



UNIVERSAL PROTECTION DEVICE

# SIPROTEC 5 Compact – 7SX800

Catalog • Edition 5

**SIEMENS**



## SIPROTEC 5 Compact

Catalog Edition 5 from V9.50

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Edition 4

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**Figure /1** SIPROTEC 5 Compact

## Editorial

We are proud to show you the new SIPROTEC 5 Compact device – a universal SIPROTEC protection device with clear focus on medium voltage, industrial and infrastructure applications, but which can also be used in high voltage applications.

Generations of Siemens protection experts have developed and produced SIPROTEC, placing vast specialist knowledge and passion in every device even before the start of the digital era. All of this experience has been incorporated into the development of our new SIPROTEC 5 Compact series.

As before, we will continue to be a faithful partner for you.

The new SIPROTEC 5 Compact – SIPROTEC 7SX800 – stands for the highest production and development quality from Siemens. It is an extension of the SIPROTEC 5 generation range and adopts all system properties and benefits of SIPROTEC 5.

Whether you need an overcurrent device for a feeder, want to protect a motor or need a device for power system decoupling, the universal approach of SIPROTEC 5 Compact ensures that it is just right for your application.

Your protection device will always be the same – SIPROTEC 7SX800!

With SIPROTEC 5 Compact, you are well equipped to meet the growing economic and availability requirements imposed on your power systems.

Our guiding theme for the development of this new device type:

### **SIPROTEC 5 Compact**

**| From Siemens | For the Future | For You**

Smart Infrastructure

Digital Grid

Energy Automation

# SIPROTEC 5 Compact

## Overview

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### I From Siemens

SIPROTEC has stood for reliable protection for over 100 years.

For generations, Siemens protection experts have used expert knowledge and passion to develop and produce the devices.

- Experience from over 2.2 million SIPROTEC devices.
- Certified and proven development and production process
- Algorithms and benefits of SIPROTEC 5 in a compact housing

### I For the Future

SIPROTEC 5 Compact is already prepared for the challenges of the future.

- Virtual tests with SIPROTEC DigitalTwin for shorter test times and less work
- IoT connectivity for quicker response times and greater power system availability
- Integrated cybersecurity to protect your device and guarantee the optimum power system availability

### I For You

For both novices and professionals

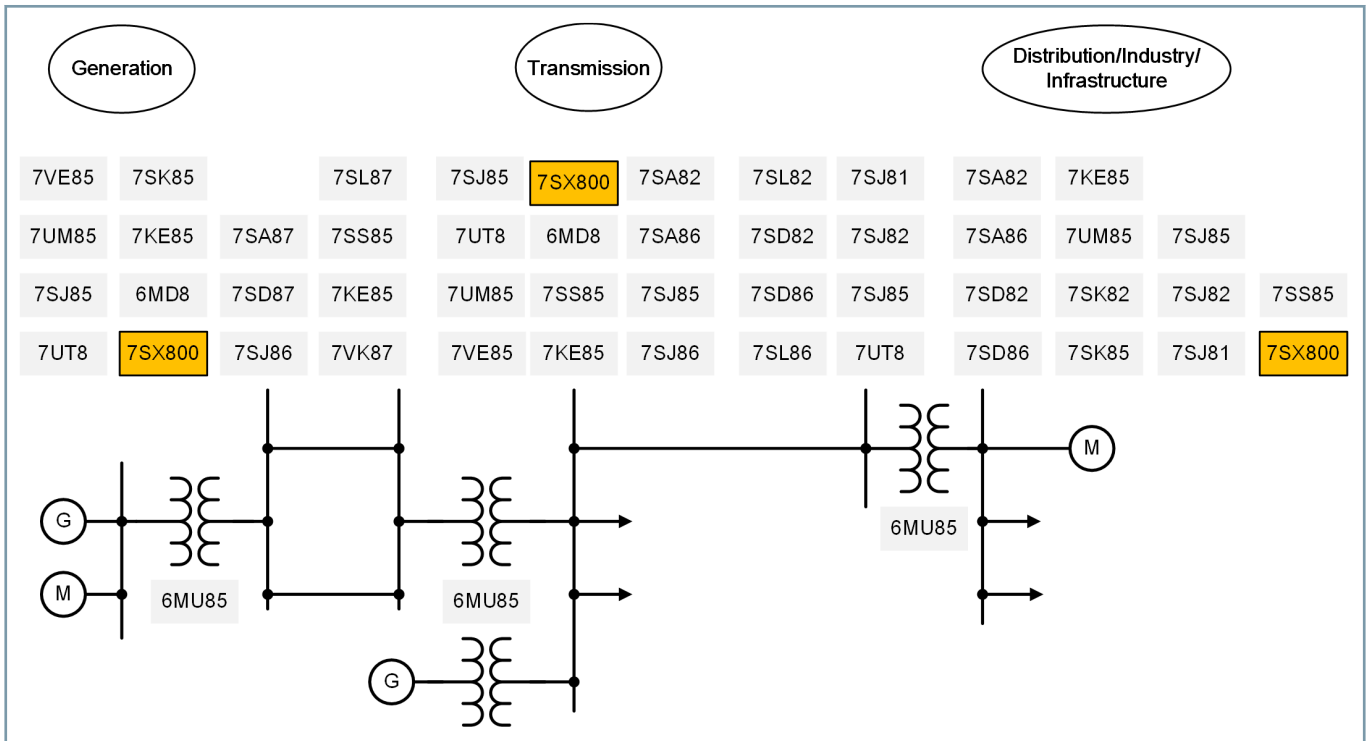
SIPROTEC 5 Compact offers the right application for everyone. We have added special functions even for experienced protection experts.

- Universal device for various uses and a low number of models
- Single-line display as quick and clear user interface
- High density of inputs/outputs for small and compact switch-gears



[img\_SIPROTECS\_C\_W9\_3\_...]

Figure 1.1/1 SIPROTEC 5 Compact – Rear View



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**Figure 1.2/1** Field of application for SIPROTEC 5 and SIPROTEC 5 Compact devices

The graphic gives an simplified overview of the utilization of SIPROTEC 5 and SIPROTEC 5 Compact devices in the power system. With renewable energy producers, in particular, there is power infeed into the grid at all voltage levels. Protected objects are busbars, overhead lines or cables, and transformers. These objects have the corresponding protection device allocated.

# SIPROTEC 5 Compact

## 7SX800 Universal Protection Device

### Description

SIPROTEC 7SX800 is a universal, compact protection device forming part of the SIPROTEC 5 device series. As a universal device it helps you renewing your device variants and the associated training and spare parts costs.

1.2

It has been specifically developed for the efficient and compact protection of feeders, lines and motors in medium-voltage systems, but can also be used in the low and high voltage range. It covers the most diverse protection, automation, and monitoring applications with its modular functional scope.

The new universal device enables the connection of a large number of inputs and outputs within a very small space and boasts a comprehensive library of protection functions that you can easily activate for your application using function points.

SIPROTEC 7SX800 already features future-proof functions today. Virtual testing with SIPROTEC DigitalTwin considerably cuts the testing and fault analysis times. IoT connectivity is required to provide simple access to your device data and guarantee quick response times. The integrated cybersecurity functions comprehensively protect your device and support your power system's maximum availability.

Based upon the SIPROTEC 5 platform and the powerful DIGSI 5 engineering tool, the functional scope and thus applications of SIPROTEC 7SX800 are continuously enhanced. Future-proof system solutions, high investment security and low operating costs – this is what SIPROTEC 7SX800 stands for.

Main function	<ul style="list-style-type: none"> <li>• Feeder and overcurrent protection for all voltage levels</li> <li>• Motor protection for small to medium-sized motors (100 kW to 2 MW)</li> <li>• Voltage and frequency protection</li> </ul>
Inputs and outputs	4 current transformers, 4 voltage transformers, 4, 14 or 17 binary inputs, 5, 11 or 8 binary outputs
Width of housing	1/6 × 19 inches

### Benefits

- Compact and inexpensive universal protection device for a wide variety of applications
- Safety thanks to powerful as well as tried-and-tested protection functions
- Easy to use thanks to the graphic display with single-line representation
- Intuitive device operation using web UI
- Cybersecurity in accordance with NERC CIP and BDEW white paper requirements is available as standard
- Full compatibility between IEC 61850 Editions 1, 2.0 and 2.1



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Figure 1.2/2 SIPROTEC 5 Compact – Universal Protection Device

### Functions

- Directional and non-directional overcurrent protection with additional functions
- Detection of ground faults of any type in arc-suppression-coil-grounded or isolated neutral power systems using the following functions: 3I0>, V0>, fleeting contact, cos φ, sin φ, harmonic, directional detection of intermittent ground faults and admittance, pulse pattern detection
- Optimized tripping times thanks to directional comparison
- Motor protection functions: Startup time monitoring, thermal overload protection for stator and rotor, restart inhibit, unbalanced-load protection, load-jam protection
- Stator and bearing temperature monitoring via temperature sensors with external RTD unit.
- Sensitive ground-fault protection (non-directional, directional) to detect stator ground faults
- Targeted automatic reclosing (AREC) of overhead line sections
- Overvoltage and undervoltage protection
- Frequency protection and frequency change protection for load shedding applications
- Underfrequency load shedding in case of underfrequency, taking into consideration changed infeed conditions thanks to decentralized power generation
- Power protection, configurable as active or reactive power protection
- PQ – Basic: Voltage unbalance; voltage changes: Overvoltage, dip, open circuit; TDD, THD and harmonic component
- Directional reactive power undervoltage protection (undervoltage-controlled reactive power protection)
- Control, synchrocheck and switchgear interlocking protection
- Circuit-breaker failure protection and reignition monitoring
- Graphical logic editor
- Single line display

### Applications

- Detection and selective 3-pole tripping of short circuits in electrical equipment of star networks, lines with infeed at one or two ends, parallel lines and open-circuited or closed ring systems of all voltage levels
- Detection of ground faults in isolated or arc-suppression-coil-ground power systems in star, ring, or meshed arrangement
- Backup protection for differential protection devices of all kind for lines, transformers, generators, motors, and busbars
- Protection and interfacing of regenerative infeeds
- Protection and monitoring of double star connection capacitor banks
- Protection against thermal overload of the stator due to over-current, cooling problems, or pollution as well as of the rotor during startup due to frequent startups, excessively long startups or locked rotor
- Monitoring for voltage unbalance or phase outage
- Monitoring the thermal state and the bearing temperatures with temperature measurement
- Detection of idling drives of pumps and compressors, for example
- Detection of ground faults and short circuits on the motor
- Protection against instability due to undervoltage.
- Detection and recording of power quality data in the medium-voltage and subordinate low-voltage power system
- Load shedding applications
- Retrofits

### Our Tip:

Register in the [Industry Mall](#), create a user account and benefit fully from our SIPROTEC 5 configurator.

