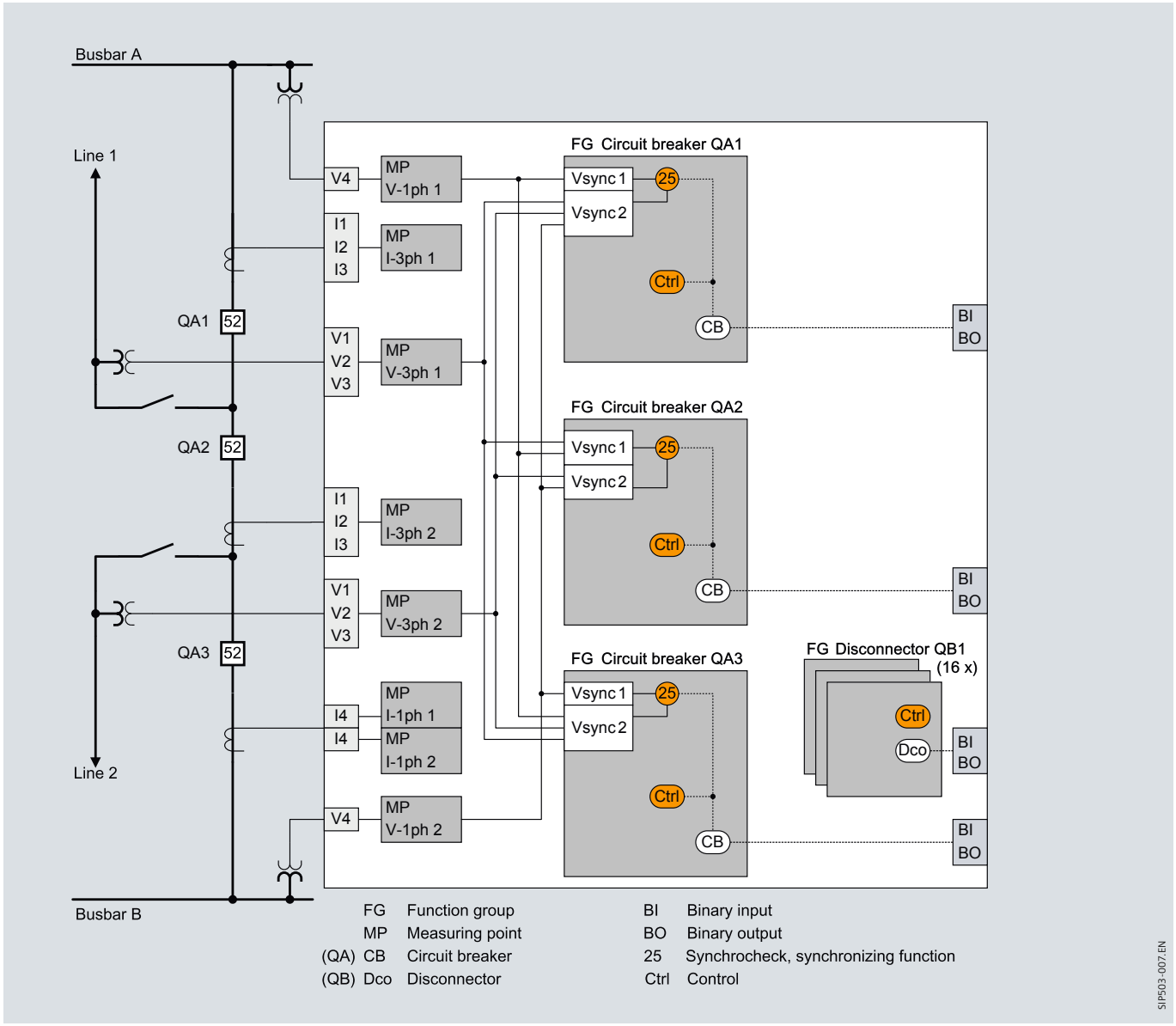


Fig. 10 Application example: Breaker-and-a-half layout with one bay controller and two line protection devices (detail for bay controller)

Fig. 10 shows the principle of dynamic changeover of measured voltage values for the synchrocheck functions of the three circuit-breakers in the bay controller 6MD86.

Every synchrocheck function (ANSI number 25) requires the two voltages Vsync1 and Vsync2 (feeder voltage and reference voltage). For the central circuit-breaker QA2 there are two possibilities each for both voltages, depending on the position of the disconnectors and the circuit-breakers. For the two exterior circuit-breakers QA1 and QA3, there is only one possibility for one voltage (that is, the adjacent busbar), whereas the other voltage is connected with one of three possibilities (also depending on the position of the switching device).

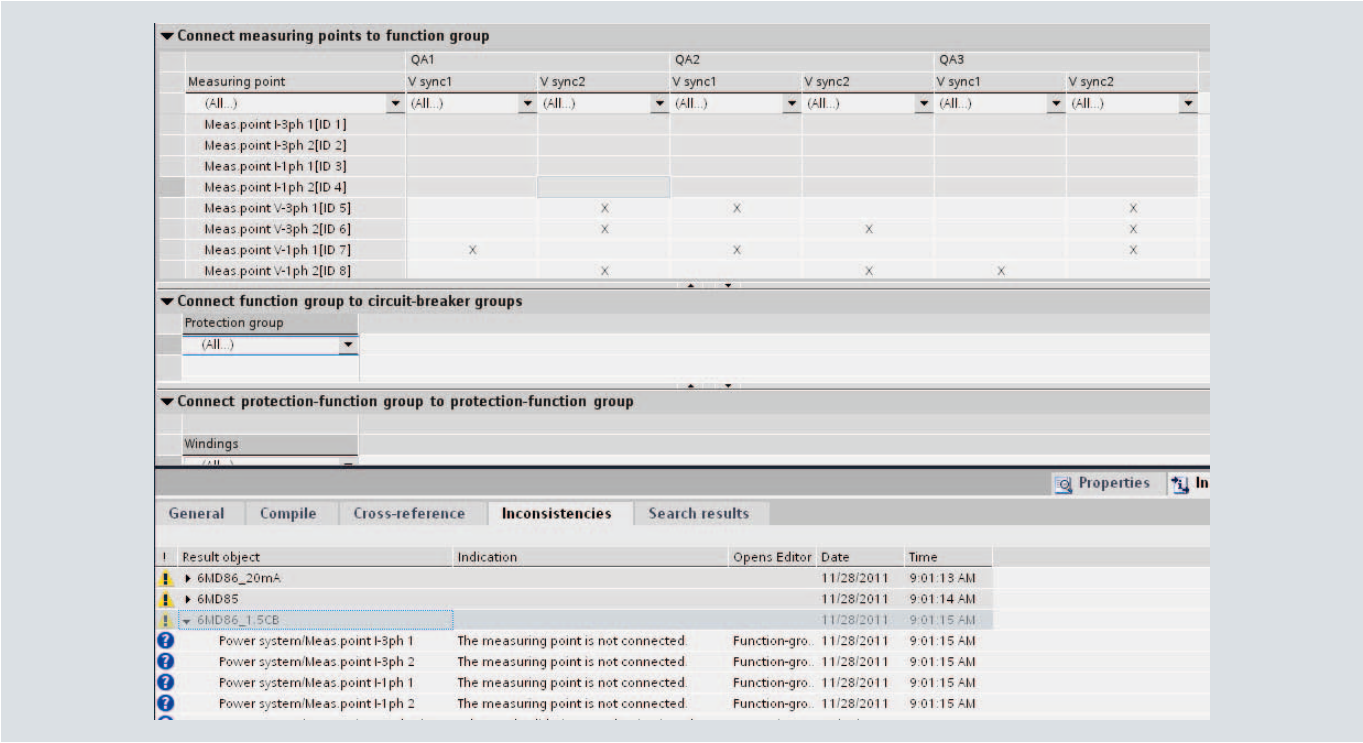


Fig. 11 Mapping of the possible voltage channels to the three circuit-breaker function groups

Fig. 11 shows the mapping in the editor "Function Group Connections". All voltages that are possible as feeder or reference voltage for the synchrocheck are assigned to the inputs Vsync1 or Vsync2. The ID number of the measured values is used to select the presently applied operational voltages in a CFC (Fig. 12).

