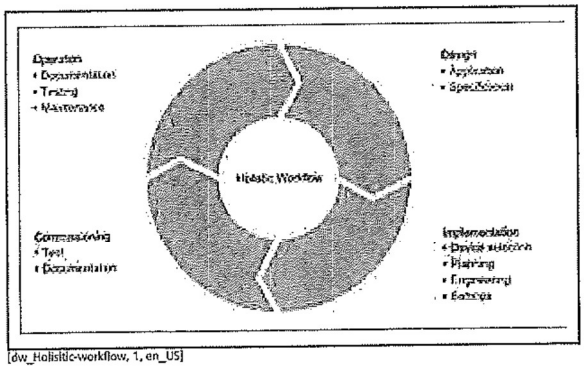
Holistic Workflow

End-to-end engineering from system design to operation makes your work easier throughout the entire process.

The highlight of SIPROTEC 5 is the improved emphasis on daily ease of operation. SIPROTEC 5 provides holistic support along all the work steps, allowing for system-view management and configuration down to the details of individual devices, saving time and improving cost-effectiveness without compromising quality (*Figure 1.2/1*).

Holistic workflow in SIPROTEC 5 means:

- Integrated, consistent system and device engineering – from the single-line diagram of the unit all the way to device parameterization
- Simple, intuitive graphical linkage of primary and secondary equipment
- Supplied and user-defined application templates for the most frequently used applications
- IEC 61850 System Configurator independent from manufacturers, for simple system engineering
- Open-circuited interfaces for seamless integration into your process environment
- Integrated tools for testing during engineering and commissioning and for simulating operational scenarios, such as system incidents or switching operations.
- SIPROTEC DigitalTwin for virtually testing SIPROTEC 5 devices in the cloud



[dw_Holistic-workflow, 1, en_US]

Figure 1.2/1 End-to-End Tools – from Design to Operation

Holistic workflow in SIPROTEC 5 means for you:

An end-to-end tool from system design to operation – even across department boundaries – saves time and ensures data security and transparency throughout the entire lifecycle of your plant.

Perfectly Tailored Fit

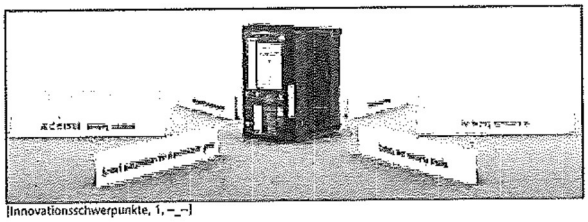
Individually configurable devices provide you with cost-effective solutions that match your needs precisely throughout the entire lifecycle. SIPROTEC 5 sets new standards in cost savings and availability with its innovative modular structure and flexible hardware, software, and communication. SIPROTEC 5 provides a perfectly tailored fit for your switchgear and applications that is unequaled by any other system.

Perfectly tailored fit in SIPROTEC 5 means:

- Modular system design in hardware, functionality, and communication ensures the perfect fit to your needs
- Functional integration of various applications, such as protection, control, measurement, power quality or fault recorder, voltage controller, ground-fault method
- Frequency-tracked protection functions over a wide frequency range (10 Hz to 80 Hz) and the option to assign the protection functions in a single device to different frequency tracking groups
- The same extension and communication modules for all devices in the family
- Innovative terminal technology ensures easy assembly and interchangeability at the highest possible degree of safety
- Identical functions throughout the entire system family mean fewer training requirements and increased safety. Example: Identical automatic reclosing (AREC) for line protection devices 7SD8, 7SA8, 7SL8.

Perfectly tailored fit in SIPROTEC 5 means:

Individually configurable devices that save money on initial investment, spare-parts storage, maintenance, extension, and adaptation of your system.



[Innovationsschwerpunkte, 1, –_–]

Figure 1.2/2 SIPROTEC 5 – Innovation Highlights

Designed to Communicate

The trendsetting system architecture places communication firmly under your control. Powerful, flexible, and above all, reliable communication is the prerequisite for distributed and decentralized system topologies such as Smart Grids. In the system architecture of SIPROTEC 5, we have attached immense importance to communication, and we have gone to exceptional lengths to ensure that you are ideally equipped for the communication demands of today and the future.

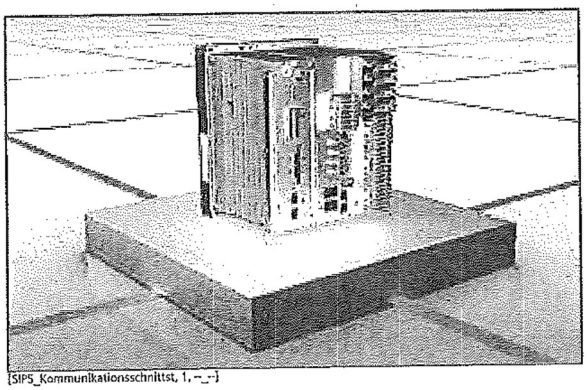
Designed to communicate in SIPROTEC 5 means:

- IoT interface to cloud applications such as MindSphere with the standard protocol OPC UA PubSub for easy use of data from the bay, for example SIPROTEC Dashboard
- Adaptation to the topology of your communication structure using parameters (ring, star, network, etc.)
- Scalable redundancy in hardware and software (protocols to match your requirements)
- Multiple communication channels to various higher-level systems at station and control-center level, as well as cloud applications
- Pluggable and upgradeable communication modules also for process-bus solutions according to IEC 61850-9-2

- Hardware modules decoupled from the currently used communication protocol
- 2 independent Ethernet protocols in one module
- Extensive routines for test connections, functions, and operating workflows

1.2

Designed to communicate in SIPROTEC 5 means for you: Communication as an integral component of the system architecture provides you with the flexibility and security you need in densely networked systems, today and in the future.



[SIPS_Kommunikationsschnittst, 1, --_--]

Figure 1.2/3 SIPROTEC 5 Device with Extensive Communication Interfaces

Safety Inside

Multilayer safety mechanisms in all links of the system safety chain provide you with the highest possible level of safety and availability. Human safety and plant safety, as well as maximum availability, are the top priorities. As the plant landscape becomes more and more open and complex, conventional security mechanisms are no longer adequate. For this reason, a safety concept has been integrated in the SIPROTEC 5 device architecture that is designed to address and implement these multilayer aspects in a holistic approach.

Safety Inside in SIPROTEC 5 means:

- Proven functions that protect plants and personnel, which have been continuously developed over 5 generations.
- Long-lasting, rugged hardware (housings, modules, plugs) and a sophisticated layout of the entire electronics for high resilience against voltage, EMC, climate, and mechanical stress
- Sophisticated self-monitoring routines identify and report device faults immediately and reliably

Comprehensive Cybersecurity

Cyberattacks on the energy infrastructure are real and are now regularly present in the media. Cybersecurity in the case of SIPROTEC 5 is therefore considered holistically in all cases. This includes the processes, personnel, and technologies.

The infrastructure used to develop the SIPROTEC 5 product family is protected in accordance with ISO/IEC 27001. Critical data, such as the software and firmware source files, are protected against unauthorized manipulation.

In addition, the following precautionary, continuous measures are in place:

- Secure development
- Security-patch management
- Antivirus and Windows patch compatibility checks
- Product hardening
- Independent security validation

The cybersecurity functions implemented in the components are state of the art and interoperable.

These include the following features:

- TLS-encrypted communication between DIGSI 5 and the SIPROTEC 5 device
- Support on the device side for role-based access control with central user management and emergency access
- Configurable read and write access restriction for DIGSI 5 and IEC 61850-MMS connections at device-port tier
- Logging of security-relevant events via syslog and in a non-erasable security buffer internal to the device
- Built-in crypto chip for secure information storage and transmission
- Device uses keys stored in the crypto chip to load only firmware signed by Siemens
- Separation of process and service communication
- Secure access with operation via the device display and Web browser

Smart Automation for Grids

Climate change and dwindling fossil fuels are forcing a total re-evaluation of the energy-supply industry, from generation to distribution and consumption. This is having fundamental effects on the structure and operation of the power systems.

Smart automation, the intelligent power automation system, is a major real-time component designed to preserve the stability of these power systems and at the same time conserve energy and reduce costs.

With SIPROTEC 5 and the unique spectrum of integrated functionality, you have the optimum smart automation platform for your smart power systems.

Smart Automation for Grids in SIPROTEC 5 means:

- Open-circuited, scalable architecture for IT integration and new functions
- Smart functions, for example for network operation, analysis of faults or power quality (power-system monitoring, power-control unit, fault location)
- Integrated automation with optimized logic blocks based on the IEC 61131-3 standard
- High-precision acquisition and processing of process values and power transmission to other components in Smart Grid
- Protection, automation, and monitoring in Smart Grid

SIPROTEC 5 devices have specifically been designed to meet the requirements of the modern grid, secure the future, and offer the necessary automation platform.

The elements that connect the 5 mentioned innovation highlights are IEC 61850 Edition 2 and its thoroughly designed, user-oriented implementation in SIPROTEC 5.

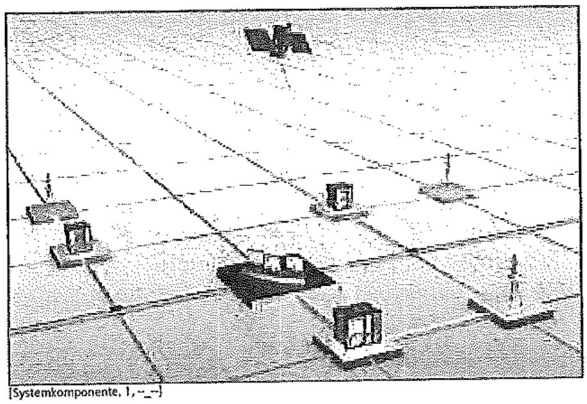

[Systemkomponente, 1, --_--]

Figure 1.2/4 SIPROTEC 5 as a System Component of the Smart Power System

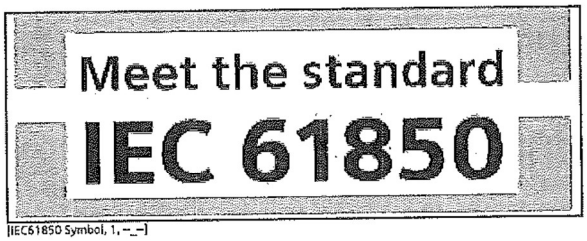
IEC 61850 – Simply Usable

Siemens, the pioneer of IEC 61850, makes the full potential of this global standard easily usable for you.

The IEC 61850 standard is more than just a substation automation protocol. It comprehensively defines data types, functions, and communication in station networks. In Edition 2, the influence of the standard is extended to more domains and applications of the energy-supply industry.

Siemens was actively involved in the process of standardization from Edition 1 to Edition 2, and with the largest number of completed installations in the world, our experience as a manufacturer in the field is unsurpassed. Jointly with key customers, we designed its implementation in SIPROTEC 5, paying close attention to interoperability, flexibility, and compatibility between Editions 1 and 2.

Besides the standard protocol IEC 61850-8-2 (station bus) and IEC 61850-9-2 (process bus), SIPROTEC 5 also supports other protocols, such as IEC 60870-5-103, IEC 60870-5-104, DNP3 (serial or TCP), or Modbus TCP.



[IEC61850 Symbol, 1, --_--]

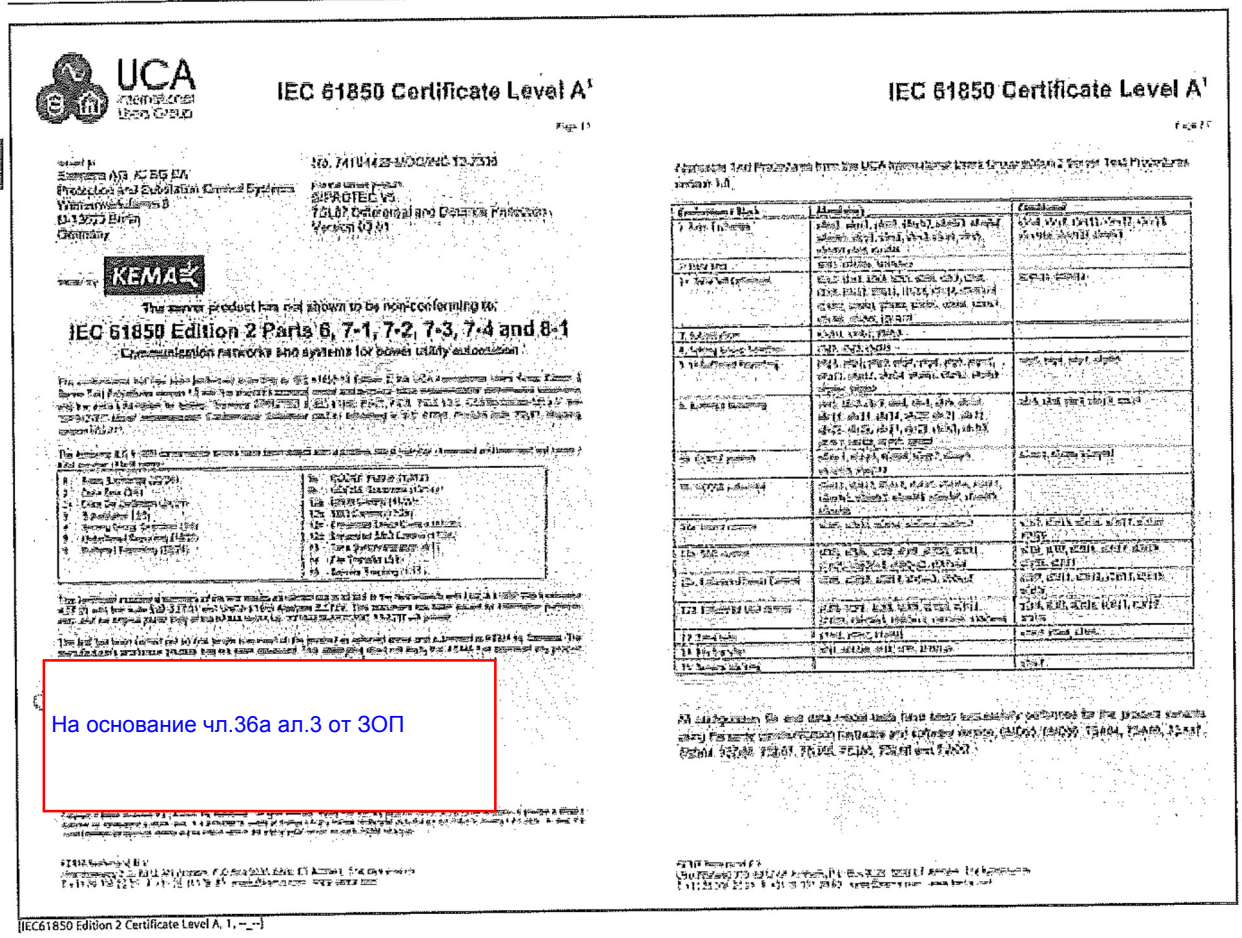
1.2

IEC 61850 – Simply usable means:

- A stand-alone IEC 61850 System Configurator that allows IEC 61850 configuration of SIPROTEC 5, SIPROTEC 4, SIPROTEC Compact, and third-party device
- Full compatibility with Editions 1 and 2
- Open-circuited interfaces to IEC 61850 ensure system configurations and interoperability that is independent from manufacturers
- Conversion of the complexity of the IEC 61850 data model into your familiar user language
- Flexible object modeling, degrees of freedom in object addressing, and flexible communication services warrant the highest possible degree of interoperability and effective exchange and extension concepts.
- Handling optimization based on many projects and close cooperation with customers from all fields of application
- Protection settings via IEC 61850
- Using several communication modules in Edition 2

The implementation of IEC 61850 Edition 2 unleashes the full potential of this standard by optimally supporting your operational needs and simplifying handling.

1.2



IEC61850 Edition 2 Certificate Level A, 1, –_–]

Figure 1.2/5 First IEC 61850 Certificate Edition 2 Worldwide

ВЯРНО С ОРИГИНАЛА

SIPROTEC 5 Devices and Fields of Application

Description

The SIPROTEC 7UT86 transformer differential protection has been designed specifically for the protection of three-winding transformers (3 sides). It is the main protection for the transformer and contains many other protection and monitoring functions. The additional protection functions can also be used as backup protection for subsequent protected objects (such as cables or lines). The modular expandability of the hardware also supports you in this process. The device supports all SIPROTEC 5 system characteristics. It enables upgradeable system solutions with high investment security and low operating costs. With its modular structure, flexibility, and the high-performance DIGSI 5 engineering tool, SIPROTEC 7UT86 offers future-oriented system solutions with high investment security and low operating costs.