Advantages/benefits for users registered and logged in to the Industry Mall:

- Personal product list, including automatic storage of the last 50 configurations
- Insertion of comments (for example designation of a feeder name for the configured device)
- Automatic saving of the function point calculation
- Visibility of regional list prices (non-logged-in users get the message: price upon request)

# SIPROTEC 5 Compact

## Application Examples – Overcurrent protection

### Overcurrent Protection

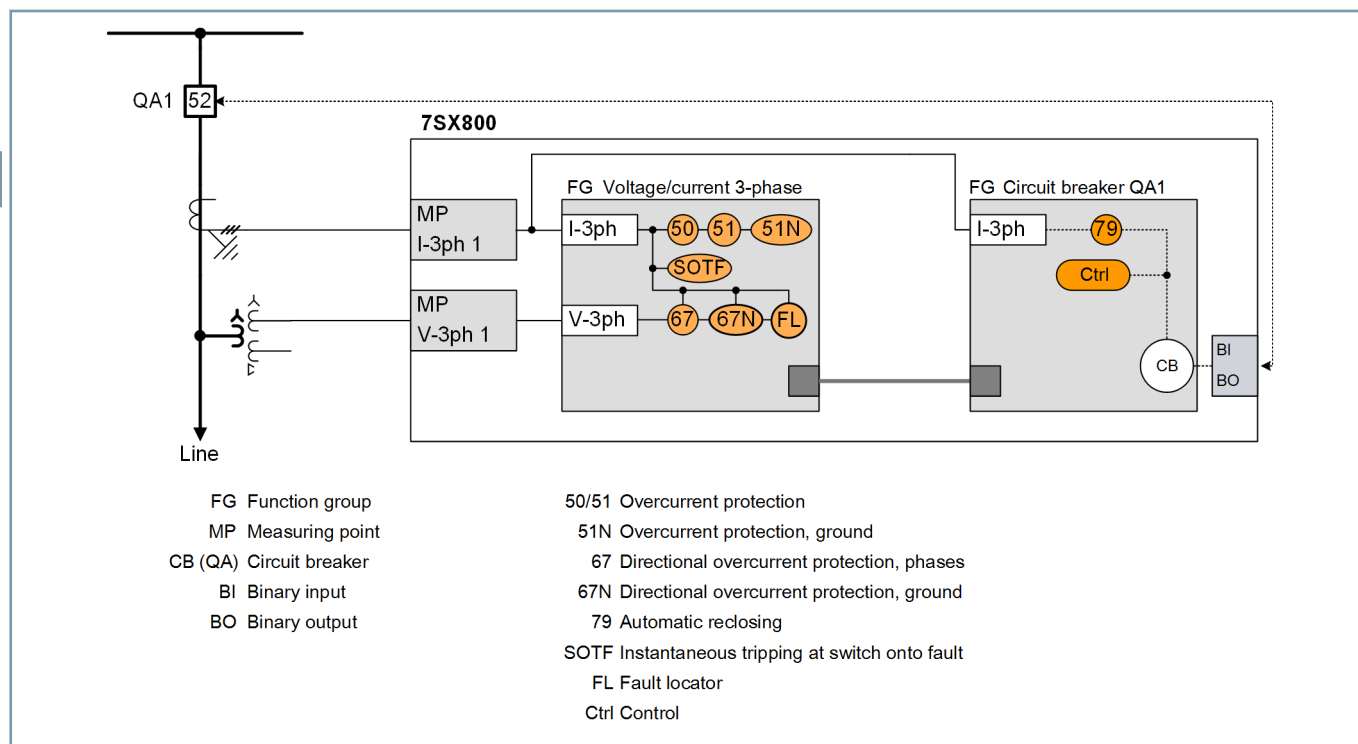


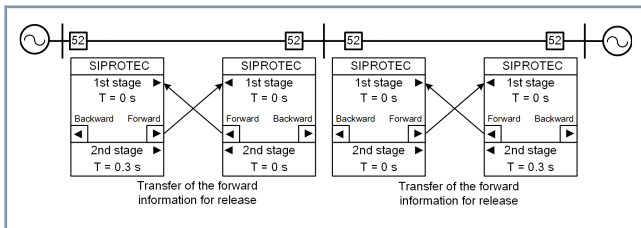
Figure 1.3/1 Application Example – Overcurrent Protection

#### Properties

- Preconfigured devices with application templates
- Easy addition of additional functions via the library

### Directional Comparison Protection for Power Line Runs with Infeed at Two Ends

Using the direction determination of the directional overcurrent protection, you can implement directional comparison protection for power line runs with an infeed at both ends (Figure 1.3/2). Directional comparison protection is used for the selective isolation of a faulty line section (subsections of closed ring feeders, for example). Sections are isolated in fast time, that is, they do not suffer the disadvantage of long grading times. This technique requires that directional information can be exchanged between the individual protection stations. You can implement this information exchange using, for example, IEC 61850 GOOSE or with pilot wires for signal transmission via an auxiliary voltage loop.



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**Figure 1.3/2** Principle of directional comparison protection for power line runs with infeed at two ends

# SIPROTEC 5 Compact

## Application Examples – Induction Motor

### Induction Motor: Protection and Control

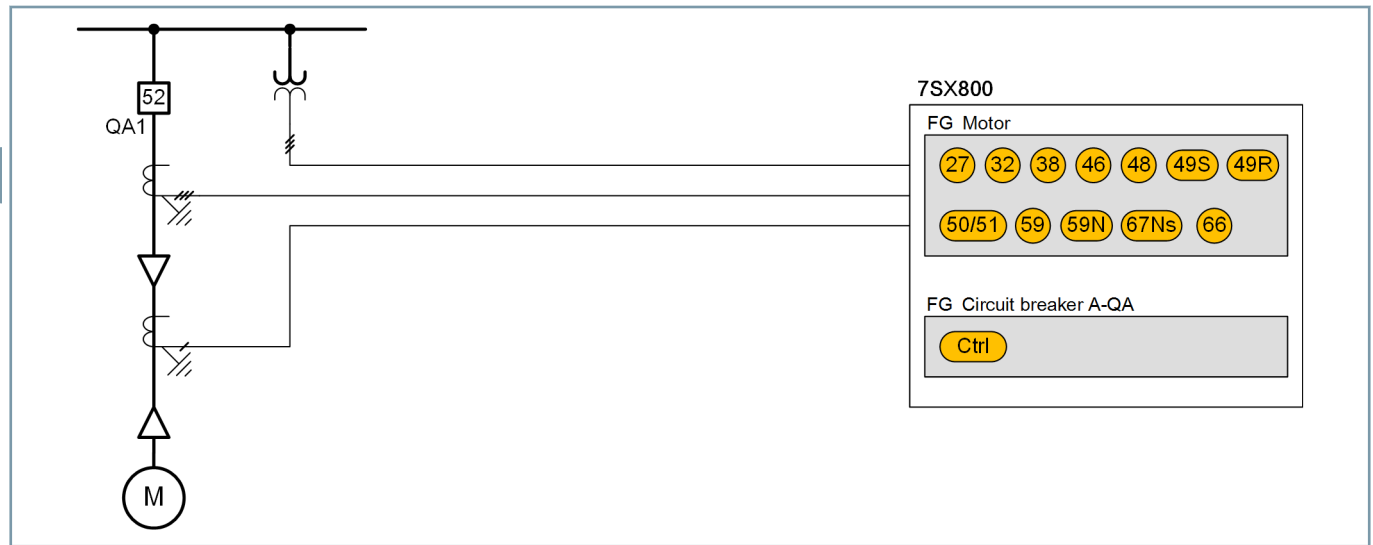


Figure 1.3/3 Induction Motor: Protection and Control

#### Properties

- Reduced investment due to protection and control in one device
- Thermal motor protection functions for safe monitoring of the motor
- Thermal motor protection functions due to connection to an RTD unit



### Application Templates

Application templates are available in DIGSI 5 for standard applications. They contain basic configurations and default settings.

ANSI	Function	Abbr.	Available	Application templates (template)							
				1	2	3	4	5	6	7	
	Protection functions for 3-pole tripping		■								
14	Locked rotor		■					■	■		
24	Overexcitation protection	V/f	■								
25	Syncheck, synchronization function	Sync	■								
27	Undervoltage protection	V<	■							■	■
	Directional reactive power undervoltage protection (undervoltage-controlled reactive power protection)	Q>V<	■								
32	Power protection active/reactive power	P<>, Q<>	■								
32R	Reverse-power protection	-P<	■								
37	Undercurrent protection, minimum power	I<, P<	■								
38	Temperature supervision	θ>	■					■	■		
46	Negative-sequence system overcurrent protection	I2>	■								
46	Unbalanced-load protection (thermal)	I2² t>	■					■	■		
46	Negative-sequence overcurrent protection with direction	I2>, ∠(V2, I2)	■								
47	Overvoltage protection: "Negative-sequence system V2" or "negative-sequence system V1/positive-sequence system V1"	V2>; V2/V1>	■								
48	Starting time monitoring for motors	I²start	■					■	■		
49	Thermal overload protection	θ, I²t	■					■	■		
49	Thermal overload protection, user-defined characteristic curve	θ, I²t	■								
49R	Thermal overload protection, rotor (motor)	θR	■					■	■		
50N/51N TD	Overcurrent protection, ground	IN>	■	■	■	■		■	■		
50/51 TD	Overcurrent protection, phases	I>	■	■	■	■	■	■	■		
	Instantaneous tripping at switch onto error	SOTF	■								
50HS	Instantaneous high-current tripping	I>>>	■								
50/51 TD	Overcurrent protection with positive-sequence current I1	I1>	■								
50N/51N TD	Overcurrent protection, 1-phase	I <sub>p</sub> , I <sub>Np</sub>	■								
50Ns/51Ns	Sensitive ground-fault detection for grounded arc-suppression coils and isolated power systems including a) 3I0> b) admittance Y0>, c) 3I0-harm>	INs>	■								
	Sensitive ground-fault detection via pulse detection; hint: This stage also requires the function 50Ns/51Ns or 67Ns "sensitive ground-fault detection for grounded arc-suppression coils and isolated power systems"	IN pulse	■								
	Intermittent ground-fault protection	IIE>	■								
50BF	Circuit-breaker failure protection, 3-pole	CBFP	■								
50L	Load-jam protection	I>L	■					■	■		
50RS	Circuit breaker reignition monitoring	CBRM	■								
51V	Voltage-dependent overcurrent protection	t=f(I, V)	■								
59C	Peak overvoltage protection, 3-phase, for capacitors	V> cap.	■								
59N	Overvoltage protection, zero-sequence system	V0>	■								
59R, 27R	Peak overvoltage protection, 3-phase, for capacitors	V> cap.	■								
59, 59N	Overvoltage protection: "3-phase" or "zero-sequence system V0" or "positive-sequence system V1" or "universal Vx"	V>	■								■
60	Voltage-comparison supervision	ΔV>	■								
60C	Current-unbalance protection for capacitor banks	Iunbal>	■								
66	Restart inhibit for motors	I²t	■					■	■		
67	Directional overcurrent protection, phases	I>, ∠(V, I)	■			■	■				

# SIPROTEC 5 Compact

## Overview of functions

ANSI	Function	Abbr.	Available	Application templates (template)						
				1	2	3	4	5	6	7
67N	Directional overcurrent protection, ground	$I_N >$ , $\angle(V, I)$	■			■				
67Ns	Sensitive ground-fault detection for grounded arc-suppression coils and isolated power systems including a) $3I_0 >$ b) $V_0 >$ , c) $\cos/\sin \Phi$ , d) transient ground fault, e) $\Phi(V, I)$ , f) admittance		■				■		■	
1.4	Directional tripping stage with one harmonic; hint: this stage also requires the function "67Ns sensitive ground-fault detection for grounded arc-suppression coils and isolated power systems"	$\angle(V_0h, I_0h)$	■							
	Directional intermittent ground-fault protection	$II_{Edir} >$	■							
74TC	Trip-circuit supervision	TCS	■							
74CC	Single circuit monitoring		■							
79	Automatic reclosing	AREC	■							
81	Frequency protection: "f>" or "f<" or "df/dt"	$f <$ ; $df/dt <$	■							■
81U	Underfrequency load shedding	$df/dt$	■							
	Vector-jump protection	$\Delta\phi >$	■							
86	Lockout		■	■	■	■	■	■	■	
87N	Restricted ground-fault protection	$\Delta I_N$	■							
FL	Fault locator	FO	■							
	PQ – Basic measured values: THD (Total Harmonic Distortion) and harmonic component and THD voltage average values		■							
	PQ – Basic measured values: Voltage unbalance		■							
	PQ – Basic measured values: Voltage changes – monitoring of voltage dips, overvoltages, and voltage interruptions		■							
	PQ – Basic measured values: TDD - Total demand distortion		■							
	Measured values, standard		■	■	■	■	■	■	■	■
	Measured values, extended: Min, max, average		■							
	Basis PQ measured values: TDH and harmonic		■							
	Switching statistics counter		■							
	Circuit-breaker wear monitoring	$\Sigma I_x, I^2t, 2P$	■							
	CFC (standard, control)		■	■	■	■	■	■	■	■
	CFC arithmetic		■							
	Switching sequence function		■							
	Inrush-current detection		■	■	■	■	■	■	■	
	External trip initiation		■							
	Control		■	■	■	■	■	■	■	■
	Fault recording of analog and binary signals		■	■	■	■	■	■	■	■
	Monitoring		■	■	■	■	■	■	■	■
	Circuit breaker		■	■	■	■	■	■	■	■
	Disconnect/grounding conductor		■							
	Temperature recording via communication protocol		■							
	Cybersecurity: Role-based access control		■							

**Table 1.4/1** SIPROTEC 7SX800 Functions, Application Templates (Templates)

- (1) Non-directional definite-time overcurrent protection/inverse-time overcurrent protection 4\*I
- (2) Non-directional definite-time overcurrent protection/inverse-time overcurrent protection 4\*I, 4\*V
- (3) Directional definite-time overcurrent protection/inverse-time overcurrent protection – grounded power system
- (4) Directional definite-time overcurrent protection/inverse-time overcurrent protection - grounded arc suppression coils/isolated Power system
- (5) Motor: Current measurement
- (6) Motor: Current and voltage measurement
- (7) Decoupling

Thanks to the modular design of the software as well as the functional integration, SIPROTEC 5 Compact devices are well suited for all tasks in the energy sector.