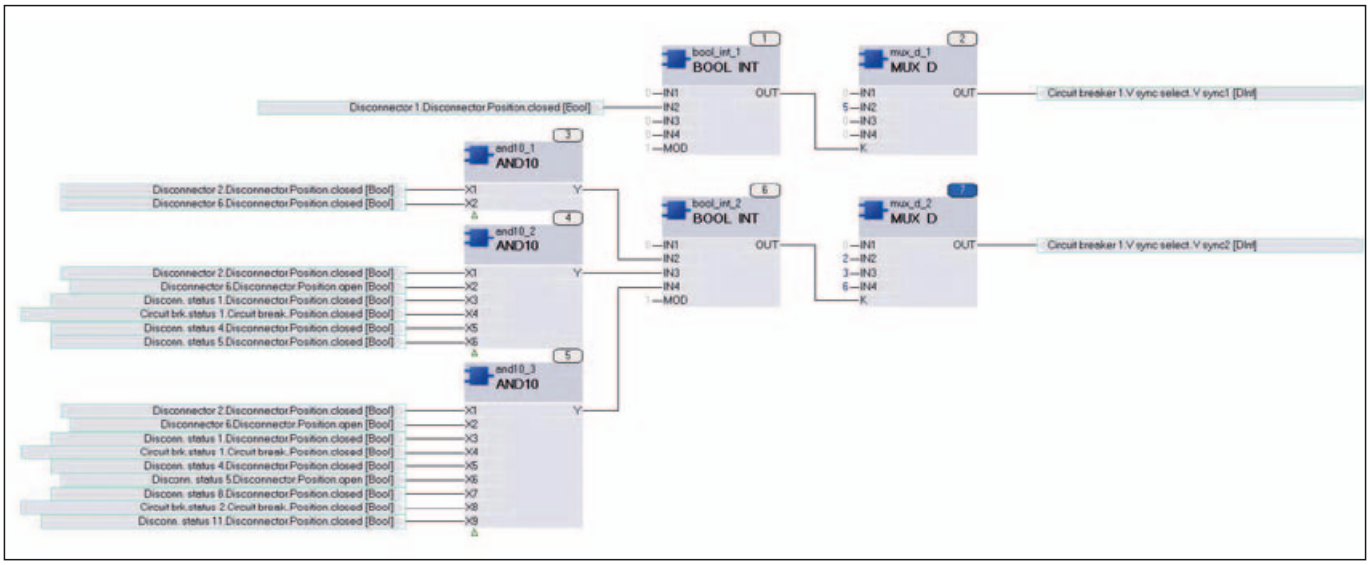


Fig. 12 CFC for selection of the synchrocheck reference voltages

Application as Phasor Measurement Unit (6MD85 and 6MD86)

Application as Phasor Measurement Unit

With the bay controller 6MD85 and 6MD86, the function "Phasor Measurement Unit" (PMU) is made available in the SIPROTEC devices for the first time.

Fig. 13 shows the principle. A measurement of current and voltage with regard to amplitude and phase is performed with PMUs on selected substations of the transmission system. Due to the high-precision time stamps assigned to these phasor quantities by the PMU, these measured values can be displayed together at a central analysis point. This provides a good overview of the condition of the system stability, and enables the display of dynamic processes, e.g., power swings.

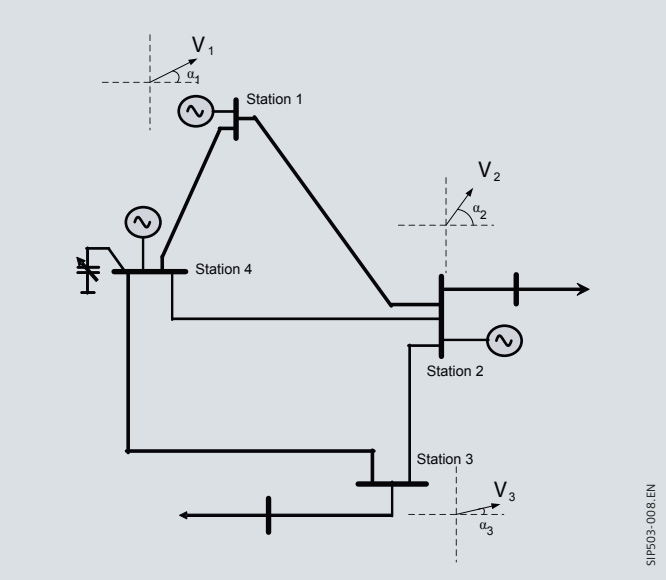


Fig. 13 Principle of distributed phasor measurement

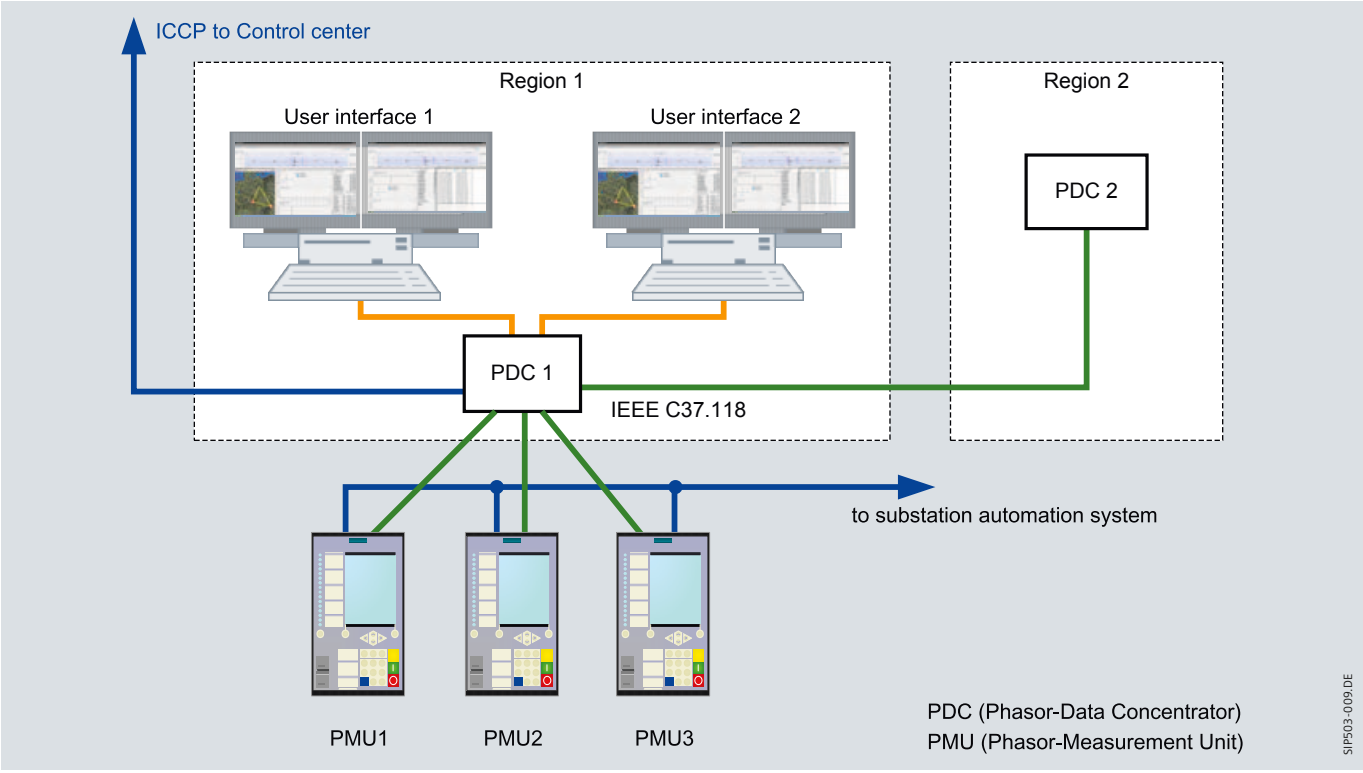


Fig. 14 Connection of 3 Phasor Measurement Units with two Phasor Data Concentrators (PDCs) SIGUARD PDP

If the option "Phasor Measurement Unit" is selected, the devices determine current and voltage phasors, mark them with high-precision time stamps, and send them to a phasor data concentrator together with other measured values (frequency, rate of frequency change) via the communication protocol IEEE C37.118, see Fig. 14.

By means of the synchrophasors and a suitable analysis program (e.g., SIGUARD PDP) it is possible to determine power swings automatically and to trigger alarms, which are sent, for example, to the network control center.