Main function	1 differential protection function (standard) with additional stabilization; up to 3 restricted ground-fault protection functions For auto transformer applications, 2 differential protection functions can be processed in an auto transformer function group.
Usable measuring points	6 x 3-phase current measuring points, 4 x 1-phase current measuring points, 4 x 3-phase voltage measuring points; expandable to 4 sides
Inputs and outputs	2 predefined standard variants with 12 current transformers, 4 voltage transformers, 11 to 23 binary inputs, 18 to 34 binary outputs
Hardware flexibility	Flexibly adjustable and expandable I/O quantity structure within the scope of the SIPROTEC 5 modular system.
Housing width	1/2 x 19 inches to 2/1 x 19 inches

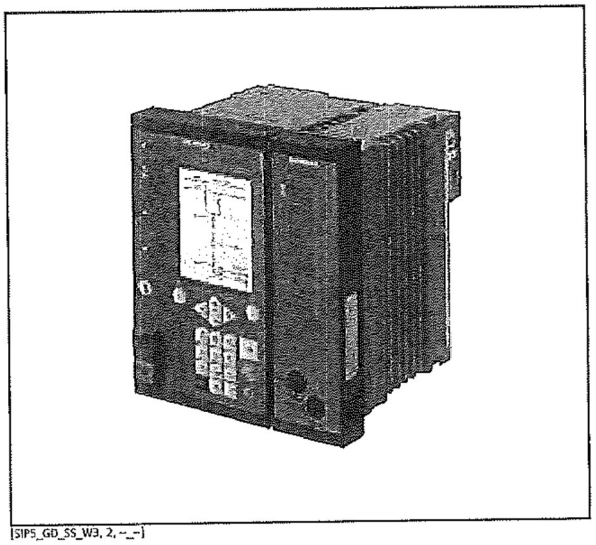
Benefits

- Safety due to high-performance protection functions
- Data security and transparency over the entire lifecycle of the plant, saving time and money
- Purposeful and easy handling of devices and software thanks to a user-friendly design
- Increased reliability and quality of the engineering process
- Highest availability even under extreme environmental conditions by standard coating of the modules
- Cybersecurity in accordance with NERC CIP and BDEW White-paper requirements
- High-performance communication components warrant safe and effective solutions
- Full compatibility between IEC 61850 Editions 1 and 2

Functions

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

- Transformer differential protection for three-winding transformers with versatile, additional protection functions; expandable to four-winding transformers
- Transformer differential protection for phase-angle regulating transformers of the single-core type and special transformers



SIPS_GD_SS_W3, 2, --_--]

Figure 2.11/9 SIPROTEC 7UT86 Transformer Differential Protection (1/2 Device = Standard Variant P1)

- Universal usability of the permissible measuring points
- Applicable from average up to extra-high voltage
- Protection of standard power transformers, auto transformers, and motors
- Typical properties of a transformer differential protection such as flexible adaptation to the transformer vector group, control of inrush, and overexcitation processes, safe behavior in case of current-transformer saturation with different degrees of saturation
- Adaptive adaptation of the operate curve to the transformer tap position
- Increased sensitivity with ground faults near the neutral point through a separate restricted ground-fault protection
- Point-on-wave switching
- Additional current and voltage inputs can be added for standard protection functions, such as overcurrent, voltage, frequency, protection etc.
- Graphical logic editor to create high-performance automation functions in the device
- Fault locator plus for accurate fault location with inhomogenous line sections and targeted automatic overhead-line section reclosing (AREC)
- Arc protection
- Voltage-controller function ANSI 90V for two-winding transformers, three-winding transformers, and grid coupling transformers with parallel control (master/follower, circulating reactive current minimization)
- Up to 4 pluggable communication modules, usable for different and redundant protocols (IEC 61850-8-1, IEC 61850-9-2 Client, IEC 61850-9-2 Merging Unit, IEC 60870-5-103, IEC 60870-5-104, Modbus TCP, DNP3 serial and TCP, PROFINET IO)

- Reliable data transmission via PRP and HSR redundancy protocols
- Extensive cybersecurity functionality, such as role-based access control (RBAC), logging of security-related events or signed firmware
- Simple, quick, and secure access to device data via a standard Web browser – without additional software
- Secure serial protection communication, also over great distances and all available physical media (optical fiber, two-wire connections, and communication networks)
- Detection operational measured variables and protection-function measured values for the evaluation of the systems, to support commissioning, and to analyze faults
- Frequency tracked protection functions over a wide frequency range (10 Hz to 80 Hz) and the option to assign the protection functions in a single device to different **frequency tracking groups.**
- Phasor Measurement Unit (PMU) for synchrophasor measured values and IEEE C37.118 protocol
- 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
- Flexibly adjustable I/O quantity structure within the scope of the SIPROTEC 5 modular system

Fields of Application

Application templates are available in DIGSI 5 for standard applications. These include basic configurations and default settings that you can use straight away, or as a template for adjustments depending on the application. The available measuring points make varied applications possible. Before ordering a device, please configure the application with DIGSI 5. The table **Function overview** shows the functional scope of the device. Use the *configurator* to determine the necessary function points.

Application Examples

The following examples show the typical structure of an application template, the measuring points used, the function groups used, their internal circuiting, and the predefined functions.

Application Templates

Besides the application templates for SIPROTEC 7UT85, the following application templates are also available:

- Three-winding transformer base (DIFF protection)
- Three-winding transformer 1.5 CB (DIFF. protection, CBFP, REF)
- Three-winding transformer (DIFF. protection, CBFP, REF, DIS)
- Auto transformer (DIFF. protection, CBFP, REF)
- Auto transformer 1.5 CB (2 DIFF. protection, CBFP, voltage protection, frequency protection)

Application Examples

Three-winding transformer basis

- Differential protection

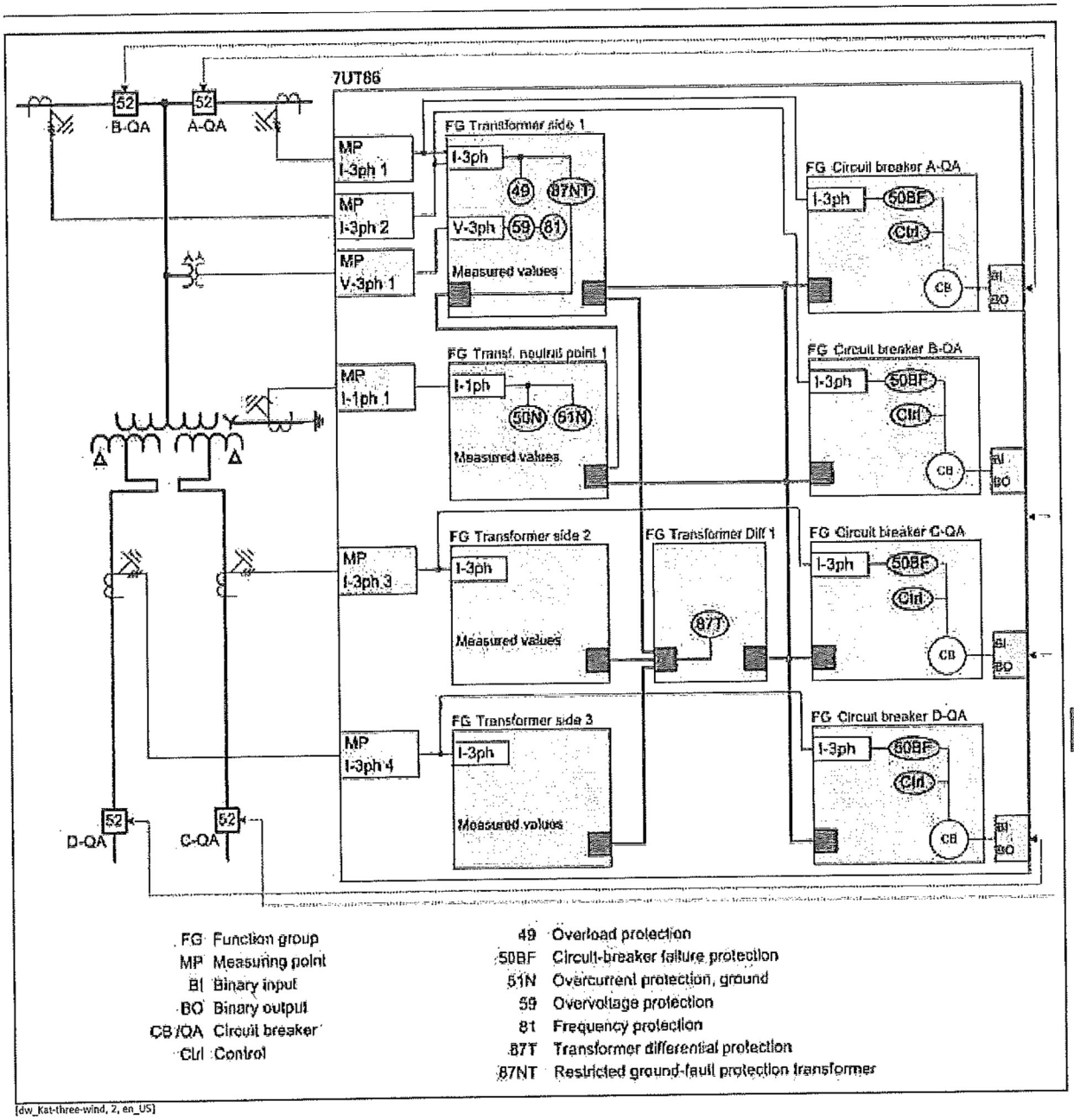
Auto transformer with stabilizing winding

- Differential protection for the complete transformer (auto transformer winding + stabilizing winding)
- Restricted ground-fault protection (neutral point + maximum side current)
- Overload protection, backup protection for the downstream power system
- Circuit-breaker failure protection

Three-winding transformer in breaker-and-a-half layout

- Differential protection
- Restricted ground-fault protection on the neutral side
- Ground-current protection on the neutral side as backup protection for the electrical power system
- Overload protection
- Circuit-breaker failure protection
- Frequency and voltage protection on the neutral side

Figure 2.11/10 shows the template for the protection of a three-winding transformer in a breaker-and-a-half layout. You can recognize the 3 required function groups for the transformer side, the integration of the restricted ground-fault protection, the internal circuiting, and selected functions. In addition, a voltage transformer is available on the upper-voltage side. Here, for example, voltage and frequency limits can be monitored. The required protection settings are made as required by the system.



[dw_Kat-three-wind, 2, en_US]

Figure 2.11/10 Application Example: Protection of a Three-Winding Transformer in Breaker-and-a-Half Layout

2.11

ANSI	Functions	Abbr.	Available	Template								
				1	2	3	4	5	6	7	8	9
	Hardware quantity structure expandable	I/O	■									
	Process Bus Client Protocol (Note: This function requires at least one dedicated ETH-BD-2FO plug-in module, with V8.0)	PB client	■									
	IEC61850-9-2 Merging Unit stream (Note: This function requires a dedicated ETH-BD-2FO per stream, with V8.0)	MU	■									
21/21N	Distance protection	Z<, V< /I>/∠ (V,I)	■			■						
21T	Impedance protection for transformers	Z<	■									
24	Overexcitation protection	V/f	■									
25	Synchrocheck, synchronization function	Sync	■									
32, 37	Power protection active/reactive power	P<>, Q<>	■									
27	Undervoltage protection: "3-phase" or "positive-sequence system V1" or "universal Vx"	V<	■									
	Undervoltage-controlled reactive power protection	Q>/V<	■									
32R	Reverse-power protection	- P<	■									
37	Undercurrent	I<	■									
37	Power-plant disconnection protection	-dP	■									
38	Temperature supervision	θ>	■									
46	Negative-sequence overcurrent protection	I2>	■									
46	Unbalanced-load protection (thermal)	$I2^2$ t>	■									
47	Overvoltage protection, negative-sequence system	V2>	■									
47	Overvoltage protection, negative-sequence/positive-sequence system	V2/V1>	■									
49	Thermal overload protection	θ, I^2t	■		■	■	■	■	■		■	■
49	Thermal overload protection, user-defined characteristic	θ, I^2t	■									
49H	Hot spot calculation	θh, I^2t	■									
50N/ 51N TD	Overcurrent protection, ground	IN>	■							■		
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, 1-phase	IN>	■		■	■	■				■	
50Ns/ 51Ns	Sensitive ground-current detection for systems with resonant or isolated neutral systems incl. a) 3I0>, b) admittance Y0>, c) 3I0-harm> (from V7.8)	INs>	■									
	Ground-fault detection via pulse pattern detection; Note: this stage additionally requires the function 50Ns/51Ns or 67Ns "Sensitive ground-fault detection for systems with resonant or isolated neutral"	IN-pulse	■									
	Intermittent ground-fault protection	Iie>	■									
50BF	Circuit-breaker failure protection, 3-pole	CBFP	■		■	■	■	■		■	■	■
50RS	Circuit-breaker restrike protection	CBRS	■									
51V	Overcurrent protection, voltage dependent	t=f(I,V)	■									
59, 59N	Overvoltage protection: "3-phase" or "zero-sequence system V0" or "universal Vx"	V>	■		■	■		■				■
59	Overvoltage protection: "3-phase" or "positive-sequence system V1" or "universal Vx"	V>	■									
60	Voltage-comparison supervision	ΔU>	■									

2.11

ANSI	Functions	Abbr.	Available	Template								
				1	2	3	4	5	6	7	8	9
67	Directional overcurrent protection, phases	I>, ∠(V,I)	■									
67N	Directional overcurrent protection for ground faults in grounded systems	IN>, ∠(V,I)	■									
67N	Directional overcurrent protection, ground	IN>, ∠(V,I)	■									
67Ns	Dir. sensitive ground-fault detection for systems with resonant or isolated neutral incl. a) 3I0>, b) V0>, c) Cos-/SinPhi, d) Transient ground-fault fct., e) Phi(V,I), f) admittance		■									
	Directional stage with a harmonic; Note: this stage additionally requires the function "67Ns Dir. sensitive ground-fault detection for systems with resonant or isolated neutral"	∠(V0h,I0h)	■									
	Directional intermittent ground-fault protection	Iie dir>	■									
68	Power-swing blocking	ΔZ/Δt	■									
74TC	Trip-circuit supervision	TCS	■	■	■	■	■	■	■	■	■	■
74CC	Closed-circuit supervision (from V7.9)	CCS	■									
79	Automatic reclosing, 3-pole	AR	■									
81	Frequency protection: "f>" or "f<" or "df/dt"	f<>; df/dt<>	■		■	■		■				
81U	Underfrequency load-shedding	f<(UFLS)	■									
85/21	Teleprotection for distance protection		■									
85/27	Weak or no infeed: echo and tripping	WI	■									
81 AF	Abnormal frequency protection	fBand	■									
	Vector-jump protection	Δφ>	■									
85/67N	Teleprotection for directional ground fault protection		■									
86	Lockout		■	■	■	■	■	■	■	■	■	■
87T	Transformer differential protection	ΔI	■	■	■	■	■	■	■	■	■	■
87T	Differential protection for special transformers	ΔI	■									
87T Node	Differential protection (Node protection for auto transformer)	ΔI Node	■					■				
87T	Transformer differential protection for phase angle regulating transformer (single core)	ΔI	■									
87N T	Restricted ground-fault protection	ΔIN	■		■	■	■			■	■	
87M	Motor differential protection	ΔI	■									
87G	Generator differential protection	ΔI	■									
87L	Differential protection for lines with 2 ends for 7UT8 (communication with 7SD82,85,86, 7SL86,87)	ΔI	■									
	Option for line differential protection charging-current compensation	ΔI	■									
87 STUB	Stub-fault differential protection (for breaker-and-a-half scheme)		■									
90V	Automatic Voltage controller for two-winding transformer		■									■
90V	Automatic Voltage controller for two-winding transformer with parallel operation		■									
	Number of two-winding transformers with parallel operation (Note: only together with the function "Automatic Voltage controller for two-winding transformer with parallel operation")		■									
90V	Automatic Voltage controller for three-winding transformer		■									
90V	Automatic Voltage controller for grid coupling transformer		■									
FL	Fault locator, single-sided	FL-one	■									
FL	Fault locator plus (from V7.9)	FL plus	■									