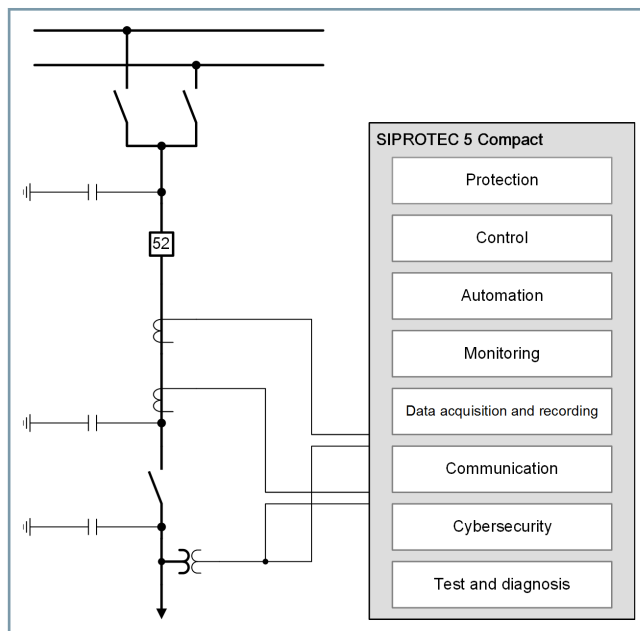
The devices include:

- Protection
- Control and automation
- Supervision and monitoring
- Data acquisition and recording for data analysis
- Communication and Internet of Things (IoT)
- Cybersecurity
- Test and diagnostics

Due to the modular design of the software and the high-performance engineering tool DIGSI 5, SIPROTEC 5 Compact is perfectly suitable for protection, automation, measurement, and monitoring tasks for the operation and monitoring of modern power systems.

The devices are not only protection and electronic control units; their performance enables them to assure functional integration of the desired depth and scope. For example, they can perform monitoring, efficient fault recording, a wide range of measuring functions, and much more, in parallel, and they have been designed to facilitate future extensions.

SIPROTEC 5 Compact provides extensive, precise data acquisition and data recording on bay level for these functions. In connection with its communication flexibility, this expands the field of application and opens up a wide variety of possibilities in meeting requirements for present and future power systems. With SIPROTEC 5 Compact, you are on the safe side for your application. The following figure shows the possible functional expansion of a SIPROTEC 5 Compact device.



**Figure 2.1/1** Possible Functional Expansion of SIPROTEC 5 Compact Devices

### *Faster results with application templates*

A common function library provides all protection, automation, monitoring, and auxiliary functions for the SIPROTEC 5 Compact devices. The same functions are truly the same for all devices. Once established, configurations can be transferred from device to device. This results in substantially reduced engineering effort.

Predefined application templates are available in DIGSI 5 for every device type. These contain basic configurations, required functions, and default settings. In addition, you can save a device as a master template in a user-defined library and reuse it as a template for your typical applications. This saves time and money. Saving user-defined application templates is possible.

[Figure 2.1/2](#) shows an example of a line feeder in a system configuration in which the functions in the application template are combined into function groups (FGs). The function groups correspond to the primary components (protected objects: feeder "V-I-3ph", motor, switching devices, circuit breakers) thereby simplifying the direct reference to the actual system.

# SIPROTEC 5 Compact – System

## Functional Integration

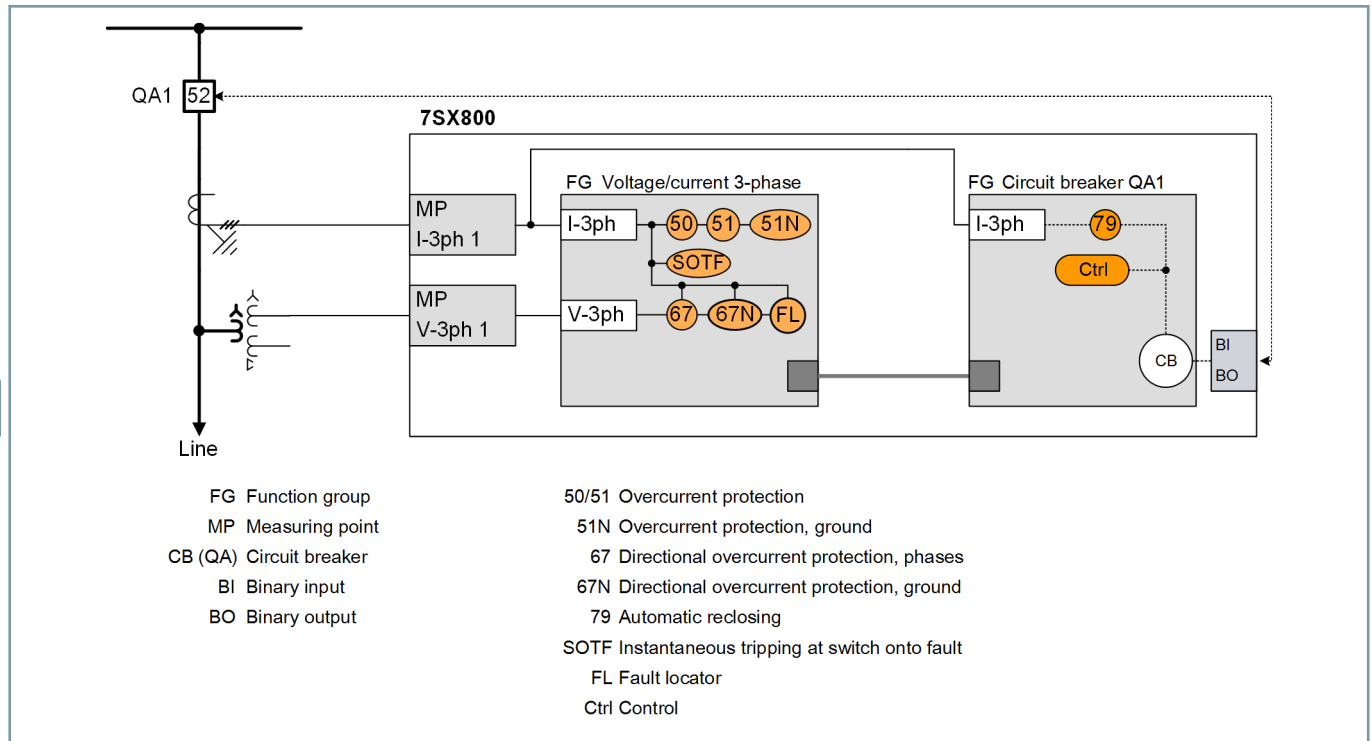


Figure 2.1/2 Feeder Protection

### Instrument and Protection-Class Current Transformers

The flexibility of the SIPROTEC 5 family enables even greater functional integration and parallel processing of an wide range of functions. If you also want to use the Synchrophasor measurement function, that is, the high-precision acquisition of current and voltage phasors and the variables derived from them such as power and frequency, this function can be assigned to the measuring input. Another possible application is monitoring power quality characteristic key values.

The high-precision measured values and status information provided by the SIPROTEC 5 devices can be transmitted to automation systems such as a SICAM substation automation technology and power systems control or central analysis systems (for example, SIGUARD PDP) via the high-performance communications system. In particular, the control and monitoring of intelligent power systems require information from power generators (conventional or renewable energy) and from consumers (line feeders). The required information may be measured values, switching states, or messages from protection and monitoring functions. In addition to performing local protection, control, and monitoring tasks, the SIPROTEC 5 devices are an excellent data source. The flexible communication among the devices enables them to be combined in various communication topologies. In this context, the widely used Ethernet-based communications standard IEC 61850 offers many advantages.

**The modular, flexible structure of the software ensures perfectly customized solutions for all your requirements in the power system.**

**With SIPROTEC 5, you have flexibility throughout the entire product lifecycle and your investment is thus protected.**

### Protection

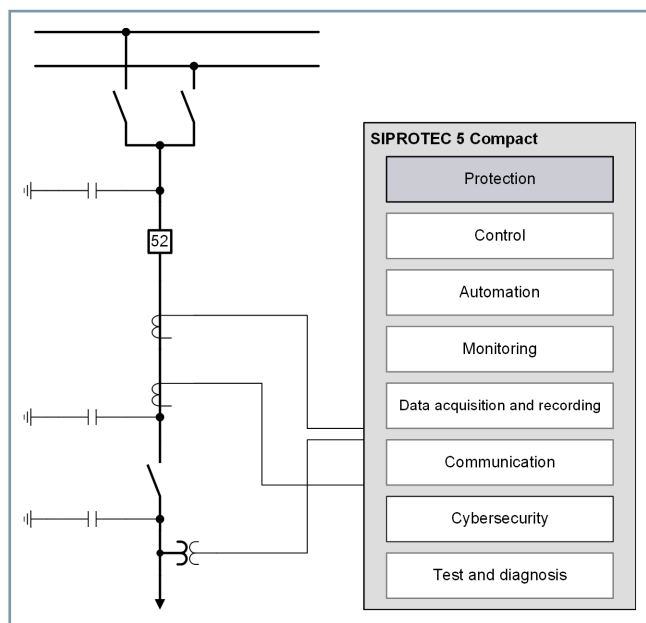


Figure 2.2/1 SIPROTEC 5 Compact – Functional Integration – Protection

SIPROTEC 5 provides all the necessary protection functions to address reliability and security of power systems and their components. The functions are based on decades of experience in using systems, including suggestions from the Siemens customers.

The modular, functional structure of SIPROTEC 5 allows exceptional flexibility and a perfect adaptation of the protection functionality to the conditions of the system and is still capable of further changes in the future.

The available device functions are described in the following sections.

#### Overexcitation Protection (ANSI 24)

The overexcitation protection is used for detecting high induction values in generators and transformers. It protects the equipment from excessive thermal loads.

The induction is recorded indirectly by the evaluation of the V/Hz ratio. Overvoltage leads to excessive magnetizing currents, while underfrequency leads to higher losses when resetting the magnetization.

There is a danger of overexcitation if the power system is disconnected and the voltage and frequency control function in the remaining system does not react quickly or the power unbalance is excessive.