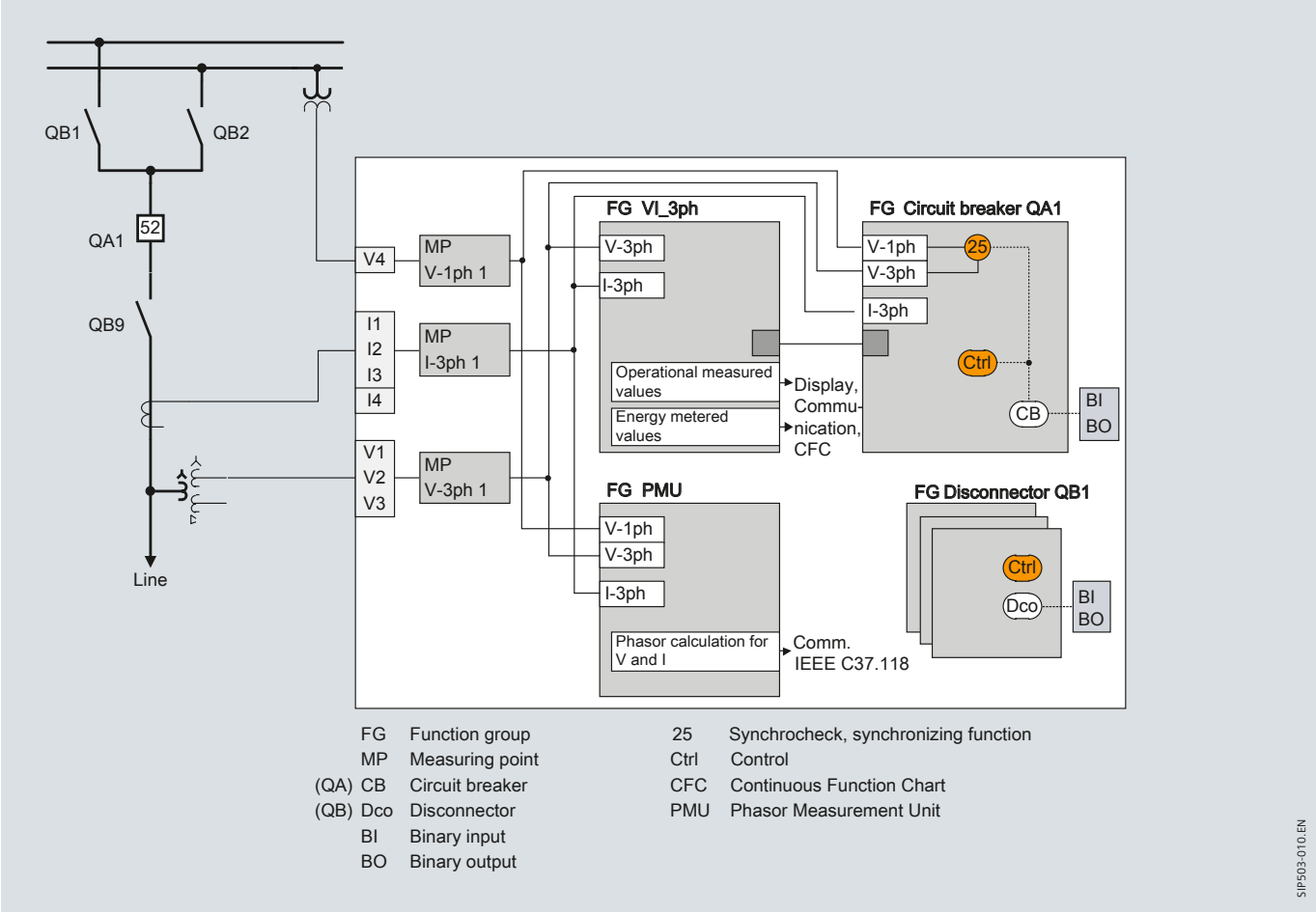


Fig. 15 Application example: Double busbar with 6MD86, used as bay controller and Phasor Measurement Unit (PMU)

When the PMU function is used, a “PMU” function is created in the device, see Fig. 15. This function group calculates the phasors and analog values, sets the time stamps and sends the data to the selected Ethernet interface with the protocol IEEE C37.118. There they can be received, stored and processed by one or more clients. Up to three client IP addresses can be allocated in the device.

Functional integration

Due to the modular design of its hardware and software and the powerful engineering tool DIGSI 5, SIPROTEC 5 is ideally suited for protection, automation, measurement and monitoring tasks in the electrical power systems.

The devices are not only pure protection and control equipment, their performance enables them to assure functional integration of desired depth and scope. For example, they can also serve to perform monitoring, phasor measurement, powerful fault recording, a wide range of measurement functions and much more, concurrently, and they have been designed to facilitate future functionality expansion. SIPROTEC 5 provides an extensive, precise data acquisition and bay level recording for these functions.

By combining device functionality with communication flexibility, SIPROTEC 5 has the ability to meet a wide range of today's applications as well as the functional expansion capability to adapt to changing needs in the future. With SIPROTEC 5 you can improve the safety and reliability of your application. Fig. 16 shows the possible functional expansion of a SIPROTEC 5 device.

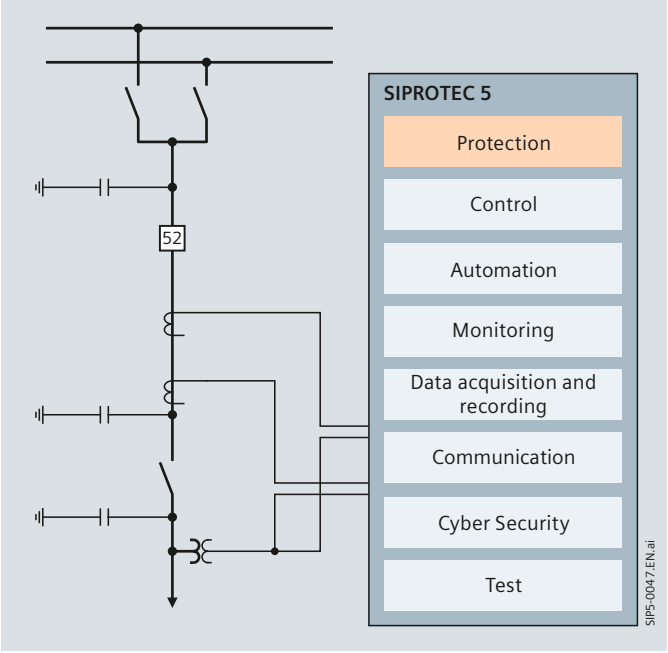


Fig. 16 SIPROTEC 5: Possible device construction

Protection

SIPROTEC 5 provides all the necessary protection functions to address reliability and security of power transmission systems. System configurations with multiple busbars and breaker-and-a-half schemes are both supported.

The functions are based on decades of experience in putting systems into operation, including feedback and suggestions from our customers.

The modular, functional structure of SIPROTEC 5 allows exceptional flexibility and enables the creation of a protection functionality that is specific to the conditions of the system while also being capable of further changes in the future. Table 1 on page 6 gives an overview of the protection functions available in the respective devices.

Hereby, the bay controller accesses the function library of the SIPROTEC 5 family, so that the individual functions have perfectly identical properties and parameters. Thus, you will orient yourself easily and fast in the SIPROTEC 5 family. In the bay controller, a range of selected functions is available for application.

Faster results with application templates:

Application templates allow you to fast track your solution. A suitable template can be selected from a library of predefined application templates containing the specific functional scope for typical applications and the necessary logical operations. For each device a table gives an overview of the respective protection functions and pre-configured application templates.

Adapting the application template to your specific application

You can adapt the application templates to your applications and create your own in-house standards. Additional functions can be loaded into the device directly from a comprehensive function library. Since the functions conform to a common design structure throughout the SIPROTEC 5 system, protection functions and even entire function groups including parameterization can be copied from one device to another.

The short descriptions of the available functions are provided hereafter.

Synchrocheck, synchronizing function (ANSI 25)

When two partial networks are closed with a control command or 3-pole auto-reclosure of the circuit-breaker, it must be ensured that the networks are synchronous with each other. For this purpose, synchronization functionalities are provided.

For synchronous networks a synchrocheck is available. Asynchronous networks can be switched with a synchronization function. In synchronous networks there are minor differences with regard to phase angle and voltage modulus and so the circuit-breaker response time does not need to be taken into account. In asynchronous networks, however, the differences are larger and the range of the connection window is traversed at a faster rate. Therefore it is wise here to take the circuit-breaker response time into consideration.

The relevant values for synchronization are the voltage magnitude difference, phase angle difference and frequency difference. Depending on the available number of voltage transformer inputs, one or two synchronizing locations (circuit-breakers) can be applied in one device.

Each function provides the option to use up to two parameter sets (stages) for synchrocheck applications and up to six parameter sets (stages) for the synchronization function per device. Thus, the device is able to react to different environmental conditions of the network always with the right synchronization parameters.

Phasor Measurement Unit (PMU)

Phasor Measurement Units make a valuable contribution to dynamic monitoring of transient processes in energy supply systems. Contrary to the RMS values, phasor measurements are transmitted as continuous data stream with adjustable reporting rate. Additionally, current and voltage are measured and transmitted with their phase angles.

Phasor Measurement Unit (PMU) (contin.)

Due to the high-precision time synchronization (via GPS), the measured values of different, widely separated substations can be compared, and it is possible to draw conclusions about the system condition and dynamic events such as power swings from the phase angles and dynamic curves.

Via an own Ethernet module, the PMU function transmits its data by means of the standardized protocol IEEE C37.118. The analysis can be carried out with a Wide Area Monitoring System, for example SIGUARD PDP, see Fig. 14.