2.11

Transformer Differential Protection – SIPROTEC 7UT86

ANSI	Functions	Abbr.	Available	Template								
				1	2	3	4	5	6	7	8	9
PMU	Synchrophasor measurement	PMU	■									
AFD	Arc-protection (only with plug-in module ARC-CD-3FO)		■									
	Measured values, standard		■	■	■	■	■	■	■	■	■	■
	Measured values, extended: Min, Max, Avg		■									
	Basic PQ measurements: THD and harmonics (from V8.01)		■									
	Switching statistic counters		■									■
	Circuit-breaker wear monitoring	ΣIx, I²t, 2P	■									
	CFC (Standard, control)		■	■	■	■	■	■	■	■	■	■
	CFC arithmetic		■									
	Switching sequences function		■									
	Inrush current detection		■		■	■	■	■	■	■	■	■
	External trip initiation		■							■	■	
	Control		■	■	■	■	■	■	■	■	■	■
PoW	Point-on-Wave Switching (from V7.9)	PoW	■									
	Fault recording of analog and binary signals		■	■	■	■	■	■	■	■	■	■
	Monitoring and supervision		■	■	■	■	■	■	■	■	■	■
	Protection interface, serial		■									
	Circuit-breaker		■	■	■	■	■	■	■	■	■	■
	Disconnector/Grounding switch		■									
	Transformer side 7UT86		■									
	Frequency-tracking groups (from V7.8)		■									
	Temperature acquisition via communication protocol		■									
	Cyber Security: Role-Based Access Control (from V7.8)		■									
Function-points class:				0	50	150	30	30	0	30	30	175
The configuration and function points for your application can be ascertained in the SIPROTEC 5 order configurator under: *www.siemens.com/siprotec*												

2.11

Table 2.11/6 SIPROTEC 7UT86 - Functions and application templates

(1) Three winding transformer basic (87T)

(2) Three winding transformer 1,5CB (87T, 50BF, 87N)

(3) Three winding transformer (87T, 50BF, 87N, 21)

(4) Autotransformer (87T, 87N, 50BF)

(5) Autotransformer 1,5CB (two 87T, 50BF, 59, 27, 81)

(6) Two winding transformer basic (87T)

(7) Two winding transformer (87T, 50BF, 87N)

(8) Two winding transformer 1,5CB (87T, 50BF, 87N)

(9) Two winding transformer (87T, 50BF, 87N, 90V)

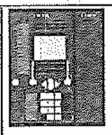
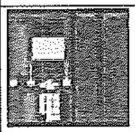
Standard Variants for SIPROTEC 7UT86		
P1	1/2, 11 BI, 18 BO, 12 I, 4 V	
	Housing width 1/2 × 19" 11 binary inputs 18 binary outputs (1 life contact, 5 standard, 12 fast) 12 current transformers 4 voltage transformers Contains the following modules: Base module with PS201 and IO203, expansion module IO208	
P2	2/3, 23 BI, 34 BO, 12 I, 4 V	
	Housing width 2/3 × 19" 23 binary inputs 34 binary outputs (1 life contact, 21 standard, 12 fast) 12 current transformers 4 voltage transformers Contains the following modules: Base module with PS201 and IO203 Expansion modules IO208, IO205	

Table 2.11/7 Standard Variants for Transformer Differential Protection Devices

You can find the technical data in the manual
www.siemens.com/siprotec.

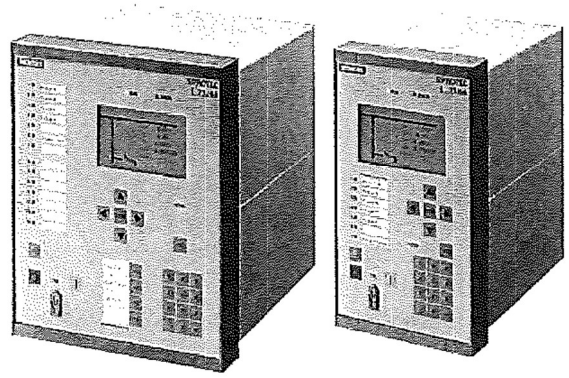


Fig. 5/127 SIPROTEC 7SJ66 multifunction protection relay

Description

The SIPROTEC 7SJ66 unit is a numerical protection, control and monitoring device, designed to use in Medium Voltage and Industry applications.

SIPROTEC 7SJ66 is featuring the "flexible protection functions". Up to 20 protection functions can be added according to individual requirements. Thus, for example, a rate-of-frequency-change protection or reverse power protection can be implemented.

The relay provides control of the circuit-breaker, further switching devices and automation functions. The integrated graphical logic editor (CFC) allows the user to implement its own functions, e. g. for the automation of switchgear (interlocking).

The communication interfaces support the easy integration into modern communication networks.

Function overview

Protection functions

- Overcurrent protection
- Directional overcurrent protection
- Sensitive directional ground-fault detection
- Displacement voltage
- Intermittent ground-fault protection
- Directional intermittent ground fault protection
- High-impedance restricted ground fault

Protection functions (continued)

- Inrush restraint
- Motor protection
- Overload protection
- Temperature monitoring
- Under-/overvoltage protection
- Under-/overfrequency protection
- Rate-of-frequency-change protection
- Power protection (e.g. reverse, factor)
- Undervoltage controlled reactive power protection
- Breaker failure protection
- Negative-sequence protection
- Phase-sequence monitoring
- Synchro-check
- Fault locator
- Lockout
- Auto-reclosure

Control functions/programmable logic

- Commands f. ctrl of CB and of isolators
- Position of switching elements is shown on the graphic display
- Control via keyboard, binary inputs, DIGSI 4 or SCADA system
- User-defined logic with CFC (e.g. interlocking)

Monitoring functions

- Operational measured values V, I, f
- Energy metering values W_p, W_q
- Circuit-breaker wear monitoring
- Slave pointer
- Trip circuit supervision
- Fuse failure monitor
- 8 oscillographic fault records
- Motor statistics

Communication (build in interfaces)

- System interface
  IEC 60870-5-103 / IEC 61850 / Modbus RTU / DNP3
- Service interface for DIGSI 4/ RTD-Box
- Electrical and optical interface
- RSTP, PRP (Redundancy Protocol for Ethernet)
- Front USB interface for DIGSI 4
- Time synchronization via IRIG B/DCF77

Hardware

- Screw-type current terminals
- Spring or Screw-type Voltage and Binary I/O terminals
- 4 current and 4 voltage transformers
- 16/22/36 binary inputs
- 7/10/23 output relays
- Graphical or 8 line text display

Application

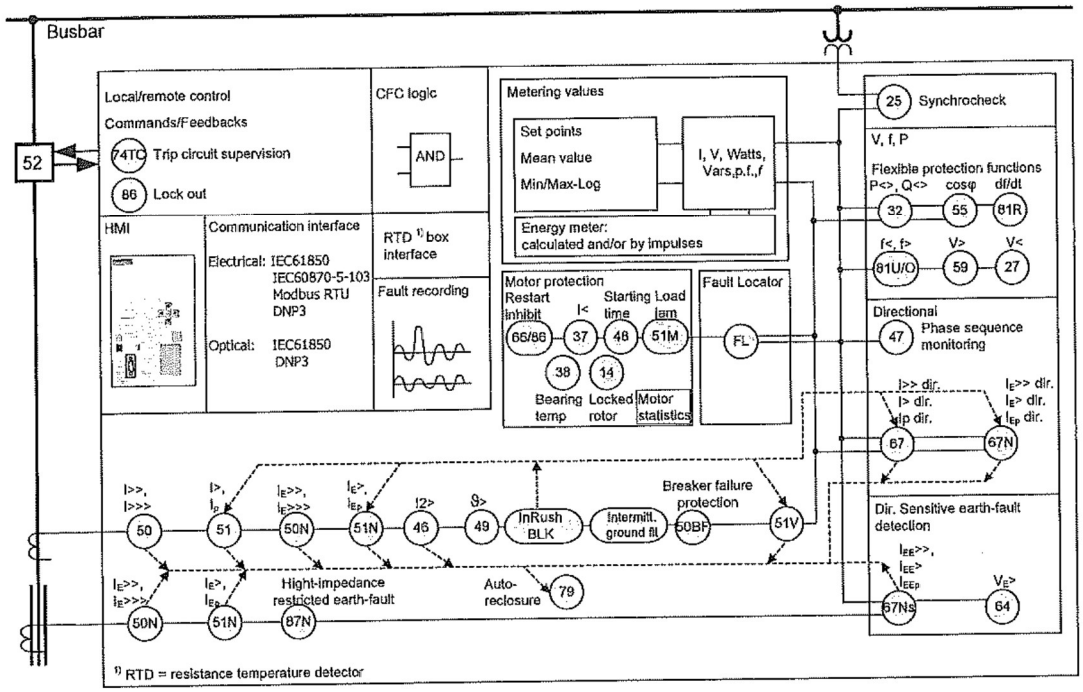


Fig. 5/128 Function diagram

Application

The SIPROTEC 7SJ66 unit is a numerical protection relay that also performs control and monitoring functions and therefore supports the user in cost-effective power system management. The relay ensures reliable supply of electric power to the customers. Local operation has been designed according to ergonomic criteria. A large, easy-to-read display was a major design aim.

Control

The integrated control function permits control of disconnect devices, grounding switches or circuit-breakers via the integrated operator panel, binary inputs, DIGSI 4 or the control and protection system (e.g. SICAM). The present status (or position) of the primary equipment can be displayed, in case of devices with graphic display. A full range of command processing functions is provided.

Programmable logic

The integrated logic characteristics (CFC) allow the user to implement their own functions for automation of switchgear (interlocking) or a substation via a graphic user interface. The user can also generate user-defined messages.

Line protection

The SIPROTEC 7SJ66 units can be used for line protection of high and medium-voltage networks with earthed (grounded), low-resistance grounded, isolated or compensated neutral point.

Synchro-check

In order to connect two components of a power system, the relay provides a synchro-check function which verifies that switching ON does not endanger the stability of the power system.

Motor protection

When protecting motors, the SIPROTEC 7SJ66 relay is suitable for asynchronous machines of all sizes.

Transformer protection

The relay performs all functions of backup protection supplementary to transformer differential protection. The inrush suppression effectively prevents tripping by inrush currents. The high-impedance restricted ground-fault protection detects short-circuits and insulation faults on the transformer.

Backup protection

The SIPROTEC 7SJ66 can be used universally for backup protection.

Flexible protection functions

By configuring a connection between a standard protection logic and any measured or derived quantity, the functional scope of the relays can be easily expanded by up to 20 protection stages or protection functions.

Metering values

Extensive measured values, limit values and metered values permit improved system management.

ANSI	IEC	Protection functions
50, 50N	$I>$, $I>>$, $I>>>$, $I_E>$, $I_E>>$, $I_E>>>$	Definite-time overcurrent protection (phase/neutral)
50, 51V, 51N	I_p, I_{Ep}	Inverse overcurrent protection (phase/neutral), phase function with voltage-dependent option
67, 67N	$I_{dir}>$, $I_{dir}>>$, $I_{p\ dir}$ $I_{Edir}>$, $I_{Edir}>>$, $I_{Ep\ dir}$	Directional overcurrent protection (definite/inverse, phase/neutral), Directional comparison protection
67Ns/50Ns	$I_{EE}>$, $I_{EE}>>$, I_{EEp}	Directional/non-directional sensitive ground-fault detection
–		Cold load pick-up (dynamic setting change)
59N/64	V_E, $V_0>$	Displacement voltage, zero-sequence voltage
–	$I_{IE}>$	Intermittent ground fault
67Ns	$I_{IE\ dir}>$	Directional intermittent ground fault protection
87N		High-impedance restricted ground-fault protection
50BF		Breaker failure protection
79		Auto-reclosure
25		Synchro-check
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
47	$V_2>$, phase-sequence	Unbalance-voltage protection and/or phase-sequence monitoring
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
51M		Load jam protection
14		Locked rotor protection
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device (RTD-box), e.g. bearing temperature monitoring
27, 59	$V<$, $V>$	Undervoltage/overvoltage protection
59R	dV/dt	Rate-of-voltage-change protection
32	$P<>$, $Q<>$	Reverse-power, forward-power protection
27/Q	$Q>/V<$	Undervoltage-controlled reactive power protection
55	$\cos\varphi$	Power factor protection
81O/U	$f>$, $f<$	Overfrequency/underfrequency protection
81R	df/dt	Rate-of-frequency-change protection
21FL		Fault locator

5

ТП-27

Construction, protection functions

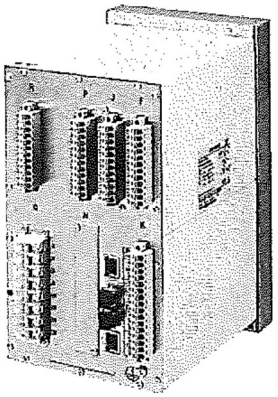


Fig. 5/129 SIPROTEC 7SJ66 rear view with optical Ethernet system interfaces

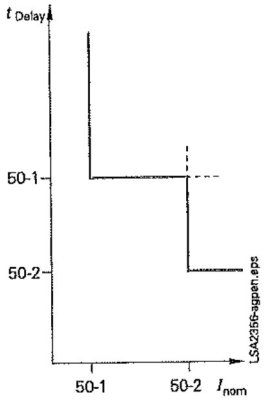


Fig. 5/130 Definite-time overcurrent protection

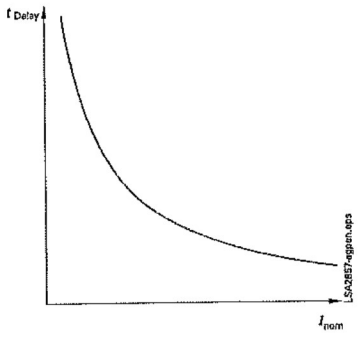


Fig. 5/131 Inverse-time overcurrent protection

Construction

Connection techniques and housing with many advantages

1/3-rack size and 1/2-rack size are the available housing widths of the SIPROTEC 7SJ66 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 244 mm for flush-mounting housing. All CT-cables can be connected with or without ring lugs.

Protection functions

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

This function is based on the phase-selective measurement of the three phase currents and the ground current (four transformers). Three definite-time overcurrent protection elements (DMT) exist both for the phases and for the ground. The current threshold and the delay time can be set within a wide range. In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated.
The inverse-time function provides – as an option – voltage-restraint or voltage-controlled operating modes.

Available inverse-time characteristics		
Characteristics acc. to	*ANSI/IEEE*	*IEC 60255-3*
Inverse	•	•
Short inverse	•	
Long inverse	•	•
Moderately inverse	•	
Very inverse	•	•
Extremely inverse	•	•

Reset characteristics

For easier time coordination with electromechanical relays, reset characteristics according to ANSI C37.112 and IEC 60255-3 / BS 142 standards are applied.

When using the reset characteristic (disk emulation), a reset process is initiated after the fault current has disappeared. This reset process corresponds to the reverse movement of the Ferraris disk of an electromechanical relay (thus: disk emulation).

User-definable characteristics

Instead of the predefined time characteristics according to ANSI, tripping characteristics can be defined by the user for phase and ground units separately. Up to 20 current/time value pairs may be programmed. They are set as pairs of numbers or graphically in DIGSI 4.

Inrush restraint

The relay features second harmonic restraint. If the second harmonic is detected during transformer energization, pickup of non-directional and directional normal elements are blocked.

Cold load pickup/dynamic setting change

For directional and non-directional overcurrent protection functions the initiation thresholds and tripping times can be switched via binary inputs or by time control.

Directional overcurrent protection (ANSI 67, 67N)

Directional phase and ground protection are separate functions. They operate in parallel to the non-directional overcurrent elements. Their pickup values and delay times can be set separately. Definite-time and inverse-time characteristics are offered. The tripping characteristic can be rotated about ± 180 degrees.

By means of voltage memory, directionality can be determined reliably even for close-in (local) faults. If the switching device closes onto a fault and the voltage is too low to determine direction, directionality (directional decision) is made with voltage from the voltage memory. If no voltage exists in the memory, tripping occurs according to the coordination schedule.

For ground protection, users can choose whether the direction is to be determined via zero-sequence system or negative-sequence system quantities (selectable). Using negative-sequence variables can be advantageous in cases where the zero voltage tends to be very low due to unfavorable zero-sequence impedances.

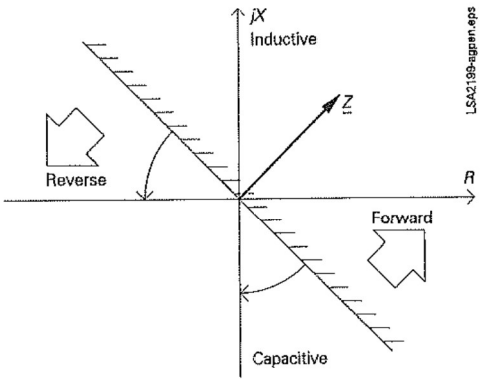


Fig. 5/132 Directional characteristic of the directional overcurrent protection

Directional comparison protection (cross-coupling)

It is used for selective protection of sections fed from two sources with instantaneous tripping, i.e. without the disadvantage of time coordination. The directional comparison protection is suitable if the distances between the protection stations are not significant and pilot wires are available for signal transmission. In addition to the directional comparison protection, the directional coordinated overcurrent protection is used for complete selective backup protection. If operated in a closed-circuit connection, an interruption of the transmission line is detected.