Within this function, the following maximum number of stages can be operated simultaneously: 1 dependent stage with user-defined characteristics and 2 independent stages.

#### Synchrocheck, Synchronization Function (ANSI 25)

When two subsystems or live equipment are connected to the power system, the voltage must be synchronous with one another at the moment of connection. The synchronization function monitors this requirement.

The synchronization function can be used for synchronous power systems (galvanically coupled, no frequency difference) as well as asynchronous networks (galvanically separated, frequency difference present).

It has 3 operating modes:

- For galvanically coupled power systems ( $\Delta f = 0$ ):
  - Synchrocheck (monitoring of voltage, frequency, and phase-angle difference)
- For non-galvanically coupled power systems:
  - Switching of synchronous power systems (control of equality of frequency, voltage and phase-angle difference and continuity over a time frame)
  - Switching of asynchronous power systems (voltage and frequency difference, connection to the synchronization point taking into consideration the make time of the circuit breaker).

Evaluation of the frequency difference causes the function to switch automatically between the synchronous and asynchronous power system functions. The synchrocheck function can be utilized for pure monitoring.

The relative parameters for synchronization are derived from voltage transformers (arranged to the left and right on the circuit breaker). Depending on the available number of voltage transformer inputs, one or two synchronizing locations (circuit breakers) can be applied in one device.

Several functions can be used with up to 2 parameter sets (stages) for the synchrocheck and up to 6 parameter sets (stages) for the synchronization function per device. This enables the device to always react to different power system or plant conditions with the correct synchronization parameters.

#### Undervoltage Protection (ANSI 27)

The undervoltage protection monitors the permissible voltage range or protects equipment from subsequent damage due to undervoltage. It can be used in the power system for decoupling or load-shedding tasks.

Various undervoltage protection functions are available. By default, 2 stages are preconfigured. Up to 3 identical stages are possible. The undervoltage protection functions can be blocked by means of a current criterion.

# SIPROTEC 5 Compact – System

## Protection – Functions

The following functions are available:

- Undervoltage protection with 3-phase voltage
  - Optionally, measurement of phase-to-phase voltages or phase-to-ground voltages
  - Methods of measurement: optionally, measurement of the fundamental component or of the RMS value (true RMS value).
- Undervoltage protection with positive-sequence voltage
  - 2-phase short circuits or ground faults lead to an unbalanced voltage collapse. In comparison to phase-related measuring systems, such events have no noticeable impact on the positive-sequence voltage. Therefore, this function particularly suitable for the assessment of stability problems.
  - Methods of Measurement: Calculation of positive-sequence voltage from the measured phase-to-ground voltages.
- Undervoltage protection with any voltage
  - Detection of any 1-phase undervoltage for special applications
  - Methods of Measurement: optionally, measurement of the fundamental component or of the RMS value (true RMS value).
- Rate-of-voltage change protection  $dV/dt$ 
  - Detects system states that are not secure caused by an unbalance between generated and consumed active power
  - Can be used as a criterion for load-shedding applications

### Reactive-Power Undervoltage Protection (QU Protection)

The reactive-power undervoltage protection (QU protection) represents a system protection for power-system disconnection. To avoid a voltage collapse in energy systems, the energy producing side, for example a generator, should be provided with voltage and frequency protection devices. An undervoltage-controlled reactive power direction protection (QU protection) is required at the power-system interconnection point. The QU protection detects critical power-system situations and ensures that the power-generation system is disconnected from the power system. It also ensures that reconnection only takes place if the network conditions are stable. The criteria for this are parameterizable and can be found in the document [Technical directive for generating plants on the medium-voltage power system \(BDEW, June 2008\)](#) and in the "FNN requirement specification reactive power direction undervoltage protection (FNN, Feb 2010)".

### Power Protection (ANSI 32, 37)

The power protection works on a 3-phase basis and detects exceedance or underrunning of the set active-power or reactive-power thresholds (Figure 2.2/2). Predefined power limits are monitored and corresponding warning indications are issued. The power direction can be determined by measuring the angle of the active power. Thus, for example, reverse energization in the power systems or at electric machines can be detected. Machines in idle state (motors, generators) are detected and can be shut down via a message.

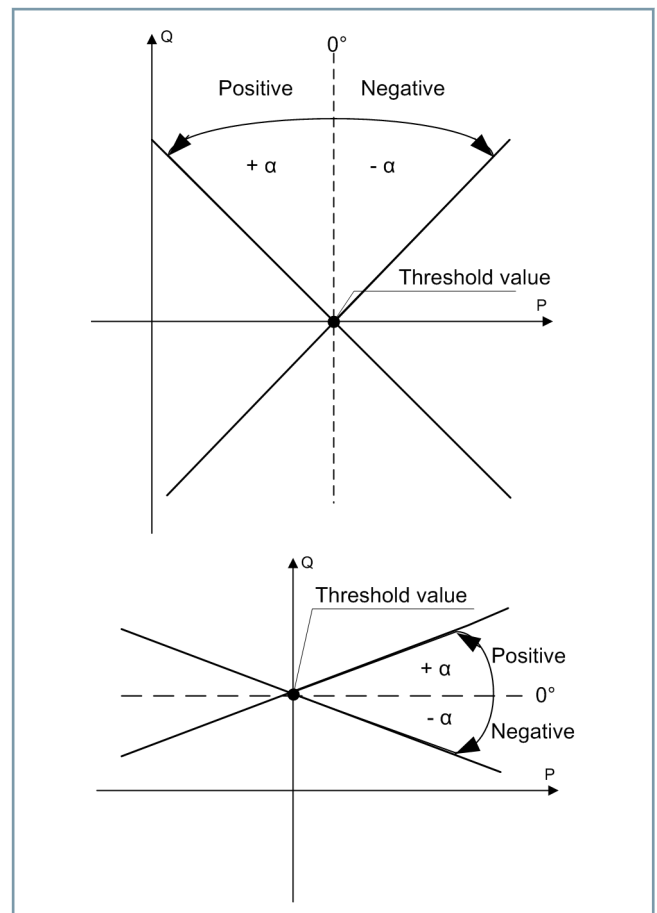
The power protection can be integrated into any automation solution, for example, to monitor very specific power limits (further logical processing in CFC).

The power protection function comes with a factory-set stage each for the active power and the reactive power. A maximum of 4 active-power stages and 4 reactive-power stages can be operated simultaneously in the function. The stages have an identical structure.

You can define thresholds for exceedance or underrunning of the power lines. The combination of the different stages via CFC result in various applications.

### Application Examples

- Detection of negative active power. In this case, the reverse-power protection can be applied using the CFC to link power protection outputs to the "direct tripping" function.
- Detection of capacitive reactive power. If overvoltage is detected due to long lines under no-load conditions, it is possible to select the lines where capacitive reactive power is measured.



[dw\_Wirk\_Bind\_KL\_1\_en\_US]

Figure 2.2/2 Active-Power Characteristic Curve and Reactive-Power Characteristic Curve

### Reverse-Power Protection (ANSI 32R)

The reverse-power protection is used in generators and power units. If the **mechanical** energy (for example, steam supply at the turbine) fails, the generator obtains the driving energy from the power system. In this operating state, the turbine can be damaged, which is prevented by tripping of the reverse-power protection. In order to react quicker if there is a steam outage, the position of the quick-stop valve is coupled additionally via binary input. It is used to switch between 2 time delays of the trip command. Furthermore, the function is used for operational disconnection (sequential circuit) of generators.

For other applications, the universal power protection (ANSI 32, 37) is recommended.

The reverse-power protection works on a 3-phase basis and monitors the absorbed active power (negative threshold value). By evaluating the positive-sequence system power and selecting a long measuring window, the function is insensitive to disturbance variables and very precise (minimum setting threshold:  $-0.3\% P/S_{\text{rated}}$ ). The measuring accuracy is substantially affected by the angle error. Because the SIPROTEC 5 devices are compensated, the primary transformers affect the measuring accuracy. The function can correct the angle error: You can find the angle error in the test report of the transformer or it can be measured using the primary system.

### Undercurrent Protection (ANSI 37)

Undercurrent protection detects the falling edge or decreasing current flow. This may be due to switching operations, for example, from a higher-level circuit breaker, or by decreasing loads, for example, pumps running empty.

In both situations, it may be necessary to open the local circuit breaker in order to prevent consequential damage. The undercurrent protection handles this task.

The function consists of an undercurrent stage with a current-independent time delay. A maximum of 2 stages can be operated in parallel.

Optionally, the auxiliary contacts of the local circuit breaker are evaluated in order to prevent overfunction.

### Temperature Supervision (ANSI 38)

The temperatures (for example winding or oil temperatures) are recorded via an external temperature-supervision device. Typical sensors are Pt 100, Ni 100, and Ni 120. The temperatures are transmitted via serial or Ethernet interfaces for protection and monitored in the temperature-supervision function to ensure that they do not exceed set limiting values. There are 2 threshold values per temperature measuring point. The function is designed so that the temperatures from up to 12 measuring points can be processed. The integrated broken-wire detection sends an alarm indication depending on the measuring point.

### Unbalanced-Load Protection (ANSI 46)

Asymmetrical current loading of the 3 windings of a generator result in heat buildup in the rotor because of the developing reverse field. The protection detects an asymmetrical loading of

3-phase current machines. It operates on the basis of symmetric components. The protection function evaluates the negative-sequence current and prevents thermal overloading of the rotor of electric machines (generators, motors). The thermal behavior is modeled using the integral method.

The following equation forms the basis of the protection function.

$$K = \left( \frac{I_2}{I_{N,M}} \right)^2 * t$$

[fo\_Schiefastschutz, 1\_en\_US]

With

K	Constant of the machine (5 s to 40 s)
$I_2$	Negative-sequence current
$I_{N,M}$	Rated current of the machine

2.2

An inverse-time characteristic curve results as the operate curve. Small unbalanced load currents result in longer tripping times. To prevent overfunction in case of large unbalanced load currents (for example, with asymmetrical short circuits), large negative-sequence currents (approx.  $10 * I$  permissible) are limited. In addition, the continuous additional unbalanced load is monitored, and if the threshold is exceeded, an alarm indication is issued after a time delay.

### Negative-Sequence System Overcurrent Protection (ANSI 46)

The protection function determines the negative-sequence current from the phase currents. It can be related to the rated object current or to the positive-sequence current (advantageous for conductor break monitoring).

The negative-sequence system overcurrent protection can be used with the transformer as a responsive backup protection on the supply side for detecting low-current 1-pole and 2-pole errors. Also low-voltage side, 1-phase errors can be detected here, which create no zero-sequence system in the current on the upper-voltage side (for example, in vector group Dyn).

With the negative-sequence overcurrent protection system, various monitoring and protection tasks can be realized:

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

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



# SIPROTEC 5 Compact – System

## Protection – Functions

### Overcurrent Protection, Negative-Sequence System with Direction (ANSI 46, 67)

The function overcurrent protection, negative-sequence system with direction serves as the backup short-circuit protection for unbalanced faults.

With the negative-sequence system, various monitoring and protection tasks can be realized:

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

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

### Overvoltage Protection Functions (ANSI 59, 47, 59N)

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

Various overvoltage protection functions are available. By default, 2 stages are configured. Up to 3 identical stages are possible.