Function groups current/voltage

The function groups current/voltage are used for the connection and use of measured current and voltage values. These function groups can contain several protection functions as function block. The required functions can be configured flexibly with DIGSI.

Directional negative-sequence protection with definite-time delay (ANSI 46, 67 *)

This function serves as the reserve short-circuit protection for asymmetrical faults. With the negative-sequence system, various monitoring and protection tasks can be realized:

- Detection of 1 or 2-phase short circuits in the network with a higher sensitivity than in classic overcurrent protection.
- Detection of phase conductor interruptions in the primary system and in the current transformer secondary circuits
- Location of short circuits or reversals in the connections to the current transformers
- Indication of asymmetrical states in the energy system
- Protection of electrical machines following asymmetrical loads that are caused by asymmetrical voltages or conductor interruptions (for example through a defective fuse).

The function comes factory-set with 1 stage. A maximum of 6 stages can be operated simultaneously. If the device is equipped with the inrush-current detection function, the tripping stages can be stabilized against tripping due to transformer inrush currents.

Circuit-breaker failure protection (ANSI 50BF)

The circuit-breaker failure protection incorporates a two-stage design and provides phase and ground backup protection if the main circuit-breaker fails to clear a power-system incident. If the fault current is not interrupted after a time delay has expired, a retrip command or the busbar trip command will be generated. The correct circuit-breaker operation is monitored via current measurement and via auxiliary circuit-breaker contacts. The current detection logic is phase-segregated and can therefore also be used in 1-pole tripping schemes.

The circuit-breaker failure protection can be initiated by all integrated protection functions as well as by external devices via binary input signals or by serial communication with GOOSE indication in IEC 61850 systems. To increase operational reliability, an external start can be applied with two binary inputs in parallel. For 1-pole and 3-pole starting separate delay times are available.

For applications with two current transformers per feeder, e.g. breaker-and-a-half, ring bus or double circuit-breaker applications, the SIPROTEC 5 device can be configured with two independent circuit-breaker failure protection functions.

* in preparation

Automatic reclosing (ANSI 79)

About 85% of the arc faults on overhead lines are extinguished automatically after being tripped by the protection. Then, the overhead line can be re-energized. Reclosure is performed by an automatic reclosing function (AR). Each protection function can be configured to start or block the AR function.

Basic features and operating modes

- Tripping controlled start with action time or without action time
- Pickup controlled start with action time or without action time
- 3-pole AR for all types of faults; different dead times are available depending on the type of fault
- Multiple-shot AR
- Cooperation with external devices via binary inputs and outputs or via serial communication with GOOSE indication in IEC 61850 systems
- Control of the integrated AR function by an external protection
- Cooperation with the internal or an external synchrocheck
- Monitoring of the circuit-breaker auxiliary contacts
- Dynamic setting change of overcurrent protection elements, depending on the AR status.

Two auto-reclosure functions

- For applications with two circuit breakers per feeder, e.g. breaker- and-a-half, ring bus or double circuit-breaker applications the devices can be configured to operate with two independent auto-reclosure functions.

Overcurrent protection, ground (ANSI 50N, 51N)

The overcurrent protection ground function captures short-circuits at electrical equipment and can be used as a reserve or as an emergency overcurrent protection in addition to the main protection. The tripping is 3-pole. Two inverse time-overcurrent protection stages and a inverse time-overcurrent protection stage are preconfigured. A maximum of three definite time-overcurrent protection stages, as well as one inverse time-overcurrent protection stage and one stage with a user-defined characteristic curve can be operated simultaneously within this function.

For the inverse time-overcurrent protection stages all usual characteristic curves according to IEC and ANSI/IEEE are available.

The protection function is structured such that the overcurrent protection stages can be activated selectively in emergency mode. This is the case, for example, when a distance protection in blocked by a measured voltage failure or a differential protection is blocked due to communication disturbance. Emergency mode can also be activated externally via binary input.

The stages of the overcurrent protection ground are, apart from the characteristic, structured identically:

- They can be blocked individually via binary input or by other functions (e.g. inrush current detection, automatic reclosing, cold-load pickup detection).
- Each stage can also be blocked only by trip command, so that there can still be pickup and recording (logs and fault records).
- Parameters can determine whether the stage works with the measured value I_E or with the calculated value 3 I_0 from the 3-phase currents.
- For each stage the method of measurement can be chosen between measurement of the fundamental component and the RMS value.
- Dropout delays can be set individually.

Overcurrent protection, phases (ANSI 50, 51)

The overcurrent protection phases function captures short-circuits at electric equipment and can be used as a reserve or as an emergency overcurrent protection in addition to the main protection. Depending on the device version, 1-/3-pole (7SA87/7SD87/7SL87) or only 3-pole tripping (7SA84/7SA86/7SD84/7SD86/7SL86) is possible.

Two definite time-overcurrent protection stages and one inverse time-overcurrent protection stage are preconfigured. A maximum of 4 definite time-overcurrent protection stages, as well as one inverse time-overcurrent protection stage and one stage with a user-defined characteristic curve can be operated simultaneously within this function.

For the inverse time-overcurrent protection stages all usual characteristic curves (see Fig. 17) according to IEC and ANSI/IEEE are available (see Technical Data).

The protection function is structured such that the overcurrent protection stages can be activated selectively in emergency mode. This is the case, for example, when a distance protection in blocked by a measuring-voltage failure or a differential protection is blocked due to communication disturbance. Emergency mode can also be activated externally via binary input.

The stages of the overcurrent protection phases are, apart from the characteristic, structured identically:

- They can be blocked individually via binary input or by other functions (e.g. inrush current detection, automatic reclosing, cold-load pickup detection).
- Every stage can also be blocked only by trip command, so that there can still be pickup and recording (logs and fault records).
- For each stage the method of measurement can be chosen between measurement of the fundamental component and the RMS value.
- Dropout delays can be set individually.

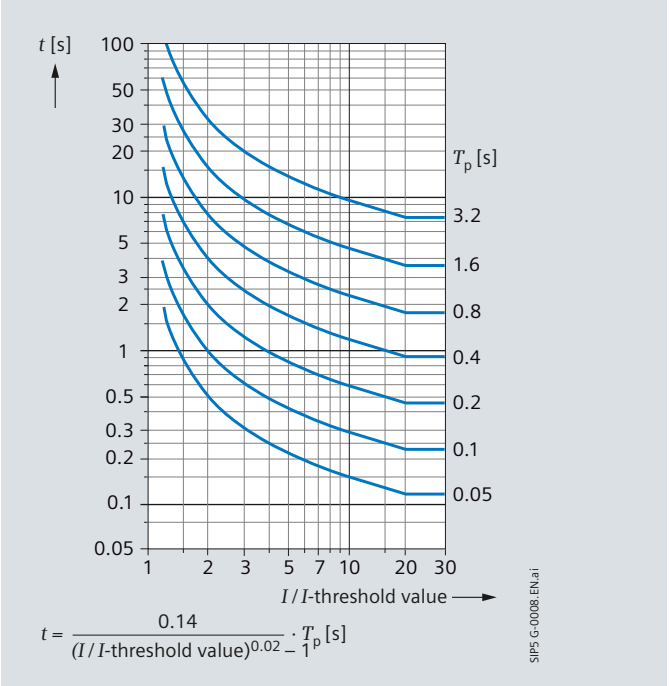


Fig. 17 xy-characteristic curves

High speed instantaneous overcurrent protection (ANSI 50HS)

When switching on a faulty line, immediate tripping is possible. In the case of high fault currents, this overcurrent protection with instantaneous tripping effects a very rapid 3-pole tripping when switching on to faults.

The function is factory-set with one stage. Within the function, a maximum of two stages can be operated at the same time. All stages are of identical design.

The actual switch-on detection takes place in the switching state detection. This is either directly activated when switching on manually, or automatically determined from the measured values (current, voltage) or by means of the circuit-breaker auxiliary contacts.

Instantaneous tripping at switch-on to fault (SOTF)

This function is available for applications in which overcurrent protection with instantaneous tripping (50HS) is not sufficient or not used.

It enables instantaneous tripping even with low fault currents. The function has no measuring function of its own. It is linked on the input side with the pickup (measurement) of another protection function, e.g., the distance protection overreach zone Z1B, or the stage of an overcurrent protection, and then trips even while switching onto a short-circuit. Typically, such protection stages are configured that themselves trip with a delay. The actual switch-on detection takes place in the detection of the switching state.

Overvoltage protection functions (ANSI 59, 47, 59N)

Overvoltages occur in long lines with little or no load. The overvoltage protection monitors the permissible voltage range, protects equipment from subsequent damage through overvoltages and serves to decouple switchgear systems (e.g., wind energy infeeds).