(Sensitive) directional ground-fault detection (ANSI 64, 67Ns, 67N)

For isolated-neutral and compensated networks, the direction of power flow in the zero sequence is calculated from the zero-sequence current I_0 and zero-sequence voltage V_0.

For networks with an isolated neutral, the reactive current component is evaluated; for compensated networks, the active current component or residual resistive current is evaluated. For special network conditions, e.g. high-resistance grounded networks with ohmic-capacitive ground-fault current or low-resistance grounded networks with ohmic-inductive current, the tripping characteristics can be rotated approximately ± 45 degrees.

Two modes of ground-fault direction detection can be implemented: tripping or "signalling only mode".

It has the following functions:

- TRIP via the displacement voltage V_E.
- Two instantaneous elements or one instantaneous plus one user-defined characteristic.
- Each element can be set in forward, reverse, or non-directional.
- The function can also be operated in the insensitive mode as an additional short-circuit protection.

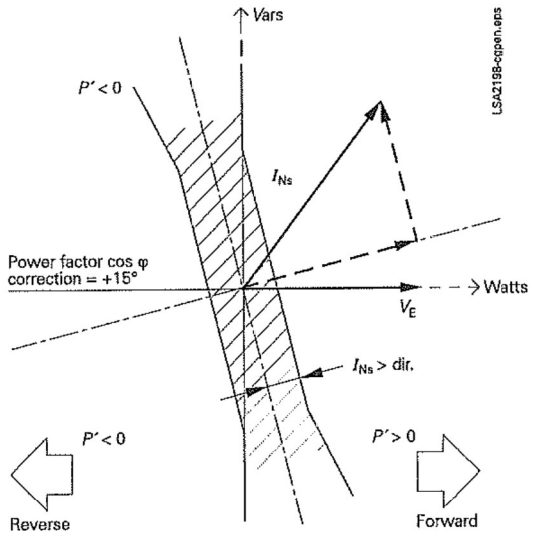


Fig. 5/133 Directional determination using cosine measurements for compensated networks

(Sensitive) ground-fault detection (ANSI 50Ns, 51Ns / 50N, 51N)

For high-resistance grounded networks, a sensitive input transformer is connected to a phase-balance neutral current transformer (also called core-balance CT).

The function can also be operated in the insensitive mode as an additional short-circuit protection.

Intermittent ground-fault protection

Intermittent (re-striking) faults occur due to insulation weaknesses in cables or as a result of water penetrating cable joints. Such faults either simply cease at some stage or develop into lasting short-circuits. During intermittent activity, however, star-point resistors in networks that are impedance-grounded may undergo thermal overloading. The normal ground-fault protection cannot reliably detect and interrupt the current pulses, some of which can be very brief.
The selectivity required with intermittent ground faults is achieved by summating the duration of the individual pulses and by triggering when a (settable) summed time is reached. The response threshold $I_{IE>}$ evaluates the r.m.s. value, referred to one systems period.

Directional intermittent ground fault protection (ANSI 67Ns)

The directional intermittent ground fault protection has to detect intermittent ground faults in resonant grounded cable systems selectively. Intermittent ground faults in resonant grounded cable systems are usually characterized by the following properties:

- A very short high-current ground current pulse (up to several hundred amperes) with a duration of under 1 ms
- They are self-extinguishing and re-ignite within one halfperiod up to several periods, depending on the power system condi tions and the fault characteristic.
- Over longer periods (many seconds to minutes), they can develop into static faults.

Such intermittent ground faults are frequently caused by weak insulation, e.g. due to decreased water resistance of old cables. Ground fault functions based on fundamental component measured values are primarily designed to detect static ground faults and do not always behave correctly in case of intermittent ground faults. The function described here evaluates specifi cally the ground current pulses and puts them into relation with the zero-sequence voltage to determine the direction.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

In line protection, the two-element phase-balance current/ negative-sequence protection permits detection on the high side of high-resistance phase-to-phase faults and phase-to-ground faults that are on the low side of a transformer (e.g. with the switch group Dy 5). This provides backup protection for high-resistance faults beyond the transformer.

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected upon issuance of a trip command, another command can be initiated using the breaker failure protection which operates the circuit-breaker, e.g. of an upstream (higher-level) protection relay. Breaker failure is detected if, after a trip command, current is still flowing in the faulted circuit. As an option, it is possible to make use of the circuit-breaker position indication.

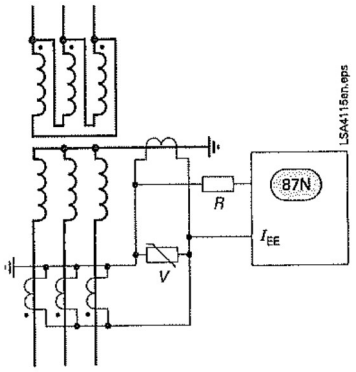


Fig. 5/134 High-impedance restricted ground-fault protection

High-impedance restricted ground-fault protection (ANSI 87N)

The high-impedance measurement principle is an uncomplicated and sensitive method for detecting ground faults, especially on transformers. It can also be applied to motors, generators and reactors when these are operated on an grounded network.

When the high-impedance measurement principle is applied, all current transformers in the protected area are connected in parallel and operated on one common resistor of relatively high R whose voltage is measured (see Fig. 5/134). In the case of 7SJ6 units, the voltage is measured by detecting the current through the (external) resistor R at the sensitive current measurement input I_{EE}. The varistor V serves to limit the voltage in the event of an internal fault. It cuts off the high momentary voltage spikes occurring at transformer saturation. At the same time, this results in smoothing of the voltage without any noteworthy reduction of the average value.

If no faults have occurred and in the event of external faults, the system is at equilibrium, and the voltage through the resistor is approximately zero. In the event of internal faults, an imbalance occurs which leads to a voltage and a current flow through the resistor R.

The current transformers must be of the same type and must at least offer a separate core for the high-impedance restricted ground-fault protection. They must in particular have the same transformation ratio and an approximately identical knee-point voltage. They should also demonstrate only minimal measuring errors.

Flexible protection functions

The SIPROTEC 7SJ66 units enable the user to easily add on up to 20 protective functions. To this end, parameter definitions are used to link a standard protection logic with any chosen characteristic quantity (measured or derived quantity). The stand- ard logic consists of the usual protection elements such as the pickup message, the parameter-definable delay time, the TRIP command, a blocking possibility, etc. The mode of operation for current, voltage, power and power factor quantities can be three-phase or single-phase. Almost all quantities can be operated as greater than or less than stages. All stages operate with protection priority.

Protection stages/functions attainable on the basis of the available characteristic quantities:

Function	*ANSI No.*
$I>$, $I_E>$	50, 50N
$V<$, $V>$, $V_E>$, dV/dt	27, 59, 59R, 64
$3I_0>$, $I_1>$, $I_2>$, I_2/I_1, $3V_0>$, $V_1><$, $V_2><$	50N, 46, 59N, 47
$P><$, $Q><$	32
cos φ (p.f.)><	55
$f><$	81O, 81U
$df/dt><$	81R

For example, the following can be implemented:

- Reverse power protection (ANSI 32R)
- Rate-of-frequency-change protection (ANSI 81R)

Undervoltage-controlled reactive power protection (ANSI 27/Q)

The undervoltage-controlled reactive power protection protects the system for mains decoupling purposes. To prevent a voltage collapse in energy systems, the generating side, e.g. a generator, must be equipped with voltage and frequency protection devices. An undervoltage-controlled reactive power protection is required at the supply system connection point. It detects critical power system situations and ensures that the power generation facility is disconnected from the mains. Furthermore, it ensures that reconnection only takes place under stable power system conditions. The associated criteria can be parameterized.

Synchro-check (ANSI 25)

In case of switching ON the circuit- breaker, the units can check whether the two subnetworks are synchronized.
Voltage-, frequency- and phase-angle-differences are being checked to determine whether synchronous conditions are existent.

Auto-reclosure (ANSI 79)

Multiple reclosures can be defined by the user and lockout will occur if a fault is present after the last reclosure. The following functions are possible:

- 3-pole ARC for all types of faults
- Separate settings for phase and ground faults
- Multiple ARC, one rapid auto-reclosure (RAR) and up to nine delayed auto-reclosures (DAR)

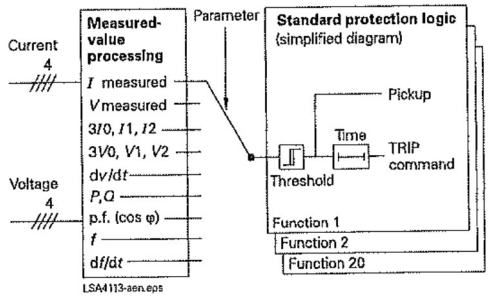


Fig. 5/135 Flexible protection functions

- Starting of the ARC depends on the trip command selection (e.g. 46, 50, 51, 67)
- Blocking option of the ARC via binary inputs
- ARC can be initiated externally or via CFC
- The directional and non-directional elements can either be blocked or operated non-delayed depending on the auto-reclosure cycle
- Dynamic setting change of the directional and non-directional elements can be activated depending on the ready AR

Thermal overload protection (ANSI 49)

For protecting cables and transformers, an overload protection with an integrated pre-warning element for temperature and current can be applied. The temperature is calculated using a thermal homogeneous-body model (according to IEC 60255-8), which takes account both of the energy entering the equipment and the energy losses. The calculated temperature is constantly adjusted accordingly. Thus, account is taken of the previous load and the load fluctuations.

For thermal protection of motors (especially the stator) a further time constant can be set so that the thermal ratios can be detected correctly while the motor is rotating and when it is stopped. The ambient temperature or the temperature of the coolant can be detected serially via an external temperature monitoring box (resistance-temperature detector box, also called RTD-box). The thermal replica of the overload function is automatically adapted to the ambient conditions. If there is no RTD-box it is assumed that the ambient temperatures are constant.

Settable dropout delay times

If the devices are used in parallel with electromechanical relays in networks with intermittent faults, the long dropout times of the electromechanical devices (several hundred milliseconds) can lead to problems in terms of time grading. Clean time grading is only possible if the dropout time is approximately the same. This is why the parameter of dropout times can be defined for certain functions such as time-over-current protection, ground short-circuit and phase-balance current protection.

Motor protection

Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current. The reclosing lockout only permits start-up of the motor if the rotor has sufficient thermal reserves for a complete start-up (see Fig. 5/136).

Emergency start-up

This function disables the reclosing lockout via a binary input by storing the state of the thermal replica as long as the binary input is active. It is also possible to reset the thermal replica to zero.

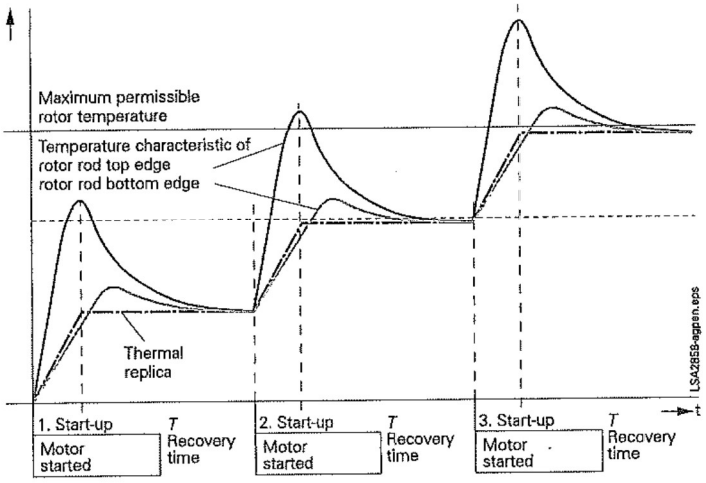


Fig. 5/136

Temperature monitoring (ANSI 38)

One temperature monitoring box with a total of 12 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device. Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are being measured with the help of temperature detectors at various locations of the device to be protected. This data is transmitted to the protection relay via one or two temperature monitoring boxes (see "Accessories", page 5/115).

Starting time supervision (ANSI 48/14)

Starting time supervision protects the motor against long unwanted start-ups that might occur in the event of excessive load torque or excessive voltage drops within the motor, or if the rotor is locked. Rotor temperature is calculated from measured stator current. The tripping time is calculated according to the following equation:

for $I > I_{MOTOR\ START}$

$$t = \left(\frac{I_A}{I}\right)^2 \cdot T_A$$

I = Actual current flowing

$I_{MOTOR\ START}$ = Pickup current to detect a motor start

t = Tripping time

I_A = Rated motor starting current

T_A = Tripping time at rated motor starting current (2 times, for warm and cold motor)

The characteristic (equation) can be adapted optimally to the state of the motor by applying different tripping times T_A in dependence of either cold or warm motor state. For differentiation of the motor state the thermal model of the rotor is applied.

If the trip time is rated according to the above formula, even a prolonged start-up and reduced voltage (and reduced start-up current) will be evaluated correctly. The tripping time is inverse (current dependent).

A binary signal is set by a speed sensor to detect a blocked rotor. An instantaneous tripping is effected.

Load jam protection (ANSI 51M)

Sudden high loads can cause slowing down and blocking of the motor and mechanical damages. The rise of current due to a load jam is being monitored by this function (alarm and tripping).

The overload protection function is too slow and therefore not suitable under these circumstances.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

The negative-sequence / phase-balance current protection detects a phase failure or load unbalance due to network asymmetry and protects the rotor from impermissible temperature rise.

Undercurrent monitoring (ANSI 37)

With this function, a sudden drop in current, which can occur due to a reduced motor load, is detected. This may be due to shaft breakage, no-load operation of pumps or fan failure.

Motor statistics

Essential information on start-up of the motor (duration, current, voltage) and general information on number of starts, total operating time, total down time, etc. are saved as statistics in the device.

Voltage protection

Overvoltage protection (ANSI 59)

The two-element overvoltage protection detects unwanted network and machine overvoltage conditions. The function can operate either with phase-to-phase, phase-to-ground, positive phase-sequence or negative phase-sequence system voltage. Three-phase and single-phase connections are possible.

Undervoltage protection (ANSI 27)

The two-element undervoltage protection provides protection against dangerous voltage drops (especially for electric machines). Applications include the isolation of generators or motors from the network to avoid undesired operating states and a possible loss of stability. Proper operating conditions of electrical machines are best evaluated with the positive-sequence quantities. The protection function is active over a

wide frequency range (25 to 70 Hz). Even when falling below this frequency range the function continues to work, however, with a greater tolerance band.

The function can operate either with phase-to-phase, phase-to-ground or positive phase-sequence voltage and can be monitored with a current criterion. Three-phase and single-phase connections are possible.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for over- frequency and underfrequency protection. Electric machines and parts of the system are protected from unwanted speed deviations. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting.

There are four elements (select- able as overfrequency or underfrequency) and each element can be delayed separately. Blocking of the frequency protection can be performed if using a binary input or by using an undervoltage element.

Fault locator (ANSI 21FL)

The integrated fault locator calculates the fault impedance and the distance-to-fault. The results are displayed in Ω, kilometers (miles) and in percent of the line length.

Circuit-breaker wear monitoring

Methods for determining circuit-breaker contact wear or the remaining service life of a circuit-breaker (CB) allow CB maintenance intervals to be aligned to their actual degree of wear. The benefit lies in reduced maintenance costs.

There is no mathematically exact method of calculating the wear or the remaining service life of circuit-breakers that takes into account the arc-chamber's physical conditions when the CB opens. This is why various methods of determining CB wear have evolved which reflect the different operator philosophies. To do justice to these, the devices offer several methods:

- ΣI
- ΣI^x, with x = 1... 3
- Σi^2t

The devices additionally offer a new method for determining the remaining service life:

- Two-point method

The CB manufacturers double-logarithmic switching cycle diagram (see Fig. 5/137) and the breaking current at the time of contact opening serve as the basis for this method. After CB opening, the two-point method calculates the number of still possible switching cycles. To this end, the two points P1 and P2 only have to be set on the device. These are specified in the CB's technical data.

All of these methods are phase-selective and a limit value can be set in order to obtain an alarm if the actual value falls below or exceeds the limit value during determination of the remaining service life.

Customized functions (ANSI 32, 51V, 55, etc.)

Additional functions, which are not time critical, can be implemented via the CFC using measured values. Typical functions include reverse power, voltage controlled overcurrent, phase angle detection, and zero-sequence voltage detection.