The following functions are available:

#### Overvoltage protection with 3-phase voltage (ANSI 59)

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

#### Overvoltage protection with positive-sequence voltage (ANSI 59)

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

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

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

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

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

#### Overvoltage protection with zero-sequence system/residual voltage (ANSI 59N/64)

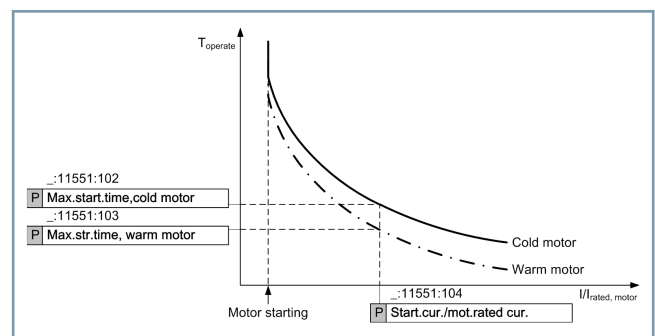
- Detection of ground faults in isolated or arc-suppression-coil-ground systems, as well as in electric equipment (for example machines)
- Detection of the faulty phase (optional)
- Method of measurement: Measurement of the residual voltage directly at the broken-delta winding or calculation of the zero-sequence voltage from the phase-to-ground voltages
- Measuring methods: Optionally, measurement of the fundamental component (standard or with especially strong attenuation of harmonics and transients) or of the RMS value

#### Overvoltage protection with any voltage (ANSI 59)

- Detection of any 1-phase overvoltage for special applications
- Measuring methods: optionally, measurement of the fundamental component or of the RMS value (true RMS value)

### Starting Time Supervision (ANSI 48)

The starting time supervision protects the motor from too long startup procedures. In particular, rotor-critical high-voltage motors can quickly be heated above their limiting temperature when multiple starting attempts occur in a short period of time. If the durations of these starting attempts are prolonged for example by excessive voltage surges during motor switching, by excessive load torque, or by blocked rotor conditions, a trip signal will be initiated by the protection device. [Figure 2.2/3](#) shows the thermal characteristic curve of the function. Different maximum starting times can be taken into account for starting with the motor cold or hot.



[0w\_therms\_03\_1\_en\_05]

Figure 2.2/3 Thermal Characteristic Curve of the Starting Time Monitoring

### Circuit-Breaker Failure Protection (ANSI 50BF)

The circuit-breaker failure protection consists of 2 stages and provides phase and ground backup protection if the main circuit breaker fails to clear a power-system incident. If the fault



current is not interrupted after a time delay has expired, a retrip command or the busbar trip command will be generated. The correct circuit-breaker operation is monitored via current measurement and via circuit-breaker position contacts. The current detection logic is phase-segregated and can therefore also be used in 1-pole tripping schemes.

The circuit-breaker failure protection can be initiated by all integrated protection functions as well as via binary input signals or by Ethernet communication via GOOSE messages in IEC 61850 systems. To increase operational reliability, an external start can be applied with 2 binary inputs in parallel. Various delays may take place for 1-pole and 3-pole starting.

### External Trip Initiations

Any signals from external protection and monitoring devices can be coupled in via binary inputs or serial communication. These signals can then be included in message and trigger processing or used to start a fault record. The trip initiation acts like a protection function. The trip command may be delayed. 1-pole tripping is available if the device and switch are capable of 1-pole disconnection. Thus the integration of mechanical protection equipment (for example, pressure or oil-level monitors or Buchholz protection) as well as protection devices working in parallel is possible with no problems. Depending on the application, you can select the required number of trip initiations.

### Instantaneous High-Current Tripping (ANSI 50HS)

When switching on a faulty line, immediate tripping is possible. In the case of high fault currents, this overcurrent protection with instantaneous tripping leads to a very fast tripping when switching onto faults.

The function comes factory-set with 1 stage. A maximum of 2 stages can be operated simultaneously within the function. The stages have an identical structure. Actual closure detection takes place in the switch-position recognition. It activates directly in case of manual closure or is automatically determined from the measured values (current, voltage) or by means of the circuit-breaker auxiliary contacts.

When used in the transformer, the current stage must be set above the maximum short-circuit current or inrush current flowing through.

### Circuit-Breaker Restrike Protection (ANSI 50RS)

The circuit-breaker restrike protection function monitors the circuit breaker for arc reignition, which may be triggered by overvoltage at the circuit-breaker poles after disconnection of the capacitor bank, for example. The function generates an auxiliary trip signal in the event of a circuit-breaker reignition.

### Instantaneous Tripping at Switch-onto Fault (SOTF)

This function is available for applications in which overcurrent protection (50HS) is not sufficient or not used. It enables instantaneous tripping even with low fault currents. The function has no measuring function of its own. It is linked on the input side with the pickup (measurement) of another protection function, for example, the stage of an overcurrent protection, and then

trips with switching to a short circuit. Typically, such protection stages are configured that themselves trip with a delay. Actual closure detection takes place in the switch-position recognition.

### Load-Jam Protection (ANSI 50L)

The load-jam protection function serves to protect the motor during sudden rotor blocking. Damage to drives, bearings, and other mechanic motor components can be avoided and reduced by means of quick motor shutdown.

The rotor blocking results in a current jump in the phases. The current jump is detected by the function as a recognition characteristic.

The thermal overload protection can also pick up as soon as the configured threshold values of the thermal replica are exceeded. The load-jam protection, however, is able to detect a blocked rotor more quickly, thus reducing possible damage to the motor and powered equipment.

### Overcurrent Protection, Phases and Ground (ANSI 50/51, 50N/51N)

The overcurrent protection functions for phases and ground detect short circuits on electric equipment. The non-directional overcurrent protection is suitable as main protection for single-side infeed radial power systems or open ring systems. As a backup or emergency overcurrent protection, it can be used additionally to the main protection, for example, on lines or transformers. With transformers, the preferred application is the backup protection for downstream parts of the electrical power system.

2 definite-time overcurrent protection stages and an inverse-time overcurrent protection stage are preconfigured. Additional definite-time overcurrent protection stages, and 1 stage with a user-defined characteristic curve can be configured within this function.

All the usual characteristic curves according to IEC and ANSI/IEEE are available for the inverse-time overcurrent protection stages, see for example [Figure 2.2/4](#).

Apart from the characteristic, the stages of the overcurrent protection are structured identically.

- They can be blocked individually via binary input or by other functions (for example, inrush-current detection, automatic reclosing, cold-load pickup detection)
- Each stage can be stabilized against over-responding because of transformer inrush currents
- Each stage can be operated as an alarm stage (no operate indication)
- You can select either the measurement of the fundamental component and the measurement of the RMS value for the method of measurement
- The ground function evaluates the calculated zero-sequence current (3I0) or the measured ground current
- Dropout delays can be set individually.

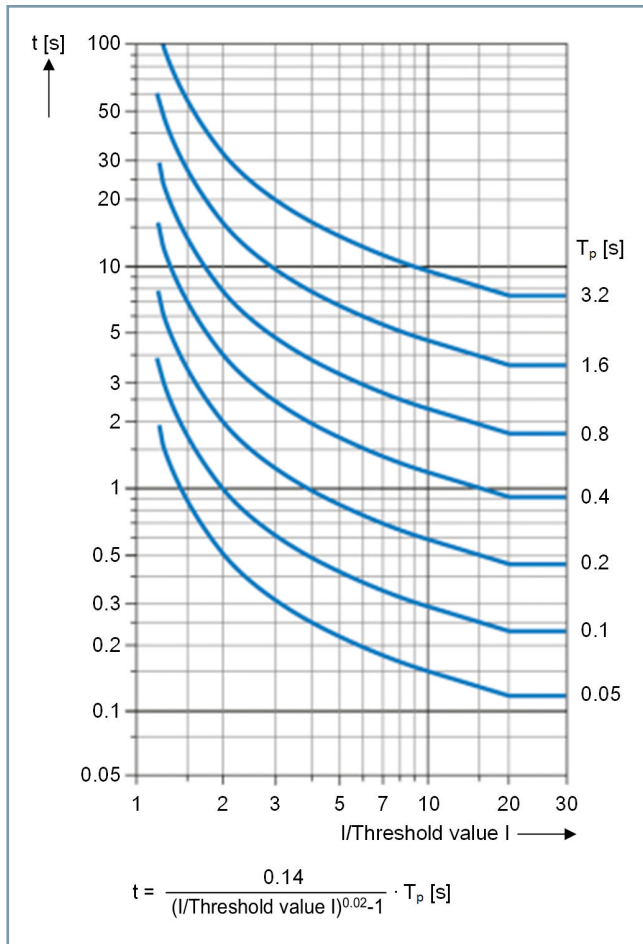


Figure 2.2/4 IEC Characteristic Curves of the "Normal Inverse" Type

### Overcurrent Protection, 1-Phase (ANSI 50N/51N)

With transformers, the preferred application is the backup protection for the parts of the electrical power system connected to the grounded star winding. The neutral-point current of the transformer is thus processed directly. Alternatively, the function can also be used as high-impedance restricted ground-fault protection.

Tank leakage protection for insulated transformers is another application.

The modular design and scope of the protection function are identical to the overcurrent protection ground function (ANSI 50N/51N).

### Sensitive Ground-Current Protection (ANSI 50Ns/51Ns)

The sensitive ground-current protection function detects ground-fault currents in isolated and arc-suppression-coil-ground systems. It can also be used for special applications where a highly sensitive current measurement is required. Responses of protection devices and trippings can be saved in the separate ground-fault log.

### Intermittent Ground-Fault Protection

Intermittent (reigniting) faults occur due to insulation weaknesses in cables or due to the ingress of water into cable joints. The faults will eventually go off by themselves or expand to permanent short-circuits. During intermittent operation, neutral-point resistors can be thermally overloaded in the case of low-impedance grounded power systems. The normal ground-fault protection cannot reliably detect and switch off the current pulses that are sometimes very brief.

The necessary selectivity of protection in the case of intermittent ground faults is achieved by adding up the single pulses over time and tripping after a reached (adjustable) total time. The pickup threshold  $I_{IE} >$  evaluates RMS values in relation to a system period.

### Transformer Inrush-Current Detection

When the device is used on a power transformer, large magnetizing inrush currents will flow when the transformer is switched on. These inrush currents may be several times the rated current, and, depending on the transformer size and type of construction, may last from several tens of milliseconds to several seconds. The inrush-current detection function detects a transformer switch-on process and generates a blocking signal for protection functions that are affected in undesirable ways when transformers are switched on. This enables a sensitive setting of these protection functions.

In order to securely record the inrush processes, the function uses the **Harmonic Analysis** method of measurement and the **CWA method** (current wave shape analysis). The two processes can optionally be activated individually or work in parallel and link the result through logical OR. This means that a **1-out-of-2 decision** is made which increases the availability of the electrical plant.

### Voltage-Controlled Overcurrent Protection (ANSI 51V)

Short circuit and backup protection are also integrated here. It is used where power system protection operates with current-dependent protection equipment.

There are 3 different forms of the function (stage types):

- Controlled
- Voltage-dependent
- Undervoltage stability

The current function can be controlled via an evaluation of the machine voltage. The **controlled** variant triggers the sensitively set current stage. In the **voltage-dependent** variant, the current pickup value drops in a linear relationship with dropping voltage. The fuse-failure monitor prevents overfunction.

IEC and ANSI characteristics are supported, see [Table 2.2/1](#).

Supported inverse-time characteristic curves		
Characteristic curve	ANSI/IEEE	IEEE/IEC 60255-3
Inverse	•	•
Moderately inverse	•	
Very inverse	•	•

Supported inverse-time characteristic curves		
Extremely inverse	•	•
Fully inverse	•	

**Table 2.2/1** IEC and ANSI Characteristic

For generator protection applications, the function **under-voltage stability** is frequently used. If the exciting transformer is connected directly to the generator lead and a short circuit occurs, the excitation voltage drops. As a result, the synchronous generated voltage and with it the short-circuit current are reduced and can drop below the pickup value. With the under-voltage stability feature, the pickup is maintained. If an external error is cleared according to protective grading, the voltage recovery results in the dropout of the pickup maintenance. If the voltage fails due to an error in the voltage-transformer circuit, this does not result in an overfunction. A pickup additionally causes an overcurrent.