Various overvoltage measuring elements are available. By default, two stages are preconfigured. Up to three identical stages are possible. Tripping by overvoltage measuring elements can be effected either at the local circuit-breaker or at the opposite end via transfer-trip signals. The following measuring elements are available:

Overvoltage protection with 3-phase voltage (ANSI 59)

- Optionally, measurement of phase-to-phase voltages or phase-to-ground voltages
- *Measuring methods: Optionally, measurement of the fundamental component or of the effective value (True RMS).*

Overvoltage protection with positive-sequence voltage (ANSI 59)

- Capturing symmetrical, stationary overvoltages with positive-sequence voltage
- *Method of measurement: Calculation of positive*-sequence voltage from the measured phase-to-ground voltages.

Overvoltage protection functions (ANSI 59, 47, 59N) (contin.)

Overvoltage protection with positive-sequence voltage and compounding (ANSI 59)

- By means of capacitive line impedances, stationary overvoltages at the opposite end of the line can arise (Ferranti effect).
- *Method of measurement:* The positive-sequence system of the voltage is calculated at the other end of the line by means of the local, measured voltages and current using the equivalent circuit of the line.

*Overvoltage protection with negative-sequence voltage (ANSI 47) **

- Monitoring the power system and electric machines for voltage unbalance.
- *Method of measurement:* Calculation of negative-sequence voltage from the measured phase-to-ground voltages.

Overvoltage protection with zero-sequence voltage/residual voltage function (ANSI 59N):

- Detection of ground fault-affected phases in case of missing neutral-point grounding
- *Method of measurement:* Measurement of the residual voltage directly at the broken-delta winding or calculation from the measured phase-to-ground voltages.
- *Measuring methods:* Optionally, measurement of the fundamental component (standard or with especially strong attenuation of harmonics and transients) or of the effective value (True RMS).

Overvoltage protection with any voltage (ANSI 59)

- Capture of any 1-phase overvoltage for special applications
- *Measuring methods:* Optionally, measurement of the fundamental component or of the effective value (True RMS).

Undervoltage protection functions (ANSI 27) *

The undervoltage protection monitors the permissible voltage range or protects equipment from subsequent damage due to undervoltage. It can be used in the network for decoupling or load shedding tasks and can protect motors and generators from possible loss of stability.

Various undervoltage measuring elements are available. By default, two stages are preconfigured. Up to three or four identical stages are possible. Tripping by undervoltage measuring elements can be effected either at the local circuit-breaker or at the opposite end via transfer-trip signal. All undervoltage measuring elements and their stages can be blocked by means of a current criterion. The following measuring elements are available:

Undervoltage protection with 3-phase voltage

- Optionally, measurement of phase-to-phase voltages or phase-to-ground voltages
- *Measuring methods:* Optionally, measurement of the fundamental component or of the effective value (True RMS).
- A maximum of four stages possible.

Undervoltage protection with positive-sequence voltage

- 2-pole short circuits or ground faults lead to an unbalanced voltage collapse. This makes this function particularly suitable for the assessment of stability problems.
- *Method of measurement:* Calculation of positive-sequence voltage from the measured phase-to-ground voltages.

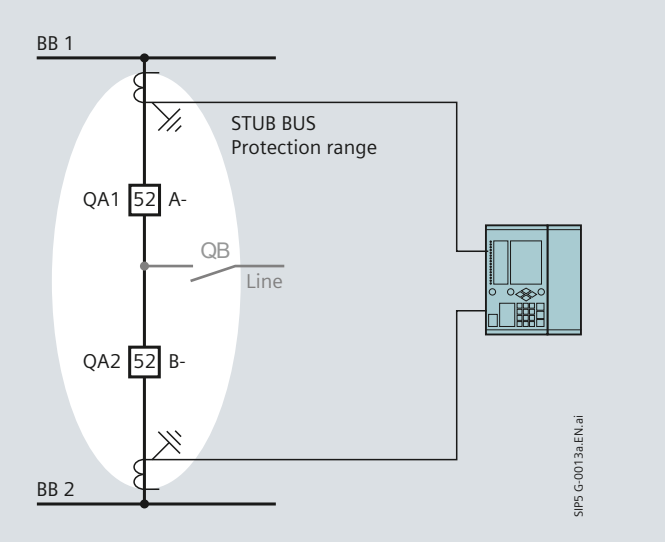


Fig. 18 Breaker-and-a-half scheme topology

Undervoltage protection with any voltage

- Capture of any 1-phase undervoltage for special applications
- *Measuring methods:* Optionally, measurement of the fundamental component or of the effective value (True RMS).

Frequency protection (ANSI 81O, 81U)

Frequency deviations are caused by an unbalance between the active power generated and consumed. Causes are, for example, load shedding, network disconnections, increased need for active power, generator failures or faulty functioning of the power and frequency regulation.

The frequency protection detects frequency deviations in the network or in electric machines.

It monitors the frequency band and outputs failure indications In case of critical power frequency entire generation blocks can be isolated or networks can be decoupled. To ensure network stability, load shedding can be initiated.

Different frequency measuring elements with high accuracy and short pickup times are available.

Tripping by frequency measuring elements can be effected either at the local circuit breaker or at the opposite end by remote tripping. The following measuring elements are available:

Overfrequency protection (ANSI 81O)

Two preconfigured stages, can be increased up to three stages. All stages are of identical design.

* in preparation

Frequency protection (ANSI 81O, 81U) (contin.)

Underfrequency protection (ANSI 81U)

Three preconfigured stages (standard), can be increased up to five stages. All stages are of identical design.

Each frequency measuring element provides two different methods of measurement:

- *Angle difference method:* Angle change of the voltage phasor over a time interval
- *Filter method of measurement:* Evaluation of immediate voltage values with special filters.

Power protection, active/reactive power (ANSI 32, 37) *

The power protection works in 3-phase operation and detects exceedance or underrunning of the set effective power or reactive power thresholds (see Fig. 19). Pre-defined power limits are monitored and corresponding warning alerts are issued. The power direction can be determined via angle measurement of the active power. Thus, for example, feeding back in the network or at electric machines can be detected. Idling machines (motors, generators) are detected and can be shut down via an indication.

The power protection can be integrated into any automation solution, for example, to monitor very specific power limits (further logical processing in CFC)

The power protection function comes with one factory-set stage each for the active and the reactive power. A maximum of four active power stages and four reactive power stages can be operated simultaneously in the function. The tripping stages are structured identically.

Thresholds for exceedance or underrunning of the power lines can be defined. The combination of the different stages via CFC results in various applications.

Application examples:

- Detection of negative active power. In this case reverse-power protection can be used in the CFC to link the power protection outputs to the "Direct trip" function.
- Detection of capacitive reactive power. In the case of overvoltage being detected due to long lines under no-load conditions it is possible to select the lines where capacitive reactive power is measured.

Thermal overload protection (ANSI 49)

The thermal overload protection function protects equipment (overhead lines, cables, motors, generators and transformers) from thermal overstraining by monitoring the thermal conditions.

The thermal overload protection calculates the overtemperature from the measured phase currents according to a thermal single body model.

Stages

A current and thermal alarm stage is provided for the thermal overload protection to initiate an alarm before tripping. The tripping time characteristics are exponential functions according to IEC 60255-8. The preload is considered in the tripping times for overloads.

*Consideration of the ambient temperature **

The currently measured ambient temperature can be taken into account in the calculation of the overtemperature. This results in a more accurate determination of this overtemperature.

If the ambient temperature is lower than the stipulated reference temperature, a larger thermal reserve results and the equipment can be put under greater strain. As the ambient temperature increases, the thermal reserve of the equipment is reduced.

Trip circuit supervision (ANSI 74TC)

The circuit-breaker coil including its supply leads is monitored by two binary inputs. If the tripping circuit is interrupted, a failure indication is generated.