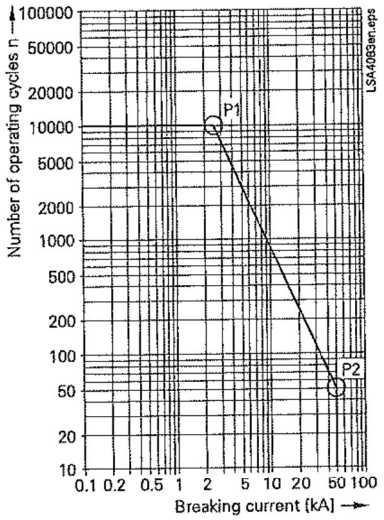


Fig. 5/137 CB switching cycle diagram

Commissioning

Commissioning could hardly be easier and is fully supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the bay controller. The analog measured values are represented as wide-ranging operational measured values. To prevent transmission of information to the control center during maintenance, the bay controller communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test marking for test purposes can be connected to a control and protection system.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

Control and automatic functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated to the SIPROTEC 7SJ66 via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:
– integrated operator panel
– binary inputs
– substation control and protection system
– DIGSI 4

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Functions

Automation / user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

Switching authority

Switching authority is determined according to parameters and communication.

If a source is set to "LOCAL", only local switching operations are possible. The following sequence of switching authority is laid down: "LOCAL"; DIGSI PC program, "REMOTE".

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and grounding switches
- Triggering of switching operations, indications or alarm by combination with existing information

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state.

Chatter disable

Chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Indication filtering and delay

Binary indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

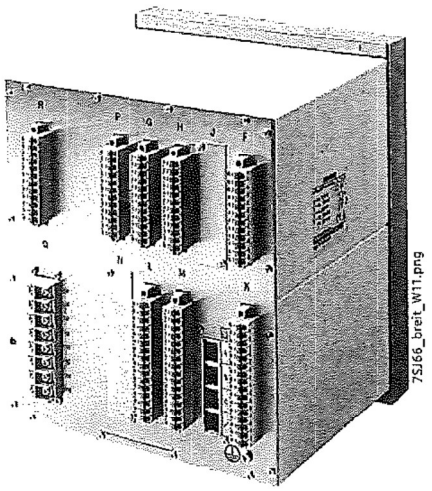

Fig. 5/138 SIPROTEC 7SJ663 rear view with communication ports

Switchgear cubicles for high/medium voltage

All units are designed specifically to meet the requirements of high/medium-voltage applications.

In general, no separate measuring instruments (e.g., for current, voltage, frequency, ...) or additional control components are necessary.

Measured values

The r.m.s. values are calculated from the acquired current and voltage along with the power factor, frequency, active and reactive power. The following functions are available for measured value processing:

- Currents I_{L1}, I_{L2}, I_{L3}, I_E, I_{EE} (67Ns)
- Voltages V_{L1}, V_{L2}, V_{L3}, V_{L1L2}, V_{L2L3}, V_{L3L1}
- Symmetrical components I_1, I_2, $3I_0$; V_1, V_2, V_0
- Power Watts, *Vars*, *VA*/*P*, *Q*, *S* (*P*, *Q*: total and phase selective)
- Power factor (cos ϕ), (total and phase selective)
- Frequency
- Energy ± kWh, ± kVarh, forward and reverse power flow
- Mean as well as minimum and maximum current and voltage values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
  Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
  In a certain range of very low measured values, the value is set to zero to suppress interference.

Communication

In terms of communication, the units offer substantial flexibility in the context of connection to industrial and power automation standards.

USB interface

There is a USB interface on the front of the relay. All the relay functions can be parameterized on PC by using DIGSI. Commissioning tools and fault analysis are built into the DIGSI program and are used through this interface.

Rear interfaces

- Time synchronization interface
  All units feature a permanently integrated electrical time synchronization interface. It can be used to feed timing telegrams in IRIG-B or DCF77 format into the units via time synchronization receivers.
- System interface
  Communication with a central control system takes place through this interface. The units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.
- Service interface
  The service interface was conceived for remote access to a number of protection units via DIGSI. It also allows communication via modem. For special applications, a temperature monitoring box (RTD box) can be connected to this interface.

System interface protocols

IEC 61850 protocol

The Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens was the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI.

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit and also control commands can be transferred by means of published, Siemens-specific extensions to the protocol.

Redundant solutions are also possible. Optionally it is possible to read out and alter individual parameters (only possible with the redundant module).

Modbus RTU protocol

This serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit manufacturers. SIPROTEC units function as Modbus slaves, making their information available to a master or receiving information from it. A time-stamped event list is available.

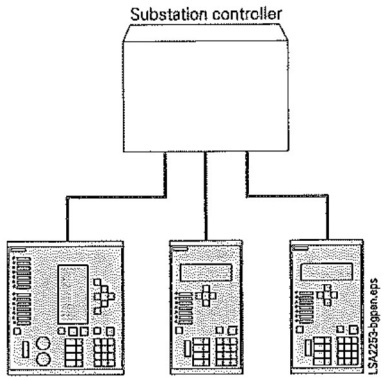

Fig. 5/139 IEC 60870-5-103: Radial electrical connection

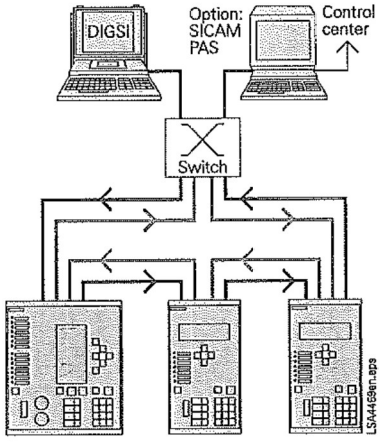

Fig. 5/140 Bus structure for station bus with Ethernet and IEC 61850, electrical and optical ring

DNP3

DNP (Distributed Network Protocol, version 3) is a messaging-based communication protocol. SIPROTEC 7SJ66 is fully Level 1 and Level 2-compliant with DNP3, which is supported by a number of protection units manufactures.

SIPROTEC 7SJ66

Selection table

Selection table for multifunctional overcurrent protection devices							
Device	*7SJ80*	*7SJ61*	*7SJ62*	*7SJ63*	*7SJ64*	*7SJ82*	7SJ66
Multifunctional protection functions	✓	✓	✓	✓	✓	✓	✓
CTs	4	4	4	4	4	4	4
VTs	0/3	0	3/4	3	4	0/4	4
Binary inputs incl. Life contact	3 - 11	3 - 11	8 - 11	11 - 37	7 - 48	11 - 23	16 - 36
Binary outputs	5 - 9	4 - 9	6 - 9	8 - 19	5 - 26	8 - 16	7 - 24
Spring-type terminals	-	-	-	-	-	-	✓
Auxiliary voltage	DC 24 - 250 V AC 115 - 230 V	DC 24 - 250 V AC 115 - 230 V	DC 24 - 250 V AC 115 - 230 V	DC 24 - 250 V AC 115 - 230 V	DC 24 - 250 V AC 115 - 230 V	DC 24 - 250 V AC 115 - 230 V	DC 110 - 250 V AC 115 - 230 V
UL listing	✓	✓	✓	✓	✓	✓	-
Surface mounting case	●	●	●	●	●	-	-
Detached on-site operation panel	-	-	-	●	●	-	-
Languages	ge/en/es/fr/it/ ru/ch	ge/en/es/fr/it/ru	ge/en/es/fr/it/ru	ge/en/es/fr	ge/en/es/fr/it/ru	ge/en/pt/es/ru	en/es/ru
Front USB	✓	-	-	-	-	✓	✓
Interfaces exchangeable	✓	✓	✓	✓	✓	✓	-
IEC 61850	●	●	●	●	●	●	●
IEC 60870-5-103	●	●	●	●	●	●	● (elec.)
Modbus RTU	●	●	●	●	●	●	● (elec.)
PROFIBUS FMS	-	●	●	●	●	-	-
PROFIBUS DP	●	●	●	●	●	-	-
PROFINET I/O	●	●	●	-	●	-	-
DNP3 serial/TCP	●	●	●	-	●	●	●
RSTP	✓	✓	✓	✓	✓	✓	✓
PRP	✓	✓	✓	✓	✓	✓	✓
HSR	✓	✓	✓	✓	✓	✓	-

✓ basic
- not available
● optional

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Typical connections

Connection of current and voltage transformers

Standard connection

For grounded networks, the ground current is obtained from the phase currents by the residual current circuit.

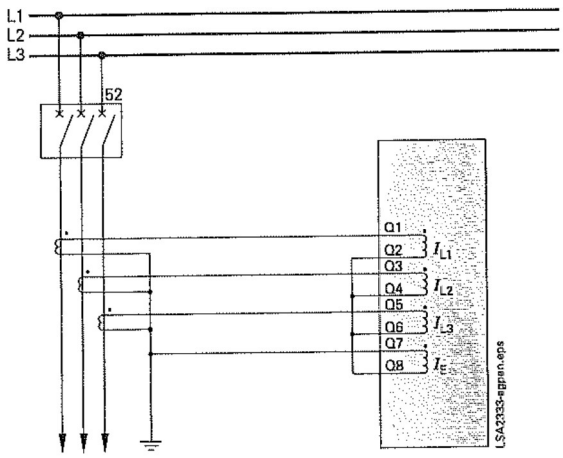

Fig. 5/141 Residual current circuit without directional element

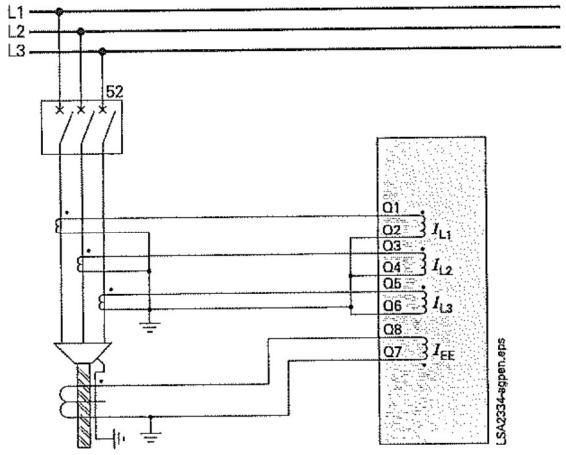

Fig. 5/142 Sensitive ground-current detection without directional element

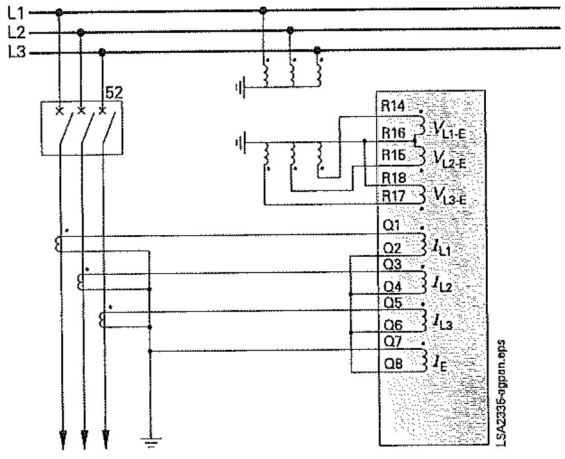

Fig. 5/143 Residual current circuit with directional element

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Typical connections

Connection for compensated networks

The figure shows the connection of two phase-to-ground voltages and the V_E voltage of the open delta winding and a phase-balance neutral current transformer for the ground current. This connection maintains maximum precision for directional ground-fault detection and must be used in compensated networks. Fig. 5/144 shows sensitive directional ground-fault detection.

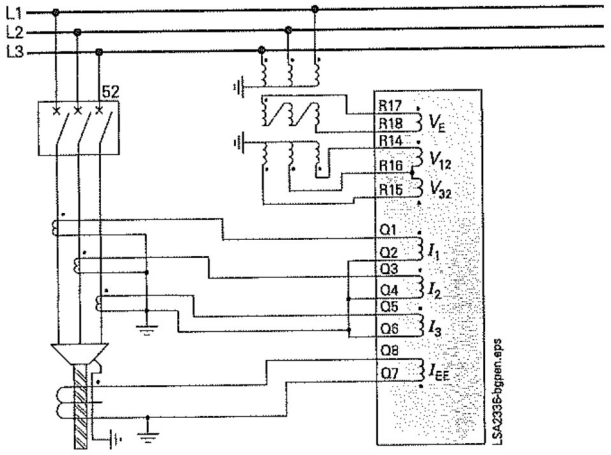


Fig. 5/144 Sensitive directional ground-fault detection with directional element for phases

Connection for isolated-neutral or compensated networks only

If directional ground-fault protection is not used, the connection can be made with only two phase current transformers. Directional phase short-circuit protection can be achieved by using only two primary transformers.

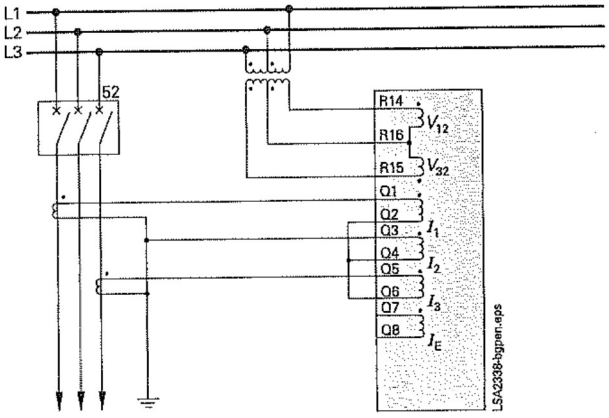


Fig. 5/145 Isolated-neutral or compensated networks

Connection for the synchro-check function

The 3-phase system is connected as reference voltage, i. e. the outgoing voltages as well as a single-phase voltage, in this case a busbar voltage, that has to be checked for synchronism.

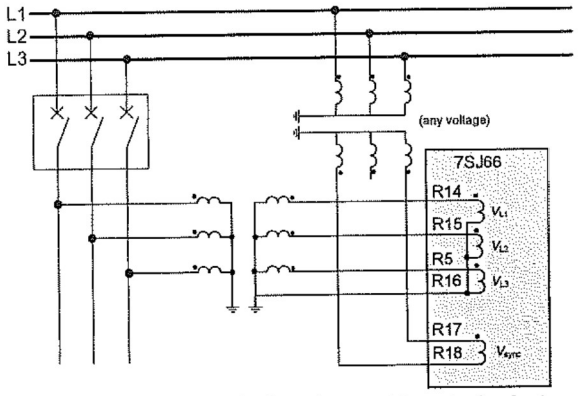


Fig. 5/146 Measuring of the busbar voltage and the outgoing feeder voltage for the synchro-check

Overview of connection types

Type of network	*Function*	*Current connection*	*Voltage connection*
(Low-resistance) grounded network	Overcurrent protection phase/ground non-directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformer possible	–
(Low-resistance) grounded networks	Sensitive ground-fault protection	Phase-balance neutral current transformers required	–
Isolated or compensated networks	Overcurrent protection phases non-directional	Residual circuit, with 3 or 2 phase current transformers possible	–
(Low-resistance) grounded networks	Overcurrent protection phases directional	Residual circuit, with 3 phase-current transformers possible	Phase-to-ground connection or phase-to-phase connection
Isolated or compensated networks	Overcurrent protection phases directional	Residual circuit, with 3 or 2 phase-current transformers possible	Phase-to-ground connection or phase-to-phase connection
(Low-resistance) grounded networks	Overcurrent protection ground directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformers possible	Phase-to-ground connection required
Isolated networks	Sensitive ground-fault protection	Residual circuit, if ground current > 0.05 I_N on secondary side, otherwise phase-balance neutral current transformers required	3 times phase-to-ground connection or phase-to-ground connection with open delta winding
Compensated networks	Sensitive ground-fault protection cos φ measurement	Phase-balance neutral current transformers required	Phase-to-ground connection with open delta winding required

5

Typical applications

▣ Connection of circuit-breaker

Undervoltage releases

Undervoltage releases are used for automatic tripping of high-voltage motors.

Example:
DC supply voltage of control system fails and manual electric tripping is no longer possible.

Automatic tripping takes place when voltage across the coil drops below the trip limit. In Fig. 5/147, tripping occurs due to failure of DC supply voltage, by automatic opening of the live status contact upon failure of the protection unit or by short-circuiting the trip coil in event of network fault.

In Fig. 5/148 tripping is by failure of auxiliary voltage and by interruption of tripping circuit in the event of network failure. Upon failure of the protection unit, the tripping circuit is also interrupted, since contact held by internal logic drops back into open position.