### Peak Overvoltage Protection for Capacitors (ANSI 59C)

The dielectric medium of a capacitor is stressed by the applied peak voltage. Hence excessively high peak voltages may lead to destruction of the dielectric medium. IEC and IEEE standards define how long capacitors should withstand which overvoltages.

The function calculates the peak voltage in a phase-segregated way from the fundamental component and superimposed harmonics. Integration of the phase currents then yields the peak voltage.

The function offers different stage types with regard to the time delay:

- Stage with inverse-time characteristic according to IEC and IEEE standards
- Stage with user-defined characteristic curve
- Stage with independent characteristic curve

A maximum of 4 stages with independent characteristic curve can be applied in parallel.

### 1-Phase Current-Unbalance Protection for Capacitor Banks (ANSI 60C)

The 1-phase current-unbalance protection for capacitors provides protection in the event of errors in capacitor elements (C elements) of a double neutral point capacitor bank. It provides very sensitive monitoring of the unbalanced current between the two neutral points and allows for the counting of individual defective C-elements.

### Measuring-Voltage Failure Detection (ANSI 60FL)

This function monitors the voltage transformer secondary circuits for:

- Non-connected transformers
- Pick up of the voltage-transformer circuit breaker (in the event of short circuits in the secondary circuit)
- Broken conductor in one or more measuring loops

All these events cause a voltage of 0 in the voltage transformer secondary circuits. Which can lead to failures of the protection functions.

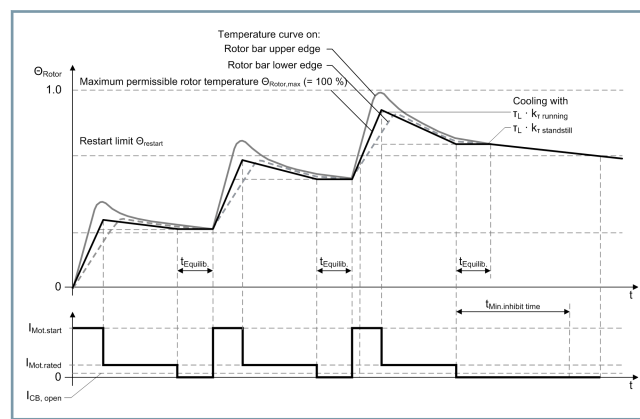
The following protection functions are automatically blocked in the case of a measuring-voltage failure:

- Directional negative-sequence protection
- Ground-fault protection for high-impedance faults in grounded-neutral power systems.

### Restart Inhibit (ANSI 66)

The restart inhibit prevents restarting of the motor if the permissible temperature limit would be exceeded as a result.

In normal operation, and also under increased load conditions, the rotor temperature of a motor is far below the permissible temperature limit. The high starting currents required during motor startup increase the risk of the rotor being damaged by overheating instead of the stator. This is related to the short thermal constant of the rotor. To prevent the circuit breaker being tripped by several attempts to start the motor, the motor must be prevented from restarting if it is obvious that the temperature limit of the rotor would be exceeded during the start attempt (*Figure 2.2/5*).



[Dw\_PrReLo\_02\_1\_en\_US]

**Figure 2.2/5** Temperature Curve of the Rotor and Repeated Attempts to Start the Motor

### Directional Overcurrent Protection, Phases and Ground (ANSI 67, 67N)

The directional overcurrent protection functions for phases and ground detect short circuits on electrical equipment. The directional overcurrent protection allows the application of devices also in electrical power systems where selectivity of protection depends on knowing both the magnitude of the fault current and the direction of power flow to the fault location. This is the case with parallel lines that have one infeed, for example, or cable runs with infeed at both ends or in lines connected to form ring topologies.

Two independent overcurrent-protection stages (definite-time overcurrent protection stages) and a dependent overcurrent-protection stage (inverse-time overcurrent protection stage) are preconfigured. Additional definite-time overcurrent protection

2.2

# SIPROTEC 5 Compact – System

## Protection – Functions

stages, as well as one stage with a user-defined characteristic curve, can be configured within this function.

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

Figure 2.2/6 shows the free configurability of the directivity of the ground function. The characteristic can be rotated for the phase function.

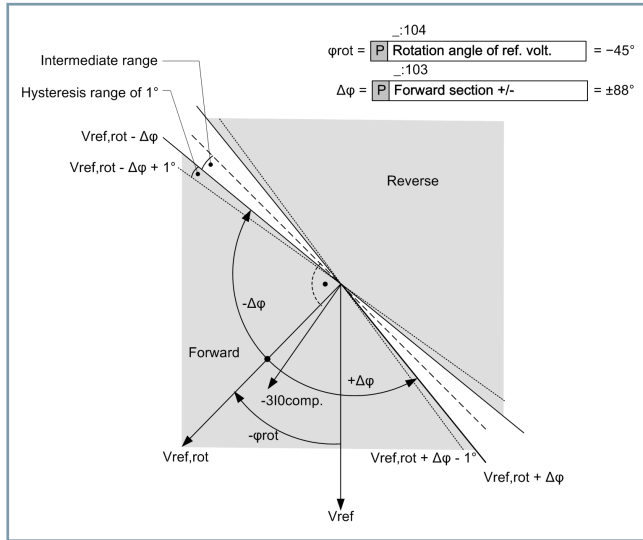


Figure 2.2/6 Directivity of the Ground Function

Apart from the characteristics, the stages are structured identically.

- Blocking options for the stage: in the event of measuring-voltage failure, via binary input signal or by means of other functions (automatic reclosing, cold-load pickup detection).
- Each stage can be stabilized against over-responding because of transformer inrush currents
- The directional mode can be set for each stage.
- The stage can optionally be used for directional comparison protection. Hence both a release procedure and a blocking method can be implemented.
- Each stage can also be used as an alarm stage (no operate indication)
- You can select the measurement of the fundamental component and the measurement of the RMS value for the method of measurement.
- The ground function evaluates the calculated zero-sequence current (3I0) or the measured ground current
- Logarithmic-inverse characteristics are also available for the ground stages.

### Directional Sensitive Ground-Fault Detection (ANSI 67Ns, ANSI 51Ns, 59N)

The directional sensitive ground-fault detection function detects ground faults in isolated and arc-suppression-coil-ground systems. Various function stages are available for this purpose

that can also be used in parallel. Thus, the working method of the function can be perfectly adapted to the conditions of the power system, the user philosophy, and different manifestations of the error:

### Overvoltage protection stage with zero-sequence system/residual voltage

The zero-sequence voltage (residual voltage) is evaluated in relation to threshold-value violation. In addition, the faulty phase can be determined when the phase-to-ground voltages are connected.

### Directional ground-current stage with direction determination using cos φ and sin φ measurement

This is the "classical" watt-metric (cos φ, in the arc-suppression-coil-ground system) or var-metric (sin φ, in the isolated power system) method of measurement for the direction determination of static ground faults. For direction determination, the current component which is perpendicular to the set direction-characteristic curve (= axis of symmetry) is decisive (3I0<sub>dir</sub>), see Figure 2.2/7. The stage can be adapted to the power-system conditions by a corresponding setting (position of the direction-characteristic curve). Therefore, highly sensitive and precise measurements are possible.

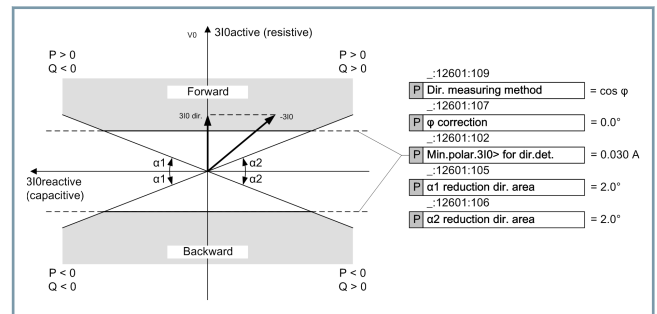
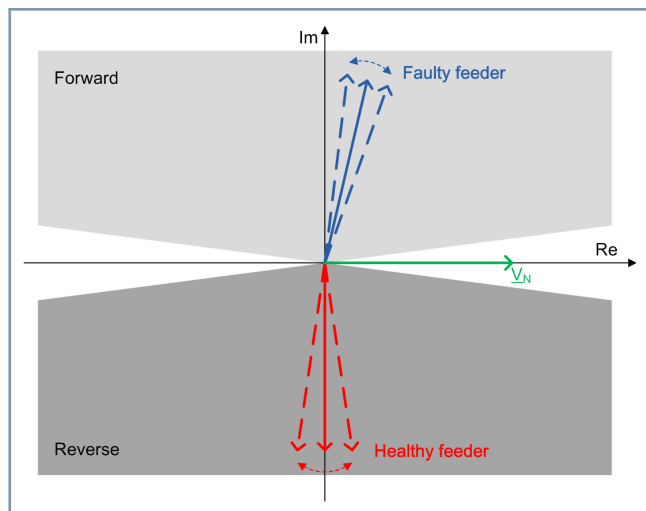


Figure 2.2/7 Direction Determination with cos φ Measurement

### Directional sensitive ground-fault detection via harmonics

The function is used for fault localization in stationary ground faults, particularly in connection with restriction circuits in circuited medium-voltage rings. It is based on a continuous measurement with direction determination. This is determined by means of the phasors of the 3rd, 5th, or 7th harmonic of the zero-sequence voltage V0 and of the zero-sequence current 3I0 (Figure 2.2/8).

The advantages of this method are the simple difference between "faulty" and "healthy" in the directional areas and the reliable directional result independent of the measuring tolerances.



[img\_dir-sens-grd-fault-detect\_farms\_1\_en\_US]

Figure 2.2/8 Sensitive Ground-Fault Detection via Harmonics

#### Directional ground-current stage with direction determination using $\varphi(V, I)$ measurement

This method can be applied as an alternative to the  $\cos \varphi$  or  $\sin \varphi$  method if this is desired because of user philosophy. The direction is determined by determining the phase angle between the angle-error compensated ground current and the rotated zero-sequence voltage  $V_0$ . To take different system conditions and applications into account, the reference voltage can be rotated via an adjustable angle. This moves the vector of the rotated reference voltage close to the vector of the ground current  $3I_{0\text{com}}$ . Consequently, the result of direction determination is as reliable as possible (see also Figure 2.2/6).

#### Sensitive ground-fault detection via pulse-pattern detection

The pulse-pattern detection function is used when a pulsating ground-fault current is generated for fault localization by connecting and disconnecting a capacitor arranged in parallel to the arc-suppression coil. The function then detects a faulty feeder using the pulse pattern during a stationary ground fault in overcompensated systems.

#### Transient ground-fault method

This transient method operates only during the first 1 to 2 periods after fault inception. It determines the direction via the evaluation of the active energy of the transient process. It is especially appropriate if direction information is required for errors that expire again very quickly (after 0.5 to a few periods). Thus, parallel use to the stage with  $\cos \varphi$  measurement or harmonic methods is appropriate.

This method can also be operated in meshed power systems. It is also especially well-suited for closed rings because circulating zero-sequence currents are eliminated. Due to additional logic, the function can also optionally clear a static error.

#### Non-directional ground-current stage

If necessary, a simple, non-directional ground-current stage can be configured.

#### Stabilization in the event of intermittent ground faults

Functions for the detection of stationary ground faults (for example,  $\cos \varphi$  function) can react adversely in the event of intermittent ground faults: Message and fault-record flooding is possible. This can be effectively avoided by automatic blocking of these functions in the event of intermittent ground faults.

#### **Trip-Circuit Supervision (ANSI 74TC)**

The circuit-breaker coil and its feed lines are monitored via 2 binary inputs. If the trip circuit is interrupted, and alarm indication is generated.