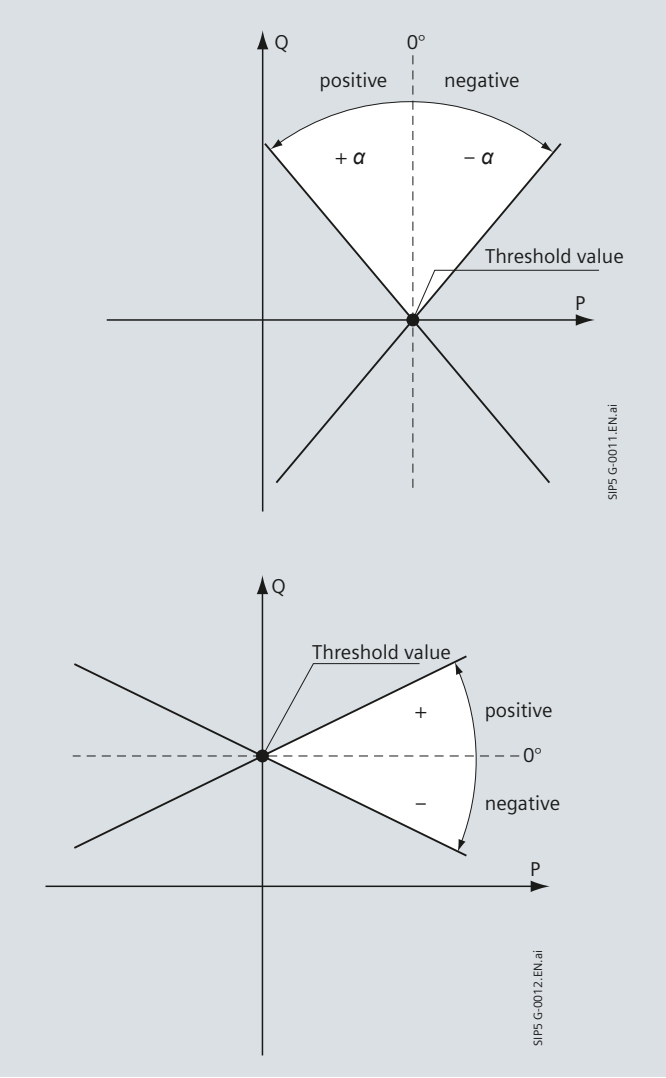


Fig. 19 Active power characteristic curve and reactive power characteristic curve

* in preparation

Control

SIPROTEC 5 includes all bay level control and monitoring functions that are required for efficient operation of the substation.

The large, freely configurable control diagram is available for comfortable local control. Frequent switching actions such as starting of switching sequences or display of the indication list can be selected via one of the 9 function keys. The key switches for local/remote and interlocked/non-interlocked operation guarantee the required safety.

The application templates supplied provide the full functionality required for your application. Protection and control functions operate with the same logical elements. In the application template for breaker-and-a-half for the individual devices, this is illustrated, for example, by the circuit-breaker function group. From the point of view of the switching device, protection and control are treated with equal priority.

The modular, scalable hardware can be optimized for the system conditions. You can simply put together the desired hardware quantity structure. For example, a single SIPROTEC 5 can be used to control and monitor an entire breaker-and-a-half diameter.

A new level of quality in control is achieved with the application of communication standard IEC 61850. For example, binary information from the field can be processed smoothly, and data (e.g., for interbay interlocking) can be exchanged between the devices. Cross communications via GOOSE enable efficient solutions, since here the hardwired circuits are replaced by data telegrams.

All devices have up to 4 switching objects (circuit-breakers, disconnectors or grounding switches) via the base control package. Optionally, additional switching objects and switching sequence blocks can be activated (CFC switching sequences).

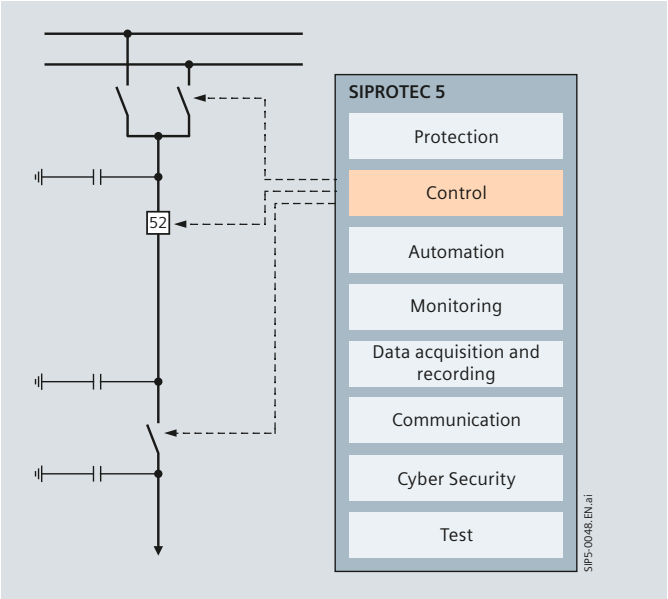


Fig. 20 Functional extension of SIPROTEC 5 devices

Automation

The integrated graphical automation editor CFC (Continuous Function Chart) enables you to create logic diagrams clearly and simply.

DIGSI 5 supports this with powerful logic modules based on the standard IEC 61131-3. All devices have a powerful base automation package. Thus, specific functions for automating a switchgear bay or a switchgear assembly can be realized easily and efficiently.

For the realization of your solutions, the following different configurations of CFCs are available:

- Basic function chart (CFC)
- Arithmetic function chart (CFC)
- Switching sequence function chart (CFC).

With the basic function chart (CFC) package you can graphically link all internal digital information, such as internal protection signals or operating states directly to the logic modules and process them in real time. The arithmetic function chart (CFC) package enables you additionally to link measured values or to monitor thresholds. The switching sequence function chart (CFC) package is used for the realization of derived switching sequences, e.g., changeovers due to a change in the network status.

Example automation applications are:

- Interlocking checks
- Switching sequences
- Indication derivations or tripping of switching actions
- Indications or alarms by processing available information
- Load shedding in a feeder
- Management of decentralized energy feeds
- System transfer depending on the grid status
- Automatic grid separations in the event of grid stability problems.

Of course, SIPROTEC 5 provides a substation automation system such as SICAM PAS with all necessary information, thus ensuring consistent, integrated and efficient solutions for further automation.

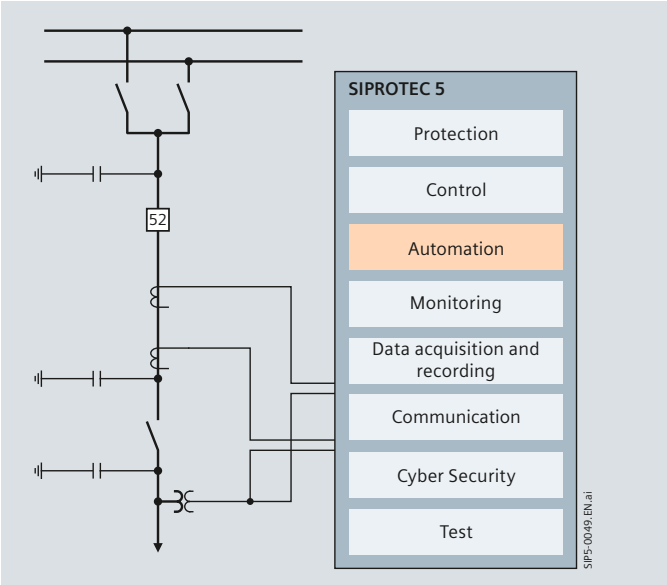


Fig. 21 Functional extension of SIPROTEC 5 devices

* in preparation

Monitoring

SIPROTEC 5 devices can take on a wide variety of monitoring tasks. These are divided into 4 groups

- Self-monitoring
- Grid stability monitoring
- Power quality monitoring
- Equipment monitoring (condition monitoring)

Self-monitoring

SIPROTEC 5 devices are equipped with many monitoring procedures. These procedures detect internal as well as external faults and store them in buffers for recording and reporting. This stored information can then be used to help determine the cause of the fault in order to take appropriate corrective actions.

Grid stability

Grid Monitoring combines all of the monitoring systems that are necessary to assure grid stability during normal grid operation. SIPROTEC 5 provides all necessary functionalities, e.g., fault recorders, continuous recorders, fault locators and Phasor Measurement Units (PMUs) for grid monitoring.

The grid monitoring functionality of SIPROTEC 5 devices allows them to be programmed to monitor grid limit violations (e.g., Dynamic Stability Assessment via load angle control) and actively trigger the appropriate responses. This data in the grid control systems can also be used as input variables for online load flow calculation and enable significantly faster response if statuses in the grid change.

Equipment

The monitoring of equipment (Condition Monitoring) is an important tool in asset management and operational support from which both the environment and the company can benefit. Equipment that typically requires monitoring includes for example: Circuit-breakers, transformers and gas compartments in gas-insulated switchgear (GIS).

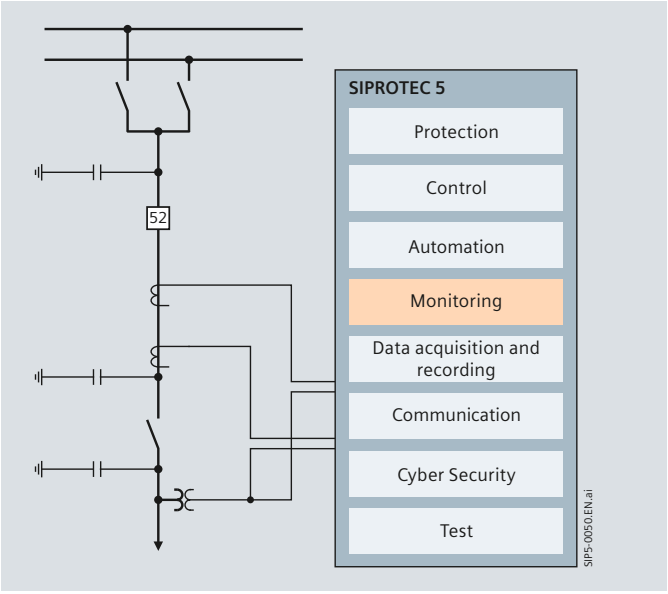


Fig. 22 Functional extension of SIPROTEC 5 devices

SIPROTEC 5 provides the process interfaces, buffers, recorders and automation functions necessary for monitoring the equipment:

- Process values are stored together with a time stamp in the operational log
- The switching statistic counters provide essential data for condition based maintenance
- Process variables (e.g., pressure, SF_6 loss, speed, temperature etc.) are monitored to ensure they remain within the limits via measurement transducers connected to the sensors.