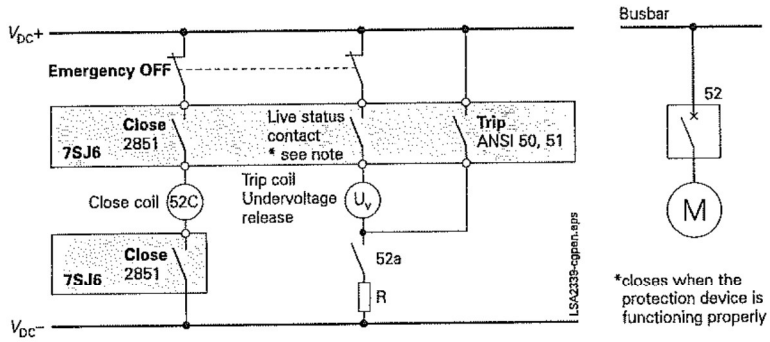


Fig. 5/147 Undervoltage release with make contact (50, 51)

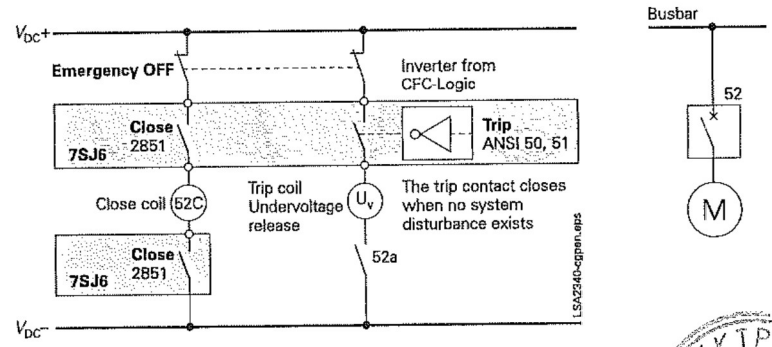


Fig. 5/148 Undervoltage trip with locking contact (trip signal 50 is inverted)

Typical applications

Trip circuit supervision (ANSI 74TC)

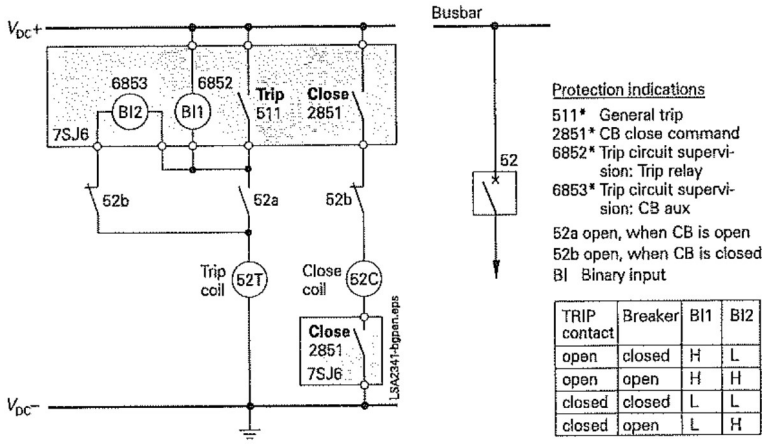
One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

Reverse-power protection for dual supply (ANSI 32R)

If power is fed to a busbar through two parallel infeeds, then in the event of any fault on one of the infeeds it should be selectively interrupted. This ensures a continued supply to the busbar through the remaining infeed. For this purpose, directional devices are needed which detect a short-circuit current or a power flow from the busbar in the direction of the infeed. The directional overcurrent protection is usually set via the load current. It cannot be used to deactivate low-current faults. Reverse-power protection can be set far below the rated power. This ensures that it also detects power feedback into the line in the event of low-current faults with levels far below the load current.
Reverse-power protection is performed via the "flexible protection functions" of the SIPROTEC 7SJ66.



TRIP contact	Breaker	BI1	BI2
open	closed	H	L
open	open	H	H
closed	closed	L	L
closed	open	L	H

Fig. 5/149 Trip circuit supervision with 2 binary inputs

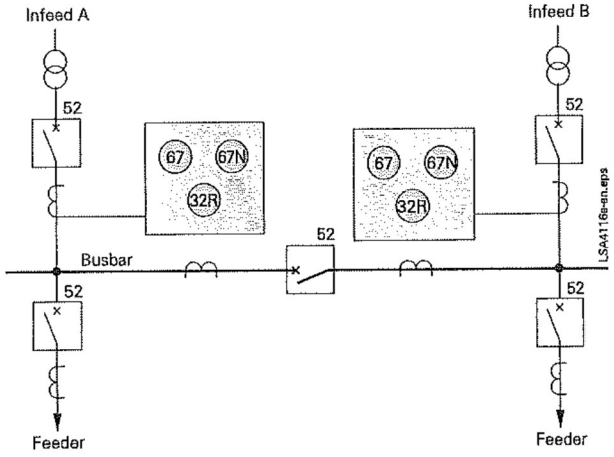


Fig. 5/150 Reverse-power protection for dual supply

Selection and ordering data

Description	Order No.	12345	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Multifunction protection relay with local control	7SJ66	☐	☐	-	☐	☐	☐	☐	☐	-	☐	☐	☐	☐	-	☐	☐	☐
Housing, binary inputs and outputs																		
Housing 1/3 19", 4 x U, 4 x I, 16 BI, 7 BO, 1 life contact		1																
Housing 1/3 19", 4 x U, 4 x I, 22 BI, 10 BO, 1 life contact		2																
Housing 1/2 19", 4 x U, 4 x I, 36 BI, 23 BO, 1 life contact, 4 function keys		3																
Measuring inputs																		
I_{ph} = 1 A, I_E = 1 A (min. = 0.05 A) Position 15 only with **A, C, E, G**			1															
I_{ph} = 1 A, I_E = sensitive (min. = 0.001 A) Position 15 only with **B, D, F, H**			2															
I_{ph} = 5 A, I_E = 5 A (min. = 0.25 A) Position 15 only with **A, C, E, G**			5															
I_{ph} = 5 A, I_E = sensitive (min. = 0.001 A) Position 15 only with **B, D, F, H**			6															
Auxiliary voltage																		
DC 110 to 250 V, AC 115 to 230 V, threshold binary input DC 69 V				5														
DC 110 to 250 V, AC 115 to 230 V, threshold binary input DC 138V				6														
Construction																		
Flush-mounting case, screw-type terminals, 8-line text display					D													
Flush-mounting case, spring-type terminals (direct connection), screw-type terminals for CT connection (direct connection/ring-type cable lugs), 8-line text display					E													
Flush-mounting case, screw-type terminals, graphical display					J													
Flush-mounting case, spring-type terminals (direct connection), screw-type terminals for CT connection (direct connection/ring-type cable lugs), graphical display					K													
Region-specific default settings/function versions and language settings																		
Region World, 50/60 Hz, IEC/ANSI, language: English (language can be changed)						B												
Region World, 50/60 Hz, IEC/ANSI, language: Spanish (language can be changed)						E												
Region RU, 50/60 Hz, IEC/ANSI, language: Russian (language can be changed)						G												
System interface (Port B)																		
No system interface							0											
IEC 60870-5-103 protocol, RS485 [1]							2											
Modbus, RS485 [1]							9									L	0	D
DNP3, RS485 [1]							9									L	0	G
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45-connector [2]							9									L	0	R
IEC 61850, 100 Mbit Ethernet, optical, double, LC-connector [2]							9									L	0	S
DNP3 + IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45-connector [2]							9									L	2	R
DNP3 + IEC 61850, 100 Mbit Ethernet, optical, double, LC-connector [2]							9									L	2	S
Service interface (Port C)									0									
No interface									2									
DIGSI 4 / Modem / RTD-Box, electrical RS485									6									
Ethernet interface (DIGSI, RTD-Box, no IEC61850), RJ45-connector																		

Continued on next page

1) only available with position 12 = 0 or 2

2) only available with position 12 = 0 or 6

Selection and ordering data

Description			Order No.	Order code
			12345 6 7 8 9 10 11 12 13 14 15 16 17 18 19	
Multifunction protection relay with local control			**7SJ66**□□-□□□□□-□□□□-□□□	
	ANSI No.			
Basic version		Control		F A
	50/51	Overcurrent protection $I>$, $I>>$, $I>>>$, I_p		
	50N/51N	Ground-fault protection $I_E>$, $I_E>>$, $I_E>>>$, I_{Ep}		
	50N/51N	Insensitive ground-fault protection via IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} [1]		
	50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I_2>$, $I>>>>$, $I_E>>>>$		
	51 V	Voltage-dependent inverse-time overcurrent protection		
	49	Overload protection (with 2 time constants)		
	46	Phase balance current protection (negative-sequence protection)		
	37	Undercurrent monitoring		
	47	Phase sequence		
	59N/64	Displacement voltage		
	50BF	Breaker failure protection		
	74TC	Trip circuit supervision, 4 setting groups, cold-load pickup Inrush blocking		
	86	Lockout		
Basic+ V,P,f		Basic version (see above), Intermittent earth-fault		F E
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27Q	Undervoltage-controlled reactive power protection		
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		
Basic + V,P,f IEF		Basic version (see above)		P E
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27Q	Undervoltage-controlled reactive power protection		
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		
Basic + Dir		Basic version (see above)		F C
	67/67N	Direction determination for overcurrent, phases and ground		
Basic + Dir V,P,f		Basic version (see above)		F G
	67/67N	Direction determination for overcurrent, phases and ground		
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27Q	Undervoltage-controlled reactive power protection		
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		
Basic + Dir V,P,f IEF		Basic version (see above)		P G
	67/67N	Direction determination for overcurrent, phases and ground		
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27Q	Undervoltage-controlled reactive power protection		
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		
Basic + Dir IEF		Basic version (see above)		P C
	67/67N	Direction determination for overcurrent, phases and ground		

Continued on next page

V, P, f = Voltage, power, frequency protection
Dir = Directional overcurrent protection
IEF = Intermittent ground fault

1) only with position 7 = 1 or 5 (non-sensitive ground current input)

Description	ANSI No.		Order No. 7SJ66□□-□□□□□-□□□□-□□□ 12345 6 7 8 9 10 11 12 13 14 15 16 17 18 19	Order code
Multifunction protection relay with local control				
Basic + Sens.earth-f-det. Dir REF[2]		Basic version included		F D
	67/67N	Direction determination for overcurrent, phases and ground		
	67Ns	Directional sensitive ground-fault detection		
	67Ns	Directional intermittent ground fault protection		
	87N	High-impedance restricted earth fault		
Basic + Sens.earth-f-det. Dir IEF REF[2]		Basic version included		P D
	67/67N	Direction determination for overcurrent, phases and ground		
	67Ns	Directional sensitive ground-fault detection		
	67Ns	Directional intermittent ground fault protection		
	87N	High-impedance restricted ground fault		
		Intermittent earth-fault		
Basic + Dir. Sens.earth-f-det. V,P,f REF[2]		Basic version included		F F
	67Ns	Directional sensitive ground-fault detection		
	67Ns	Directional intermittent ground fault protection		
	87N	High-impedance restricted ground fault		
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27Q	Undervoltage-controlled reactive power protection		
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		
Basic + Dir. Sens.earth-f-det. REF[2]		Basic version included		F B
	67Ns	Directional sensitive ground-fault detection		
	67Ns	Directional intermittent ground fault protection		
	87N	High-impedance restricted ground fault		
Basic + Dir. Sens.earth-f-det. Motor V,P,f REF[2]		Basic version included		H F
	67Ns	Directional sensitive ground-fault detection		
	67Ns	Directional intermittent ground fault protection		
	87N	High-impedance restricted ground fault		
	48/14	Starting ime supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Motor load jam protection		
		Motor statistics		
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27Q	Undervoltage-controlled reactive power protection		
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		
Basic + Sens.earth-f-det. Motor Dir V,P,f REF[2]		Basic version included		H H
	67/67N	Direction determination for overcurrent, phases and ground		
	67Ns	Directional sensitive ground-fault detection		
	67Ns	Directional intermittent ground fault protection		
	87N	High-impedance restricted ground fault		
	48/14	Starting ime supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Motor load jam protection		
		Motor statistics		
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27Q	Undervoltage-controlled reactive power protection		
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		

Continued on next page

V, P, f = Voltage, power, frequency protection
Dir = Directional overcurrent protection
IEF = Intermittent ground fault
REF = Restricted earth fault
Motor = Motor protection

2) For isolated/compensated networks, only with postition 7=2,6 (sensitive earth current input)

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Selection and ordering data

Description			Order No.	Order code
			12345 6 7 8 9 10 11 12 13 14 15 16 17 18 19	
SIPROTEC 7SJ66 multifunction protection relay and bay controller			**7SJ66**□□-□□□□□-□□□□ □□□	
	ANSI No.	Description		
Basic + Dir. S.EF Motor[2]	Basic version included			R H
	67/67N	Direction determination for overcurrent, phases and ground		
	67Ns	Directional sensitive ground-fault detection		
	67Ns	Directional intermittent ground fault protection		
	87N	High-impedance restricted ground fault		
	48/14	Starting ime supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Motor load jam protection Motor statistics		
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27Q	Undervoltage-controlled reactive power protection		
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		
Basic + Motor Dir V,P,f		Basic version included		H G
	67/67N	Direction determination for overcurrent, phases and ground		
	48/14	Starting ime supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Motor load jam protection Motor statistics		
	27/59	Under-/overvoltage		
	81O/U	Under-/overfrequency		
	27Q	Undervoltage-controlled reactive power protection		
	27/47/59(N) 32/55/81R	Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection		
Basic + Motor		Basic version included		H A
	48/14	Starting ime supervision, locked rotor		
	66/86	Restart inhibit		
	51M	Motor load jam protection Motor statistics		
			13	
		Measuring/fault recording	□	
		With fault recording	1	
		Slave pointer, average values, min/max-values with fault recording	3	
			16	
		ARC, fault locator, synchro-check	□	
		without	0	
	79	with autoreclose	1	
	21FL	with fault locator	2	
	79,21FL	with 79 and fault locator	3	
	25	with synchro-check [3]	4	
	25, 79, 21FL	with synchro-check [3], with auto reclose, with fault recorder	7	

Motor = Motor protection
V, P, f = Voltage, power, frequency protection
Dir = Directional overcurrent protection
IEF = Intermittent ground fault

2) Only with position 7 = 2, 6 (sensitive earth current input).
3) Synchrocheck (no asynchronous switching), one function group

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Accessories	Description	Order No.
	Temperature monitoring box	
	RTD-box TR1200 (RS 485)	7XV5662-6AD10
	RTD-box TR1200 IP (Ethernet)	7XV5662-8AD10
	Varistor / Voltage Arrester	
	Voltage arrester for high-impedance REF protection 125 Vrms; 600 A; 1S/S 256	C53207-A401-D76-1
	240 Vrms; 600 A; 1S/S 1088	C53207-A401-D77-1
	Manual for 7SJ66	
	English	C53000-B1140-C383-x [1]

1) x = please inquire for latest edition (exact Order No.)