#### **Automatic Reclosing (ANSI 79)**

About 85 % of the arc faults on overhead lines are extinguished automatically after being tripped by the protection function. The overhead line can therefore be put back into operation. Reclosure is performed by an automatic reclosing function (AR). Each protection function can be configured to start or block the automatic reclosing function.

#### Basic features and operating modes

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

#### Voltage-dependent supplementary functions

The integration of automatic reclosing in the feeder protection allows evaluation of the line side voltages.



# SIPROTEC 5 Compact – System

## Protection – Functions

A number of voltage-dependent supplementary functions are thus available:

- **Dead-line check (DLC)**  
By means of a dead-line check, reclosure is triggered only when the line is de-energized (prevention of asynchronous pickup), if no synchrocheck can be used
- **Adaptive dead time (ADT)**  
The adaptive dead time is used only if automatic reclosing at the opposite end was successful (reduction of stress on equipment).
- **Reduced dead time (RDT)**  
Reduced dead time is used together with the automatic reclosing function where no teleprotection scheme is used: When faults within the overreach zone, but outside the protected line, are switched off for short-time interruption, the RDT function decides on the basis of the measured of the reverse polarity voltage from the opposite end which has not tripped whether to reduce the dead time.

### Frequency Protection (ANSI 81)

Frequency deviations are caused by an unbalance between generated and the consumed active power. This is caused by, for example, load shedding, network disconnections, increased need for active power, generator failures, or faulty functioning of the load-frequency control. The frequency protection detects frequency deviations in the power system or in electric machines.

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

Different frequency-measuring elements with high accuracy and short pickup times are available. Tripping by frequency-measuring elements can be triggered either at the local circuit breaker or at the opposite end by automatic remote tripping.

The following measuring elements are available:

- **Overfrequency protection (ANSI 81O)**  
Two-stage designs can be increased up to 3 stages. All stages are of identical design.
- **Underfrequency protection (ANSI 81U)**  
Three-stage design (default), can be increased up to 5 stages. All stages are of identical design.

Each frequency-measuring element provides 2 different methods of measurement:

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

The DIGSI 5 library provides the corresponding protection function for every method of measurement.

### Rate-of-Frequency Change Protection (ANSI 81R)

With the rate-of-frequency change protection, frequency changes can be detected quickly. The function can prevent system states that are not secure, caused by an unbalance

between the generated and the consumed active power. For this purpose, it is integrated into power-system decoupling and load-shedding measures.

The function offers 2 stage types:

- df/dt rising
- df/dt falling

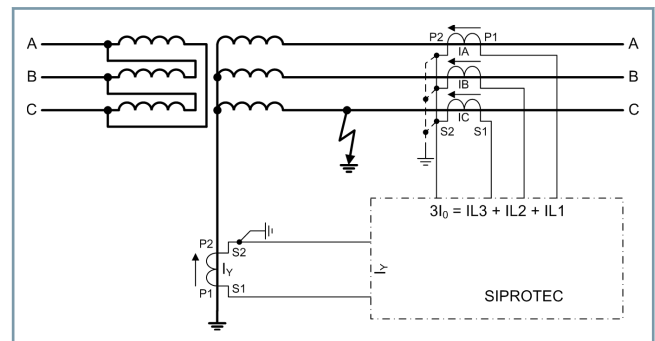
A maximum of 5 stages of each stage type can be applied in the function.

Either the measuring accuracy or the pickup time can be optimized for the specific application by defining the measuring-window length.

The function is automatically blocked in the event of undervoltages, in order to rule out imprecise or incorrect measurements.

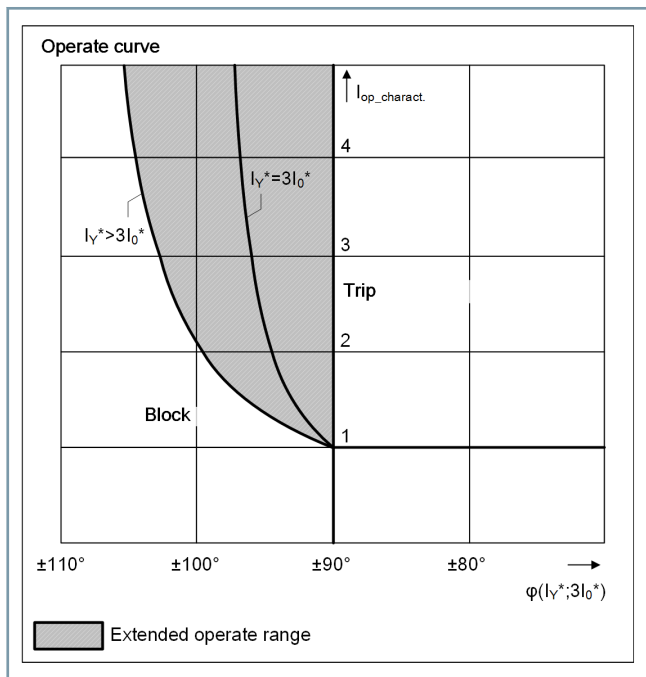
### Restricted Ground-Fault Protection (ANSI 87N)

The longitudinal differential protection can detect ground faults close to the neutral point of a grounded star winding only to a limited extent. The restricted ground-fault protection assists you with this. The neutral-point current and the calculated zero-sequence current of the phase currents are evaluated according to [Figure 2.2/9](#) and [Figure 2.2/10](#). Overfunction in response to external ground faults is prevented by stabilizing measures. In addition to the differential and restraint currents, based on the zero-sequence variables, the phase angles of the zero-sequence currents between each other are monitored. The tripping variable is the zero-sequence current in the neutral point.



[dw\_grdprn\_2\_en\_US]

Figure 2.2/9 Restricted Ground-fault Protection Basic Principle



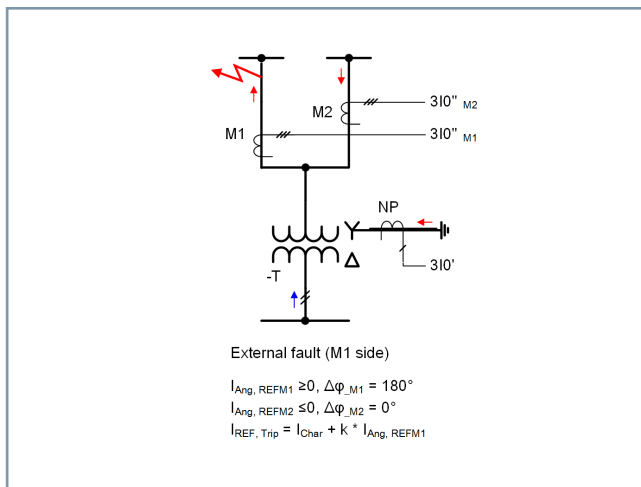
[dw\_austen, 3, en\_US]

Figure 2.2/10 Operate Curve

For use in auto transformers, an additional measure was adopted in order to prevent a failure in response to external ground faults. The protection function independently determines the side of the auto winding that is necessary for reliable operation of the protection function. A measuring point is selected that results in the greatest restraint current (see also [Figure 2.2/11](#)).

This method is also used if multiple 3-phase current measuring points are present on the line side, for example in breaker-and-a-half arrangements (see [Figure 2.2/9](#) and [Figure 2.2/10](#)).

In the differential protection devices, other protection functions are available that can be used as supplemental protection and monitoring functions as well as backup protection for the upstream and downstream power system. It is also possible to monitor limiting values.



[dw\_fault\_M1 side, 2, en\_US]

Figure 2.2/11 Measuring Point Selection for Multiple Infeeds on the Neutral Side

### Fault Locator (FL)

#### Single ended fault locator

The integrated fault locator calculates the fault impedance and the fault distance. The result is displayed in ohms, miles, kilometers, or in percent of the line length. The influence of parallel lines and of load currents can also be compensated.

# SIPROTEC 5 Compact – System

## Control

### Control

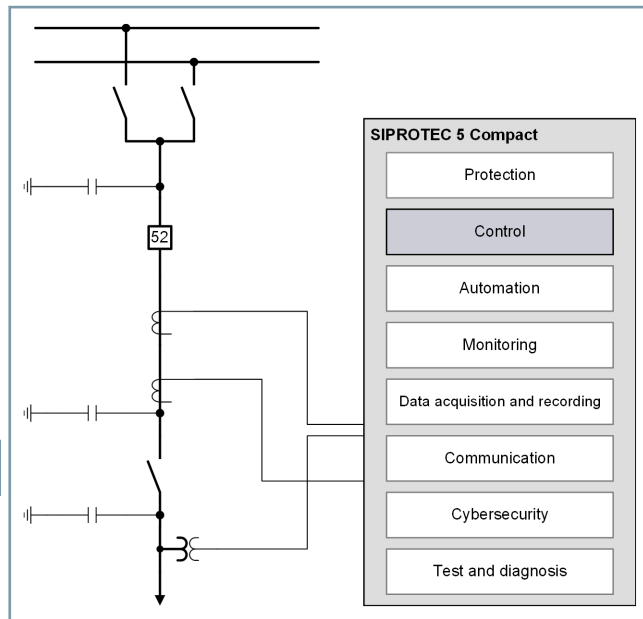


Figure 2.3/1 SIPROTEC 5 Compact – Functional Integration – Control

SIPROTEC 5 Compact includes all control and supervision function at bay level, required for an efficient operation of the switchgear.

The , freely configurable, color graphic display for control diagrams is available for convenient local control. Frequent operating actions, such as starting switching sequences or displaying the indication list, can be called up via one of the 9 function keys.

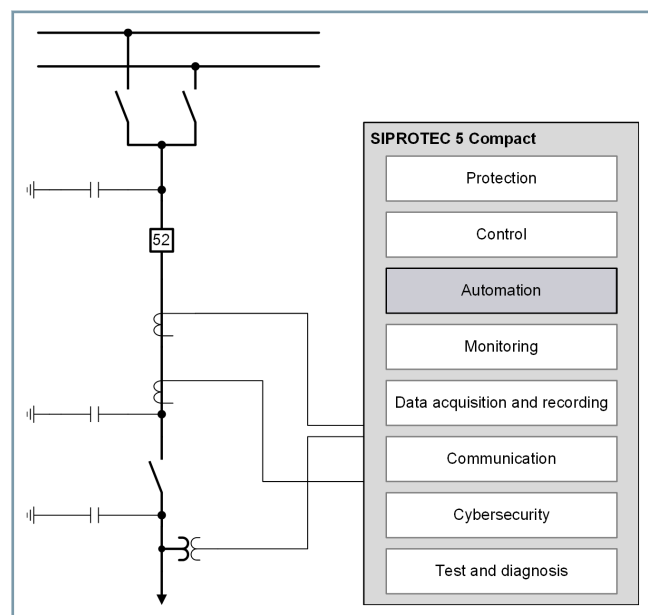
The application templates supplied provide the full functionality that you need for your application. Protection and control functions access the same logical elements. From the perspective of switching devices, protection and control are treated with equal priority.

A new level of quality in control is achieved with the application of the communication standard IEC 61850. For example, binary information from the bay can be processed very elegantly and data (such as for interlocking across multiple fields) can be exchanged between the devices. Cross communications via GOOSE enable efficient solutions, since here the wiring is replaced with data telegrams.

All devices already have up to 4 switching objects (switches, disconnectors, or grounding conductors) via the base control package. Optionally, additional switching objects and switching sequences can be configured using CFC blocks in accordance with IEC 61131-3.



## Automation



[dsw\_automation\_SIPSC\_1\_en\_US]

**Figure 2.4/1** SIPROTEC 5 Compact – Functional Integration – Automation

The integrated CFC (Continuous Function Chart) graphical automation editor enables you to create logic diagrams clearly and simply. DIGSI 5 supports this with powerful logic blocks based on the standard IEC 61131-3. All devices already have a powerful base automation package. This makes it easy to provide specific functions for automation of a switchgear.