Data acquisition and recording

The comprehensive acquired and recorded field data represents the image and history of the bay. It is also used by the functions in the SIPROTEC 5 device for monitoring, substation and interbay automation tasks. It therefore provides the basis both for functions available today and for future applications.

Measurement

A large number of measured values are derived from the analog input variables and present a current image of the process.

Depending on the device design, the following base measured values are available:

- Operational measured values
- Fundamental phasor and symmetrical components
- Protection-specific measured values, e.g., differential and restraint current for differential protection
- Mean values
- Minimum values and maximum values
- Energy measured values
- Statistical values
- Limiting values.

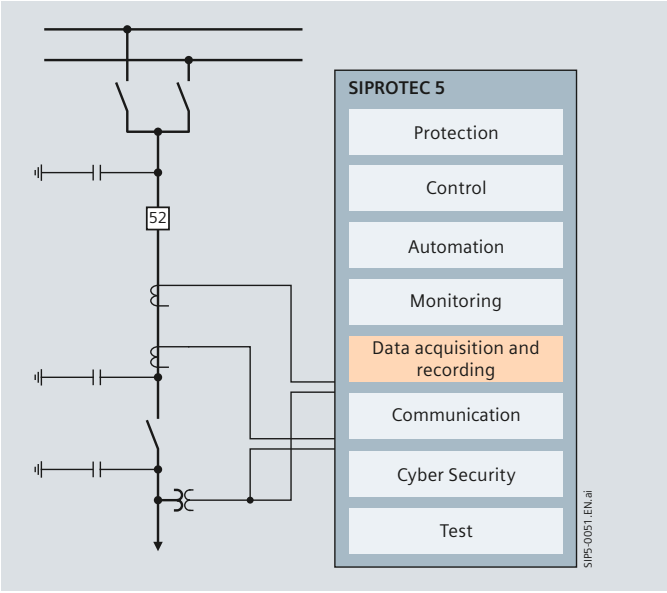


Fig. 23 Functional extension of SIPROTEC 5 devices

Data acquisition and recording (contin.)

Besides the base measured values, phasor measurement values can also be determined in the devices (application as PMU, Phasor Measurement Unit).

Phasor measurement values support a range of applications for monitoring grid stability. For this purpose, SIPROTEC 5 devices acquire the necessary PMU data. These are high-precision, time-stamped phasors, power frequency and the change in the power frequency. They can be transmitted to central analysis systems via the high-performance communication system.

Measured values are displayed both as primary and secondary values, and also as reference values. These values are also made available to other applications, e.g., transferred to a Wide Area Monitoring System according to standard IEEE C37.118. Such a system is shown in Fig. 14, with SIGUARD PDP (Phasor Data Processor) being used as Wide Area Monitoring System there.

Standard devices can be supplied with up to 24 analog inputs.

The current inputs of the SIPROTEC 5 devices can be selected with a corresponding accuracy class and dynamic range suitable for connection to both protection and measuring cores. The innovative current terminal technology enables the inputs to be easily readjusted on site. All analog inputs are set at the factory and therefore guarantee maximum precision. The following precisions are typical:

Processing via the protection-input transformer:

- V, I ≤ Cl. 0.5
- P, Q ≤ Cl. 1

Processing via the measuring-input transformer:

- V, I ≤ Cl. 0.2
- P, Q ≤ Cl. 0.5.

Separate measuring transducers (analog inputs) are therefore unnecessary. The highly precise measured data enables extended energy management and makes commissioning much easier. SIPROTEC 5 thus provides the following measured values for analysis and further processing:

- The base measured values with high dynamic range and high accuracy (protection transformer)
- The base measured values with very high accuracy (instrument transformer)
- Phasor measurement values with highly precise time stamping for subsequent task such as grid stability monitoring.

Recorder

In SIPROTEC 5, recorders can acquire comprehensive data. They feature a large number of analog and binary inputs, and a high sampling frequency. An extremely wide range of records can be implemented, either continuously or as determined by various trigger criteria.

Besides storing the data on internal bulk storage units, SIPROTEC 5 devices can also transfer the data to central analysis systems. Consequently, you are able to monitor networks with regard to typical characteristics.

Fig. 24 Devices for evaluation of fault records

Fault recorder

The fault recording traces analog and binary data during a fault event, e.g., in the event of short circuits or ground faults, and preserves the records, including high-precision time stamps, for subsequent analysis. Calculated measurement values, e. g., power or frequency can also be incorporated into the fault recording function. Analysis takes place after the data is read out from the device by DIGSI using SIGRA. Recorded is archived to prevent data loss in the event of supply voltage failure. Analog and binary tracks for recording are freely configurable, and pretrigger and seal-in times can be programmed within a very wide range. SIPROTEC 5 fault recording provides long recording times with outstanding accuracy.

- Recording of up to 24 analog channels
- Sampling frequencies programmable between 1 kHz and 8 kHz
- High recording capacity for individual records of 20 s for 24 channels with 8 kHz sampling frequency
- Storage capability for up to 128 fault records
- The recording duration for all records is limited by the available storage capacity of the device, and depends on the number of configured channels and sampling frequency.
  Example
  – Line protection with 8 analog channels (4 I, 4 V),
  – Sampling frequency 1 kHz, 6 measured value channels and 20 binary channels: Resulting recording capacity of the device about 890 ms!
- Up to 100 freely configurable binary and 50 additional measured-value tracks.
- The 7KE85 fault and power quality recorder has yet more features:
  – Extended trigger criteria: Gradient trigger (ΔM/Δt); binary trigger; network trigger
  – Higher-frequency sampling of 16 kHz for up to 40 analog channels
  – Longer recording duration due to internal mass storage media.

Event-log buffers, communication

Event-log buffer

Event-log buffers mark important events with a time stamp (accurate to 1 ms) for subsequent analysis.

The long recording length is achieved with large event-log buffers and separate buffers for different event categories. The events to be logged are freely configurable and for improved manageability. Configuration of user-specific event-log buffers for cyclical or event-driven recording is also supported.

Convenient and thorough analysis

Event-log buffers of different categories enable easier, targeted analysis. Changes to parameters and configuration data are recorded.

Ease of maintenance

Hardware and software are constantly monitored and irregularities are detected immediately. In this way, extremely high levels of security, reliability and availability are achieved at the same time. Important information about essential maintenance activities (e.g., battery supervision), hardware defects detected by internal monitoring or compatibility problems are recorded separately in the diagnostic buffer.

All entries include specific instructions for taking action. Table 4 provides an overview of typical operational logs.

Operational log	2000 indications	Cyclical recording of operational indications (e.g. control processes)
Fault log	1000 indications	Storage of data after a protection trigger or external triggering; no limit on the number of faults
User-specific log	200 indications	Option of cyclical or event-drive recording of user-defined signals
Ground-fault log	200 indications	Storage of indications in ground-fault situations
Logs of parameter setting history (cannot be erased)	200 indications	Recording of all parameter changes and configuration downloads
Communication buffer	500 indications	Recording of status of all configured communication connections, such as e.g. faults that arise, testing and diagnostic operation and communication loads
Security log (cannot be erased)	500 indications	Recording of successful and unsuccessful access attempts to areas of the device with restricted access rights
Diagnostic buffer	500 indications	Recording and display of concrete instructions for action in case of necessary maintenance (e.g. battery monitoring), detected hardware defects or compatibility problems.

Table 4 Overview of typical operational logs

Communication

SIPROTEC 5 devices are equipped with high-performance communication interfaces.

These are integrated interfaces or interfaces that are extendable with plug-in modules to provide a high level of security and flexibility. There are various communication modules available. At the same time, the module is independent of the protocol used. This can be loaded according to the application. Particular importance was given to the realization of full communication redundancy:

- Multiple redundant communication interfaces
- Redundant, independent protocols with control center possible (e.g., IEC 60870-5-103 and IEC 61850 or double IEC 60870-5-103)
- Full availability of the communication ring when the switchgear bay is enabled for servicing operations.
- Redundant time synchronization (e.g., IRIG-B and SNTP).