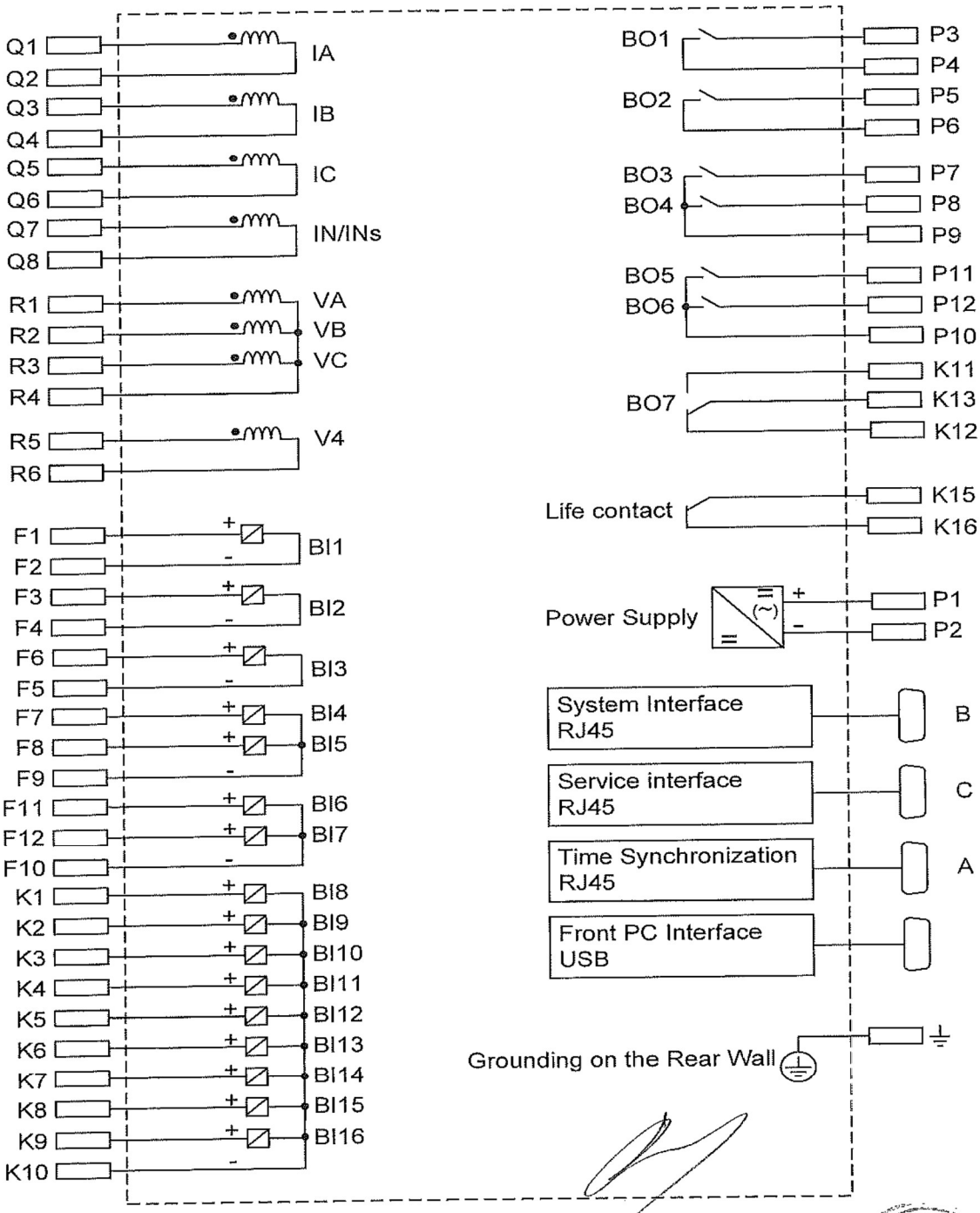

Fig. 5/151 SIPROTEC 7SJ661 connection diagram

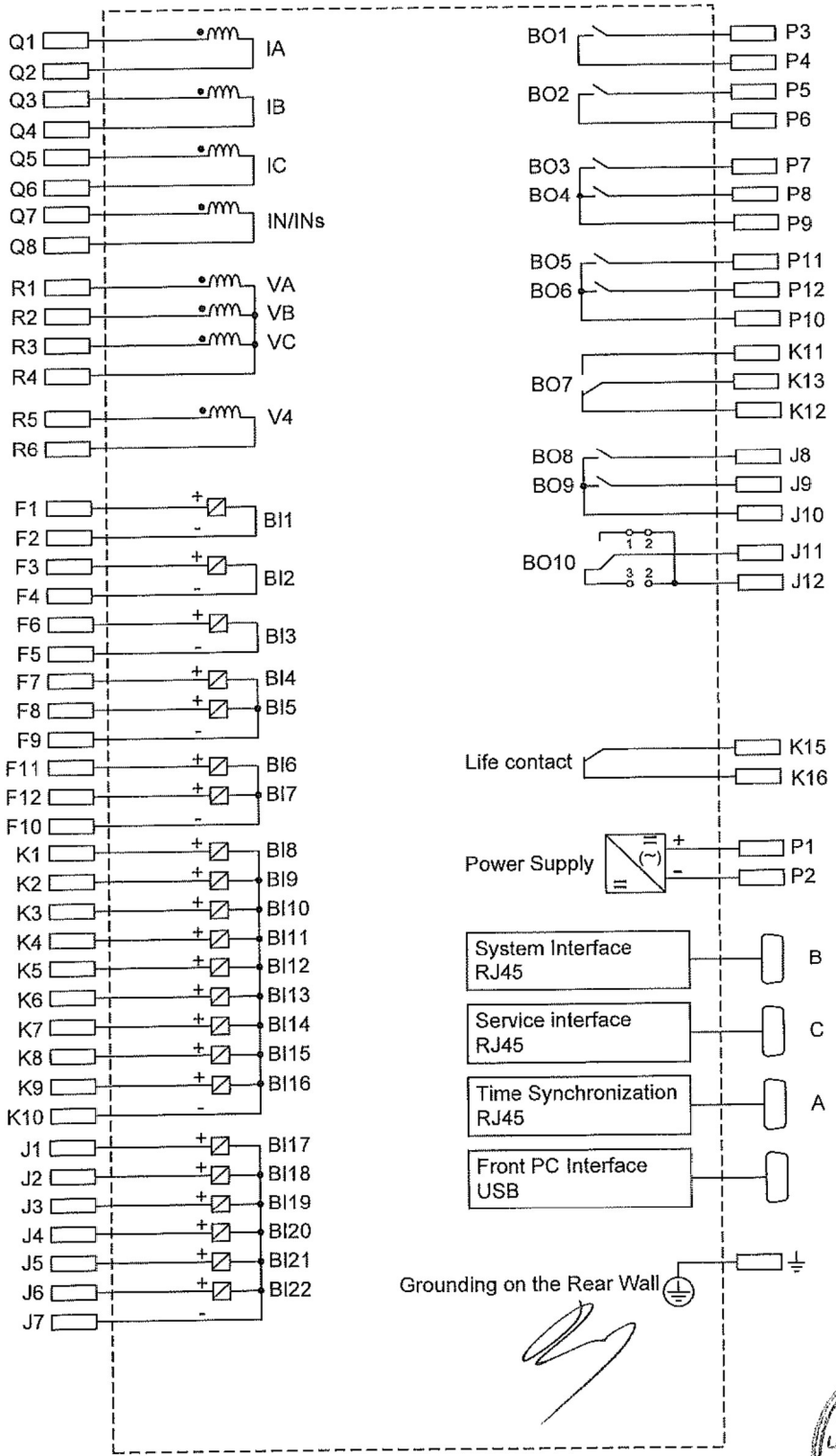

Fig. 5/152 SIPROTEC 7SJ662 connection diagram

Connection diagram

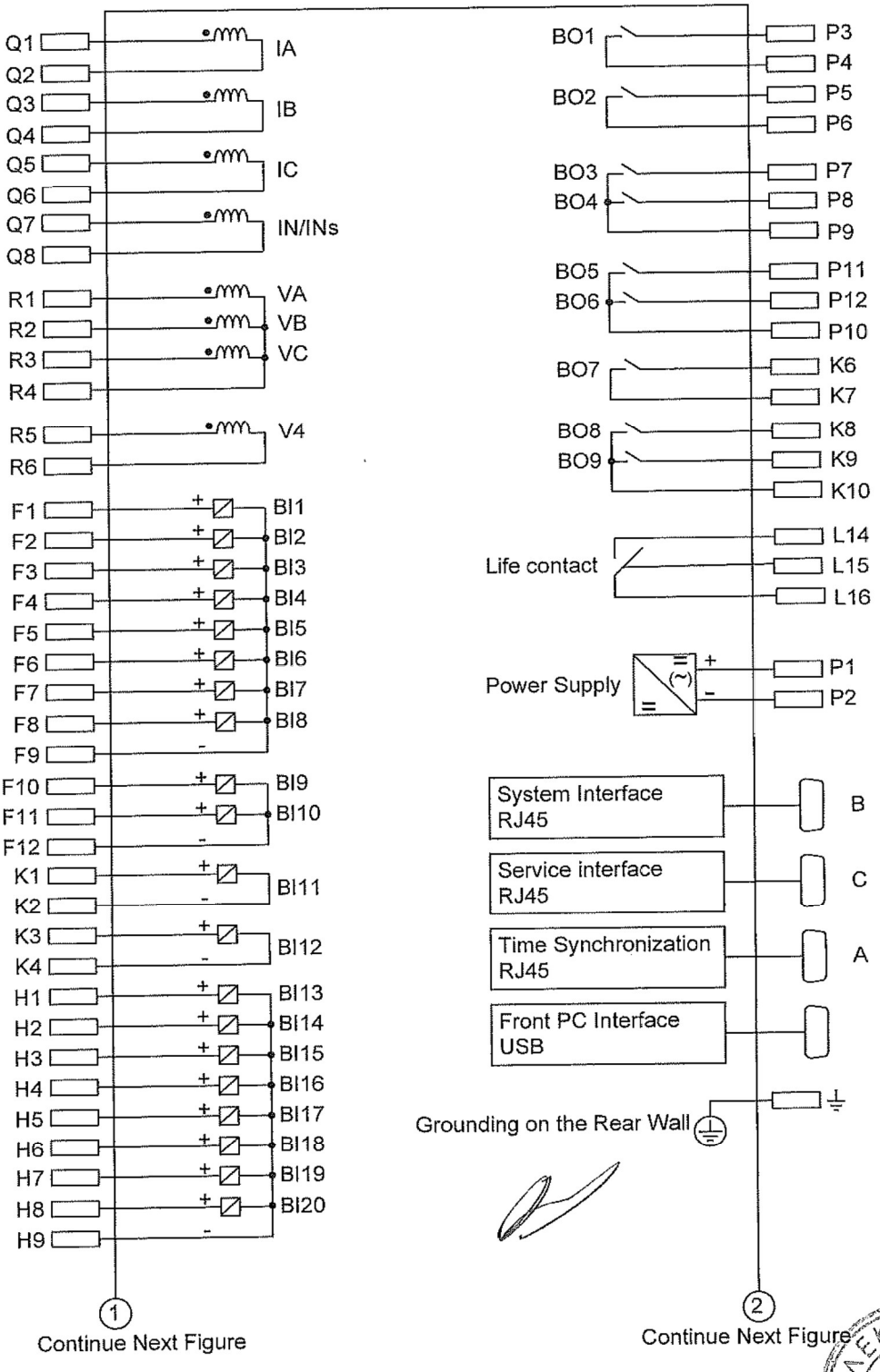

Fig. 5/153 SIPROTEC 7SJ663 connection diagram

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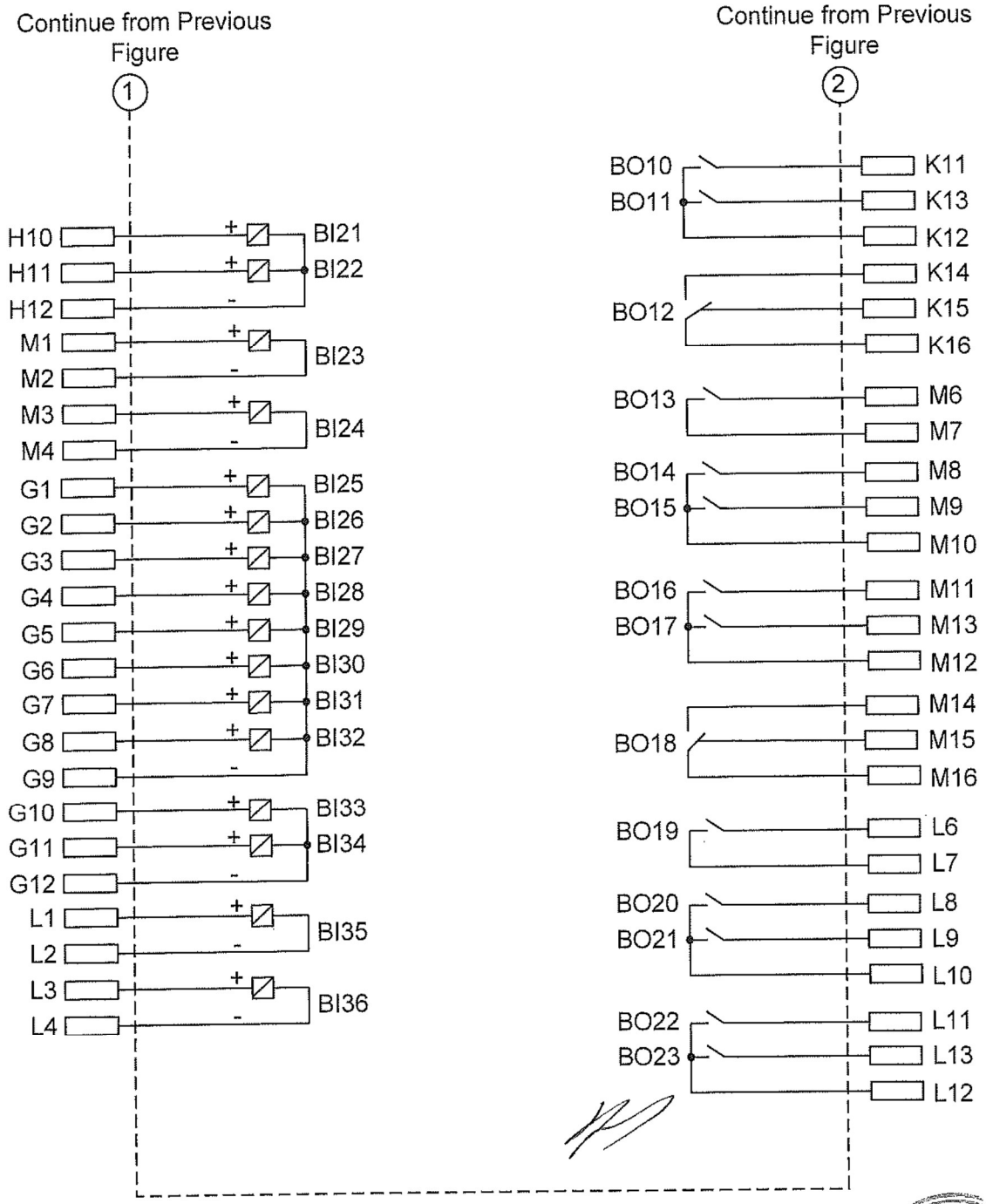
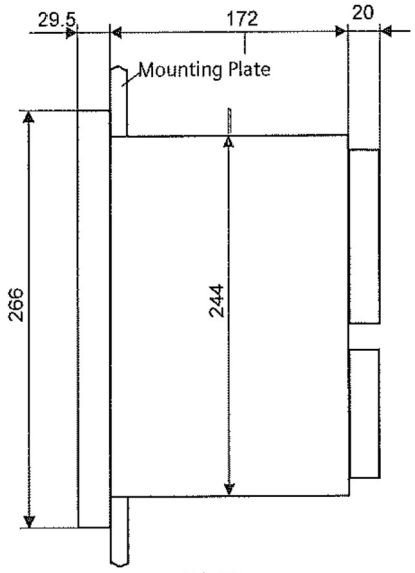
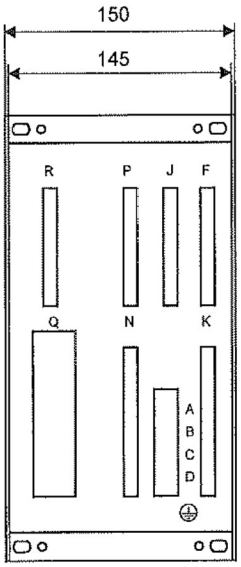


Fig. 5/154 SIPROTEC 7SJ663 connection diagram

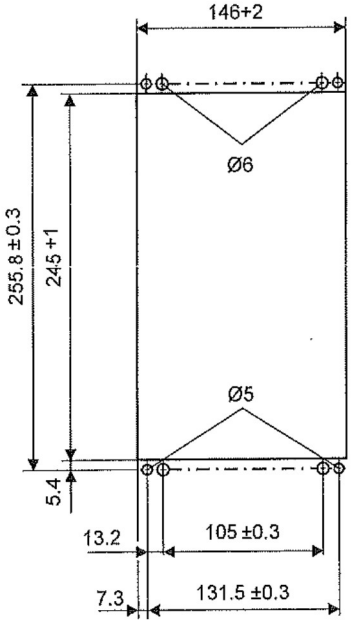
Dimensions



Side View



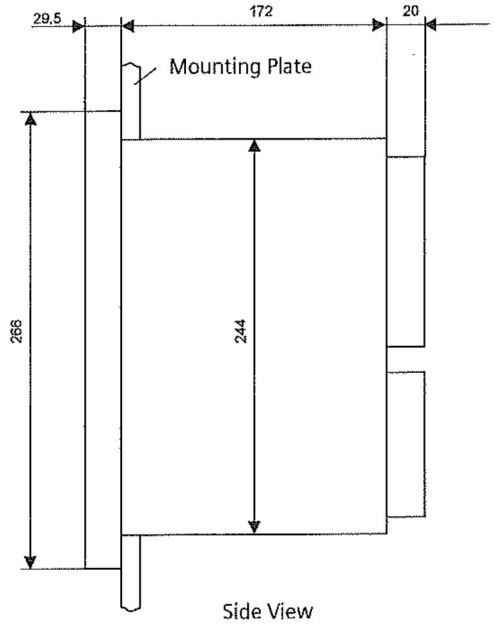
Rear View



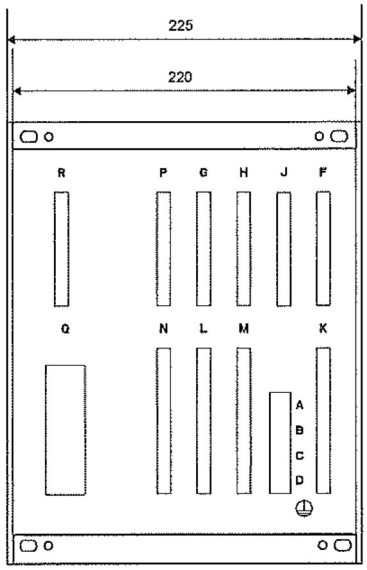
Dimensional Drawing
(Front View)

Fig. 5/155 Dimensional drawing for SIPROTEC 7SJ66 (housing size 1/3)

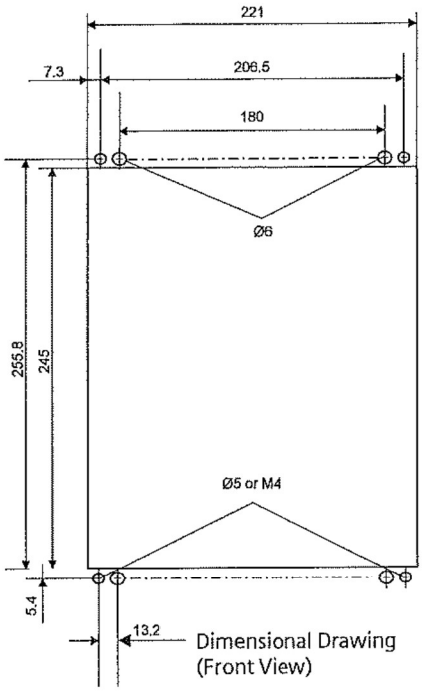
Dimensions in mm



Side View



Rear View



Dimensional Drawing
(Front View)

Fig. 5/156 Dimensional drawing of a SIPROTEC 7SJ66 (housing size 1/2)

SIPROTEC 5 Devices and Fields of Application

Bay Controllers – SIPROTEC 6MD85

Description

The SIPROTEC 6MD85 bay controller is a general-purpose control and automation device with protection function. It is designed for use in all voltage levels from distribution to transmission. As part of the SIPROTEC 5 family, it enables a wealth of protection functions from the SIPROTEC library. The modular hardware permits integration of the IOs depending on the action. Adapt the hardware exactly to your requirements and rely on future-oriented system solutions with high investment security and low operating costs.

Main function	Bay controller for medium and high to extra-high voltage switchgear with integrated operation and comprehensive protection functions. Powerful automation, simple configuration with DIGSI 5
Inputs and outputs	5 predefined standard variants with 4 current transformers, 4 voltage transformers, 11 to 75 binary inputs, 9 to 41 binary outputs
Hardware flexibility	Flexibly adjustable and expandable I/O quantity structure within the scope of the SIPROTEC 5 modular system. If high requirements are placed on the quantity structure, the device can be extended in the 2nd row. For example, 240 (and more) binary inputs are possible with the IO230.
Housing width	1/3 x 19 inch to 2/1 x 19 inch

Benefits

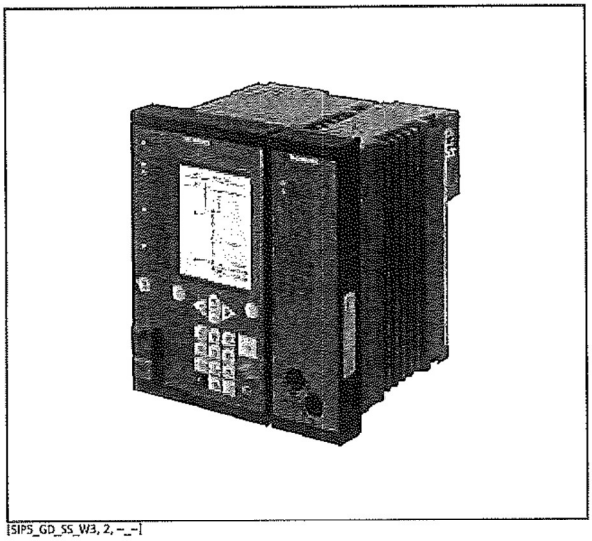
- Safe and reliable automation and control of your plants
- Purposeful and simple operation of the devices and software thanks to user-friendly design
- Cybersecurity to NERC CIP and BDEW Whitepaper requirements
- Highest availability even under extreme environmental conditions by standard coating of the modules
- Powerful communication components ensure safe and effective solutions
- High investment security and low operating costs due to future-oriented system solution

2.16

Functions

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

- Integrated bay controller with versatile protection function from medium to extra-high voltage
- Control of switching devices
- Synchrocheck and switchgear interlocking protection
- Fixed integrated electrical Ethernet RJ45 interface for DIGSI 5 and IEC 61850 (reporting and GOOSE)
- Up to 4 pluggable communication modules, usable for different and redundant protocols (IEC 61850-8-1, IEC 61850-9-2 Client, IEC 61850-9-2 Merging Unit, IEC 60870-5-103, IEC 60870-5-104, Modbus TCP, DNP3 serial and TCP, PROFINET IO)



[SIP5_GD_SS_W3, 2, --_--]

Figure 2.16/2 Bay Controller SIPROTEC 6MD85 (1/3 Device with 1/6 Expansion Module with Key Switch Operation Panel)

- Reliable data transmission via PRP and HSR redundancy protocols
- Arc protection
- Extensive cyber security functionality, such as role-based access control (RBAC), logging of security-related events or signed firmware
- Simple, quick and secure access to device data via a standard Web browser – without additional software
- Graphical logic editor to create powerful automation functions in the device
- Optional overcurrent protection for all voltage levels with 3-pole tripping
- Also used in switchgear with breaker-and-a-half layout
- Selective protection of overhead lines and cables with single-ended and multi-ended feeders using protection communication
- Overcurrent protection also configurable as emergency function
- Secure serial protection communication, also over great distances and all available physical media (optical fiber, two-wire connections and communication networks)
- Capturing operational measured variables and protection function measured values to evaluate the plant state, to support commissioning, and to analyze faults
- Synchrophasor measured values with the IEEE C37.118 protocol integrated (PMU)
- Powerful fault recording (buffer for a max. record time of 80 sec. at 8 kHz and 320 sec. at 2 kHz)
- Auxiliary functions for simple tests and commissioning
- Flexibly adjustable I/O quantity structure within the scope of the SIPROTEC 5 modular system.

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Applications

The SIPROTEC 6MD85 bay controller is a general-purpose control and automation device with a protection function based on the SIPROTEC 5 system. The standard variants of the SIPROTEC 6MD85 device are delivered with instrument transformers. Furthermore, protection-class current transformers are also possible in SIPROTEC 6MD85 devices, thus allowing protection functions to be used. Due to its high flexibility, the device is suitable as selective protection equipment for overhead lines and cables with single-ended and multi-ended infeeds when protection communication is used. The device supports all SIPROTEC 5 system characteristics. It enables upgradeable system solutions with high investment security and low operating costs.

Application Templates

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

The following application templates are available:

- *SIPROTEC 6MD85 Standard*
  - Double busbar feeder with switchgear interlocking protection
- *SIPROTEC 6MD85 Not preconfigured*
- *SIPROTEC 6MD85 Extended control*
  - In addition to the SIPROTEC 6MD85 Standard application template, this template also includes the CFC building blocks for switching sequences and arithmetic.
  - Switching sequence for automatic busbar switchover is preconfigured (triggered by function key)

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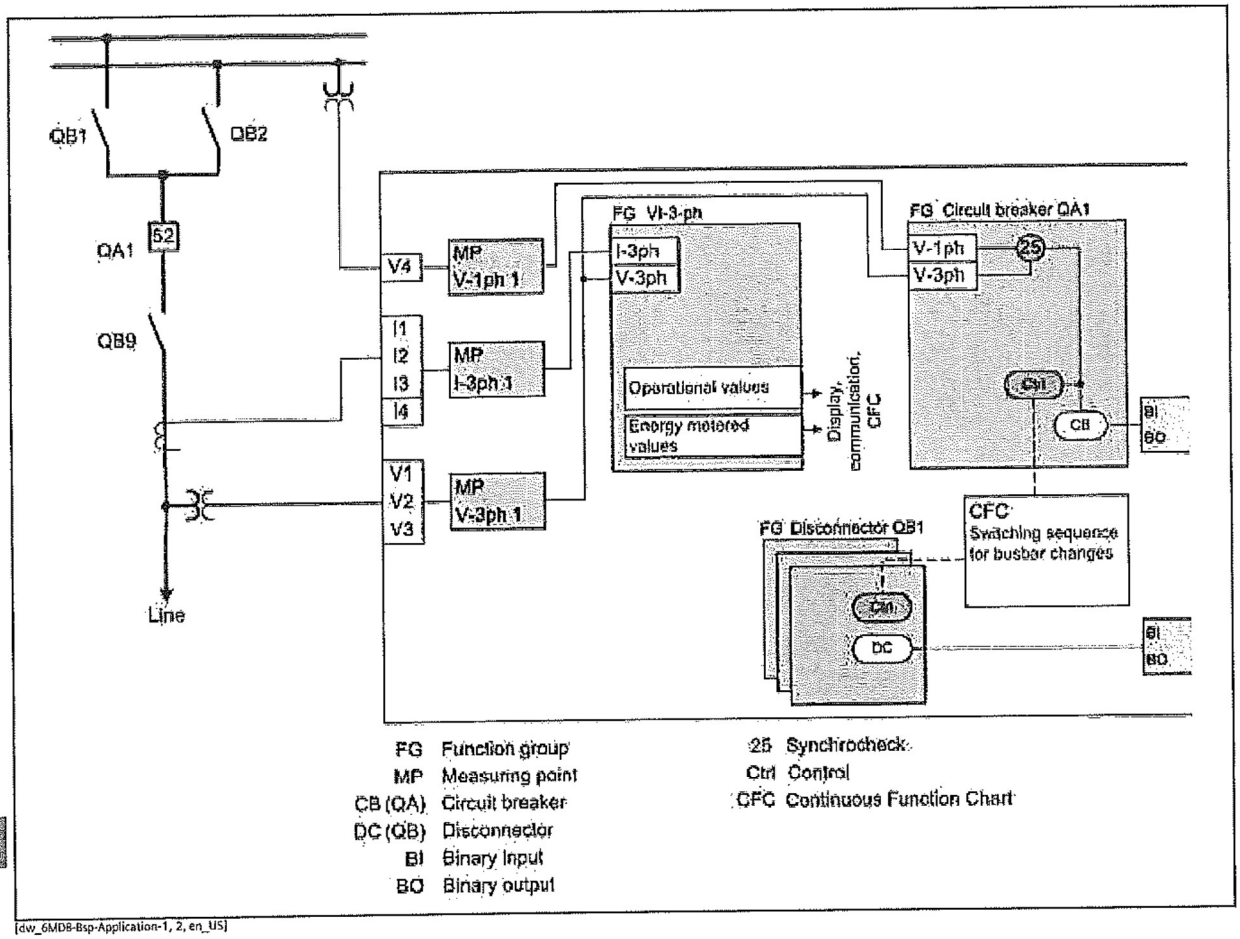
Application Example

Double Busbar with Switching Sequences

Figure 2.16/3 shows a simple typical application with a SIPROTEC 6MD85 on a double busbar. The **FG Circuit breaker** function group includes the synchrocheck. The disconnectors are also controlled by 1 function group each. Operational measured values and energy metered values are calculated in the **FG VI-3-ph** function group. They are available for output on the display, transfer to the substation automation technology, and processing in the CFC. A switching sequence stored in the CFC that is activated via a function key starts an automatic busbar switchover process.



[dw_6MD8-Bsp-Application-1, 2, en_US]

Figure 2.16/3 SIPROTEC 6MD85 Bay Controller for Double Busbars with Switching Sequence for Busbar Switchover

ANSI	Functions	Abbr.	Available	Template		
				1	2	3
	Protection functions for 3-pole tripping	3-pole	■	■	■	■
	Hardware quantity structure expandable	I/O	■	■	■	■
	Process Bus Client Protocol (Note: This function requires at least one dedicated ETH-BD-2FO plug-in module, with V8.0)	PB client	■			
	IEC61850-9-2 Merging Unit stream (Note: This function requires a dedicated ETH-BD-2FO per stream, with V8.0)	MU	■			
25	Synchrocheck, synchronization function	Sync	■			
32, 37	Power protection active/reactive power	P<>, Q<>	■			
27	Undervoltage protection: "3-phase" or "universal Vx"	V<	■			
38	Temperature supervision	θ>	■			
46	Negative-sequence overcurrent protection	I2>	■			
49	Thermal overload protection	θ, I²t	■			
50N/ 51N TD	Overcurrent protection, ground	IN>	■			
50/51 TD	Overcurrent protection, phases	I>	■			
	Instantaneous tripping at switch onto fault	SOTF	■			
50HS	Instantaneous high-current tripping	I>>>	■			
51V	Overcurrent protection, voltage dependent	t=f(I,V)	■			
59	Overvoltage protection: "3-phase" or "positive-sequence system V1" or "universal Vx"	V>	■			
67	Directional overcurrent protection, phases	I>, ∠(V,I)	■			
67N	Directional overcurrent protection, ground	IN>, ∠(V,I)	■			
74TC	Trip-circuit supervision	TCS	■			
74CC	Closed-circuit supervision (from V7.9)	CCS	■			
81	Frequency protection: "f>" or "f<" or "df/dt"	f<>; df/dt<>	■			
81U	Underfrequency load-shedding	f<(UFLS)	■			
86	Lockout		■			
90V	Automatic Voltage controller for two-winding transformer		■			
90V	Automatic Voltage controller for two-winding transformer with parallel operation		■			
	Number of two-winding transformers with parallel operation (Note: only together with the function "Automatic Voltage controller for two-winding transformer with parallel operation")		■			
90V	Automatic Voltage controller for three-winding transformer		■			
90V	Automatic Voltage controller for grid coupling transformer		■			
PMU	Synchrophasor measurement	PMU	■			
AFD	Arc-protection (only with plug-in module ARC-CD-3FO)		■			
	Measured values, standard		■	■		■
	Measured values, extended: Min, Max, Avg		■			■
	Basic PQ measurements: THD and harmonics (from V8.01)		■			
	Switching statistic counters		■	■		■
	Circuit-breaker wear monitoring	ΣIx, I²t, 2P	■			
	CFC (Standard, control)		■	■		■
	CFC arithmetic		■			
	Switching sequences function		■			■
	Inrush current detection		■			

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ANSI	Functions	Abbr.	Available	Template 1	Template 2	Template 3
	External trip initiation		■			
	Control		■	■		■
	Fault recording of analog and binary signals		■	■		■
	Monitoring and supervision		■	■		■
	Protection interface, serial		■			
	Circuit-breaker		■	■		■
	Disconnector/Grounding switch		■	■		■
	Frequency-tracking groups (from V7.8)		■			
	Temperature acquisition via communication protocol		■			
	Cyber Security: Role-Based Access Control (from V7.8)		■			
Function-points class:				0	0	20
The configuration and function points for your application can be ascertained in the SIPROTEC 5 order configurator under: *www.siemens.com/siprotec*						

Table 2.16/2 SIPROTEC 6MD85 - Functions and application templates

(1) Standard

(2) Not Configured

(3) Extended Control

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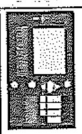
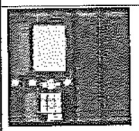
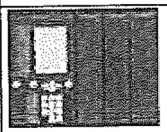
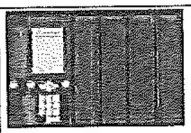
Standard Variants for SIPROTEC 6MD85		
J1	1/3, 11 BI, 9 BO, 4 I, 4 V	
	Housing width 1/3 x 19" 11 binary inputs 9 binary outputs (1 life contact, 2 standard, 6 fast) 4 sensitive current-transformer inputs 4 voltage-transformer inputs Contains the following modules: base module with PS201 and IO202	
J2	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 sensitive current-transformer inputs 4 voltage-transformer inputs Contains the following modules: base module with PS201 and IO202 Expansion module IO207	
J4	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 sensitive current-transformer inputs 4 voltage-transformer inputs Contains the following modules: base module with PS201 and IO202 Expansion modules 2 x IO207	
J5	5/6, 59 BI, 33 BO, 4 I, 4 V	
	Housing width 2/3 x 19" 59 binary inputs 33 binary outputs (1 life contact, 26 standard, 6 fast) 4 sensitive current-transformer inputs 4 voltage-transformer inputs Contains the following modules: base module with PS201 and IO202 Expansion modules 3 x IO207	
J7	1/1, 75 BI, 41 BO, 4 I, 4 V	
	Housing width 1/1 x 19" 75 binary inputs 41 binary outputs (1 life contact, 34 standard, 6 fast) 4 sensitive current-transformer inputs 4 voltage-transformer inputs Contains the following modules: base module with PS201 and IO202 Expansion modules 4 x IO207	

Table 2.16/3 Standard Variants for Bay Controllers SIPROTEC 6MD85

2.16

You can find the technical data of the devices in the manual
www.siemens.com/siprotec

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