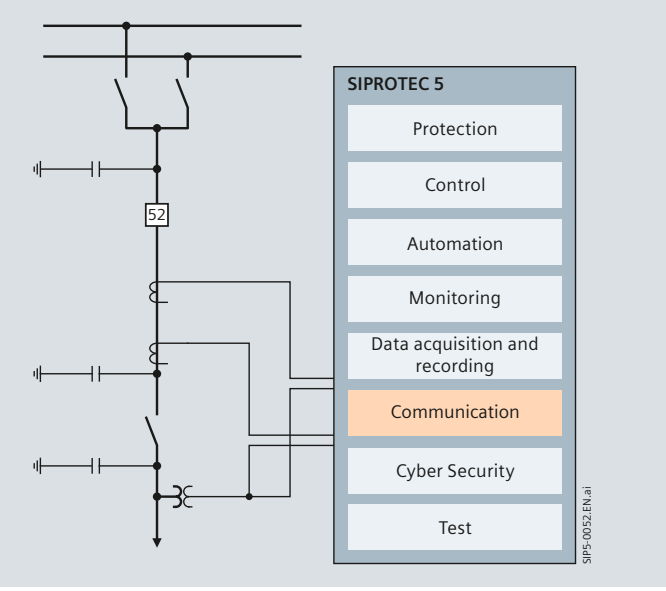


Fig. 25 Functional extension of SIPROTEC 5 devices

Cyber Security

A multilevel security concept for the device and DIGSI 5 provides the user with a high level of protection against IT attacks from the outside and conforms to the requirements of the BDEW Whitebook and NERC CIP.

Authentication

In general, secure authentication takes place between the device and DIGSI 5. This precludes another program from accessing the devices and reading or writing data there.

Establishment of connection after password checking

If the optional connection password has been activated for remote access, remote access via the Ethernet cannot take place until the password has been entered. Once the connection has been established, the user has only read access to the device.

Access control with confirmation code

Security prompts must be answered for security-critical actions, e.g., changing parameters, in order to obtain write access to the device. These prompts can be configured by the user, and may be different for different application areas.

Accesses to areas of the device with restricted access rights are logged. This makes it possible to track which groups had access to protected areas and when. Unsuccessful and unauthorized access attempts are also recorded and an alarm can be triggered by an independent telecontrol link.

In addition, security-critical operations are logged in the device and safeguarded against deletion. All files that can be loaded into the device via DIGSI 5 are signed. In this way, corruption from outside by viruses or trojans is reliably detected. Unused Ethernet services and the associated ports can be disabled in the device with DIGSI.

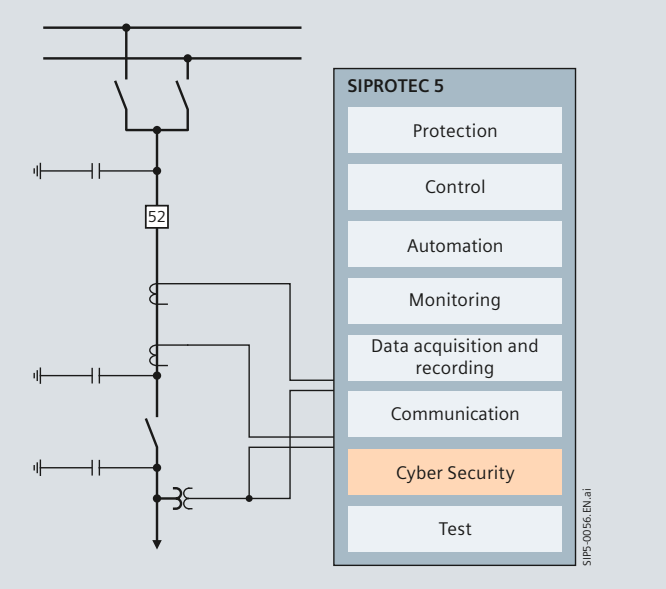


Fig. 26 Functional extension of SIPROTEC 5 devices

Test

To shorten testing and commissioning times, extensive test and diagnostic functions are available to the user in DIGSI 5. These are combined in the DIGSI 5 Test Suite.

The test spectrum includes, among other tests:

- Hardware and wiring test
- Protection function test
- Simulation of binary signals and analog sequences by integrated test equipment
- De-bugging of function charts
- Circuit-breaker test and AR (automatic reclosing) test function
- Communication testing
- Loop test for communication connections
- Protocol test.

The engineering, including the device test, can therefore be done with one tool.

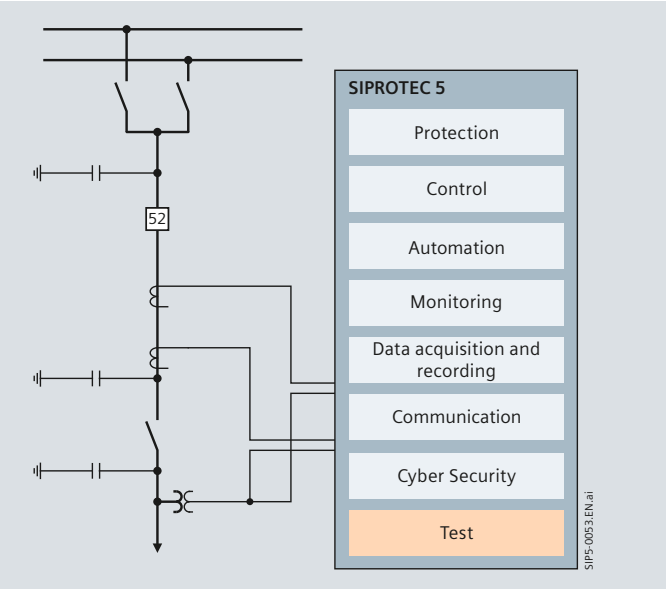


Fig. 27 Functional extension of SIPROTEC 5 devices

Overview of the Standard Variants

for 6MD85 and 6MD86

Standard variants for 6MD85 and 6MD86

Type 1	1/3, 11 BI, 9 BO, 4 I, 4 V	
	Housing width 1/3 x 19” 1 electrical Ethernet module ETH-L1-2EL 11 binary inputs, 9 binary outputs (1 lifecontact, 2 standard, 6 fast), 4 current transformer inputs, 4 voltage transformer inputs Contains the modules: Base module with PS201 and IO202.	
Type 2	1/2, 27 BI, 17 BO, 4 I, 4 V	
	Housing width 1/2 x 19", 1 electrical Ethernet module ETH-L1-2EL 27 binary inputs, 17 binary outputs (1 lifecontact, 10 standard, 6 fast), 4 current transformer inputs, 4 voltage transformer inputs Contains the modules: Base module with PS201 and IO202, expansion module IO207.	
Type 3	In preparation	
Type 4	2/3, 43 BI, 25 BO, 4 I, 4 V	
	Housing width 2/3 x 19", 1 electrical Ethernet module ETH-L1-2EL 43 binary inputs, 25 binary outputs (1 lifecontact, 18 standard, 6 fast), 4 current transformer inputs, 4 voltage transformer inputs Contains the modules: Base module with PS201 and IO202, expansion modules 2x IO207.	
Type 5	In preparation	
Type 6	5/6, 59 BI, 33 BO, 4 I, 4 V	
	Housing width 5/6 x 19", 1 electrical Ethernet module ETH-L1-2EL 59 binary inputs, 33 binary outputs (1 lifecontact, 26 standard, 6 fast), 4 current transformer inputs, 4 voltage transformer inputs Contains the modules: Base module with PS201 and IO202, expansion modules 3x IO207.	
Type 7	1/1, 75 BI, 41 BO, 4 I, 4 V	
	Housing width 1/1 x 19", 1 electrical Ethernet module ETH-L1-2EL 75 binary inputs, 41 binary outputs (1 lifecontact, 34 standard, 6 fast), 4 current transformer inputs, 4 voltage transformer inputs Contains the modules: Base module with PS201 and IO202, expansion modules 4x IO207.	

Standard variant additionally for 6MD86

Type 8	1/1, 75 BI, 39 BO, 8 I, 8 V	
	Housing width 1/1 x 19", 1 electrical Ethernet module ETH-L1-2EL 67 binary inputs, 39 binary outputs (1 lifecontact, 26 standard, 12 fast), 8 current transformer inputs, 8 voltage transformer inputs Contains the modules: Base module with PS201 and IO202, expansion modules IO202, 2x IO207.	

The technical data for the bay control devices can be found in the bay control device manuals.
www.siemens.com/siprotec

Legal Notice

Indication of conformity

CE This product complies with the directive of the Council of the European Communities on harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low Voltage Directive 2006/95/EC).

This conformity has been proved by tests performed according to the Council Directive in accordance with the generic standards EN 61000-6-2 and EN 61000-6-4 (for EMC directive) and with the standard EN 60255-27 (for Low Voltage Directive) by Siemens AG.

The device is designed and manufactured for application in an industrial environment. The product conforms with the international standards of IEC 60255 and the German standard VDE 0435.

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