You can graphically link all internal digital information, such as internal protection signals or operating states, directly to the logic blocks and process them in real time using CFCs. You can also link measured values or monitor them with respect to limiting values.

Examples of automation applications are:

- Interlockings
- Switching sequences
- Message derivations or the tripping of switching operations
- Messages or alarms by linking available information
- Load shedding in a feeder
- Administration of decentralized energy infeeds
- System switchovers depending on the network status
- Automatic grid separations in the event of grid stability problems

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

Using macros makes it possible to reuse CFC subplans simply and clearly, in the device, project, or in other projects. CFC online monitoring makes it possible to track and check the sequence of the plans in the device. Corrections can therefore be made quickly and efficiently.

# SIPROTEC 5 Compact – System

## Monitoring

### Monitoring

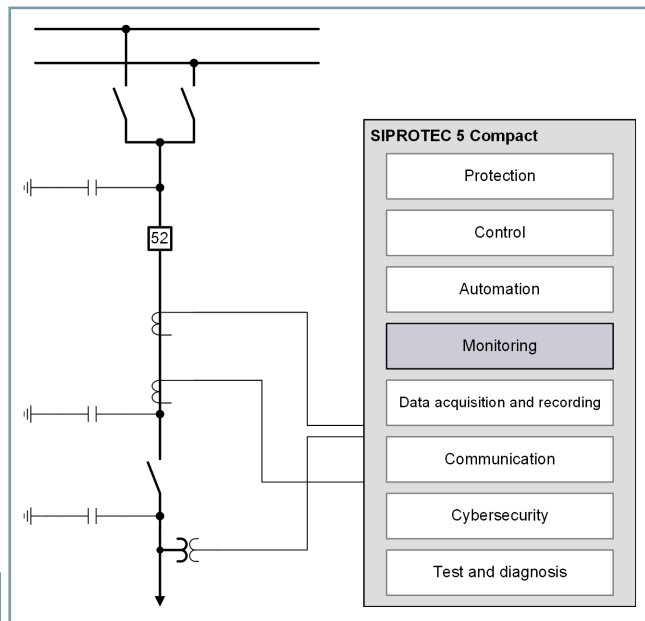


Figure 2.5/1 SIPROTEC 5 Compact – Functional Integration – Monitoring

SIPROTEC 5 Compact devices can take on a wide variety of monitoring tasks.

These can be divided into the following groups:

- Self-monitoring
- Monitoring power-system stability
- Monitoring of equipment (condition monitoring)
- Monitoring power quality

#### Self-Monitoring

SIPROTEC 5 Compact devices are equipped with many monitoring procedures. These detect faults, internal as well as external, in secondary circuits, store them in buffers, and report them. This information is used to record the device fault and helps to determine the cause of the error in order to take appropriate corrective actions.

#### Monitoring power-system stability

Grid Monitoring combines all of the monitoring systems that are necessary to assure power-system stability during normal operation. SIPROTEC 5 Compact provides all necessary functionalities, such as fault recorders, continuous recorders, for Grid Monitoring. This functionality allows to monitor power system limit violations (for example, stability monitoring via load-angle control) and to trigger the appropriate responses actively. This data in the network control systems can also be used as input variables for online power-flow calculation and enable a significantly faster response in case of status changes in the power system.

#### Monitoring of equipment (condition monitoring)

Condition monitoring is an important tool in asset management and operational support from which both the environment and the company can benefit. Equipment that typically requires

monitoring includes for example: circuit breakers, transformers, and gas compartments in gas-insulated switchgear (GIS).

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

- Process values are stored together with a time stamp in the operational log
- The circuit-breaker statistics provide essential data for condition-based maintenance of switchgear
- Process variables (for example, pressure, SF6 loss, speed, and temperature) are monitored for limit violations via measuring transducers connected to the sensors.
- Using external 20 mA or temperature measuring devices that are connected serially or by Ethernet, other measured values can be captured and processed.

#### Monitoring power quality

Besides availability, the ultimate consumers demand also a high quality concerning the electrical energy (power quality). This depends on process management and the responsibility of the power utilities and consumers among other factors. The increasing use of power electronic components (for example, nonlinear motor drives, renewable infeeds) can have loading effects on power quality. Switching operations in the electrical power system can result in brief voltage dips. An inadequate power quality can lead to interruptions of supply, damages, production outages, and high follow-up costs. Consequently, a reliable measurement of the appropriate power quality features becomes more and more important.

SIPROTEC 5 Compact offers basic detection and recording of some power quality data with PQ Basic:

- Voltage changes (overvoltage, dips, interruption) and voltage unbalance
- Harmonic component voltages and currents, THD and TDD

Many applications do not require detections according to the most stringent PQ standards. PQ-Basic offers a cost-effective, simple solution without having to install and operate additional power-quality devices. In this way, you can quickly get an overview of your PQ status for the entire power system since all the installed SIPROTEC 5 Compact devices can simply be upgraded via a firmware update without having to install additional hardware. You can then, for example, perceive trends and be warned if the power quality has reached problematic limits at sensitive points. This can be used to detect weak points early so that corrective measures can be taken.

If a detection and evaluation of the power-system quantities is necessary as per the entire scope of grid codes, such as the EN 50160 standard, SIPROTEC 5 provides appropriate power quality recorders such as the SIPROTEC 7KE85. A SICAM PQS system provides centralized data archiving and an elegant evaluation of the weekly reports as per, for example, EN 50160, among others.

#### **Power Quality – Basic (PQ-Basic)**

##### Voltage Unbalance

In a 3-phase power system, the voltages are normally balanced, as well as the connected loads. In some cases, however, the balanced conditions can be disturbed due to various influences.

Voltage unbalances can be caused by various factors:

- Unbalanced load, for example, caused by different consumers in the individual phases
- Phase failure, for example, due to a tripped 1-phase fuse or a broken conductor
- Faults in the primary system, for example, at the transformer

The function **Voltage unbalance**:

- Detects the voltage-unbalance conditions in the distribution and industrial power systems.
- Monitors the voltage-unbalance conditions.

In the function **Voltage unbalance**, the following stage types are available:

- **V2/V1**: ratio of the negative-sequence voltage to the positive-sequence voltage
- **V0/V1**: ratio of the zero-sequence voltage to the positive-sequence voltage

All the measured values are displayed under **Power quality basic > Voltage unbalance** of a specific function group in the HMI.

The specific function group in which the function **Voltage unbalance** is instantiated must be connected to the 3-phase voltage measuring point.

#### Voltage Variation

The function **Voltage variation** is used for measuring and monitoring short-duration variations of the voltage in distribution and industrial power systems. The power-quality events such as voltage dips, swells, and interruptions in 3-phase systems are detected.

This measuring function provides the RMS value of the voltage for the minimum value in the event of a voltage dip, the lowest residual voltage in the event of an interruption or the highest swell, as well as the duration of the event.

All events can be logged in operational or user-defined logs. They can enable the fault recorder via binary warning indications, and write their values as tracks.

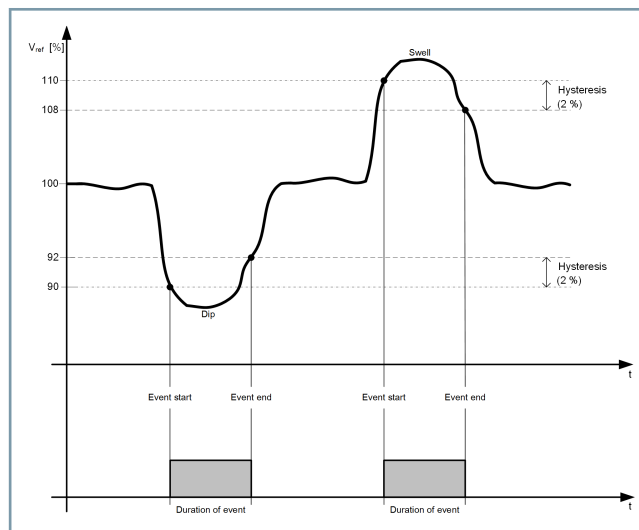


Figure 2.5/2 Duration of a Voltage Dip or Overvoltage Event

#### THD and Harmonics

At the connection point to the public power system, the allowed total harmonic distortion (THD) is limited according to the power-quality related standards. The function **THD and harmonics** can be used to monitor the THD value.

The function **THD and harmonics** serves for the calculation of the following values:

- THD values of the 3-phase currents and 3-phase voltages
- Aggregated THD values of the 3-phase voltages  
If the aggregated THD value exceeds the threshold, a warning is generated.
- Harmonics of the 3-phase currents and 3-phase voltages

The calculated THD values and harmonics are displayed under **Power quality basic > THD and harmonics** of a specific function group in the HMI or via the DIGSI Online-Editor. If routed, the calculated THD values and harmonics are available in the communication protocols and in the fault record. Abnormal values can be logged in the operational or user-defined log if routed.

#### Total Demand Distortion

At the connection point to the public power system, the allowed total demand distortion (TDD) is limited according to the power-quality related standards. The function **Total demand distortion** can be used to monitor the TDD value.

The function **Total demand distortion** serves for calculating the following values of the 3-phase currents:

- 3-s TDD value
- TDD value within an interval  
If the TDD value **TDD intv1** exceeds the threshold value, a warning is generated.

The TDD values are displayed under **Power quality basic > TDD** of a specific function group in the HMI or via the DIGSI Online-Editor. If routed, the TDD values are available in the communication protocols and the fault records. Abnormal values can be logged in the operational log or user-defined logs.

# SIPROTEC 5 Compact – System

## Monitoring

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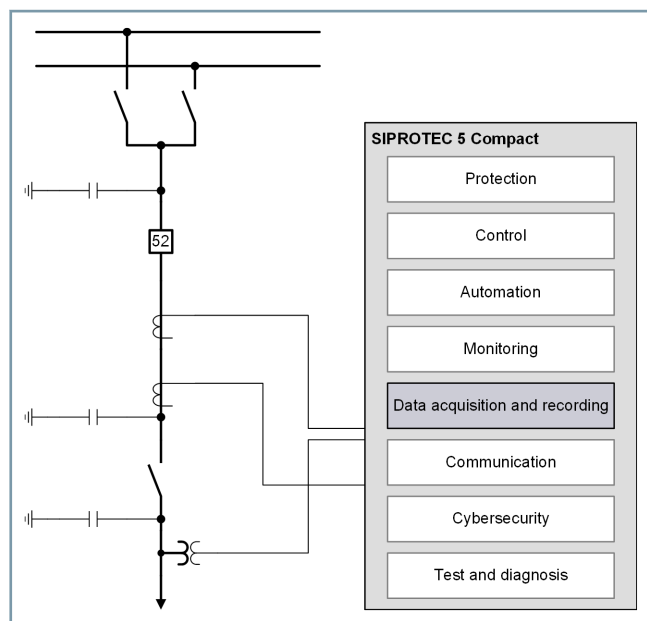
### *General Properties, Power Quality – Basic:*

Values of the 3 phases (phase-selective) can

- be viewed on the device display as well as remotely using DIGSI 5 and even used with CFC
- be transmitted using the protocols supported by SIPROTEC 5 Compact (typically, as per IEC 61850) for additional use or for documentation,
- optionally be recorded in the fault record; started via CFC (it is possible to configure one binary input to the external starting condition of the fault recorder).
- All events and anomalous PQ data can be logged in operational message or user-defined logs with a time stamp and they can be displayed on the HMI and DIGSI 5 information list. The data is stored in nonvolatile memories (and are not lost in a power outage). You can also export data to a file with DIGSI.
- If limiting values are exceeded, beacons can be generated.
- Statistical values such as meters and previous maximum values can be reset via the HMI, BI or remotely via DIGSI or via the log (resetting of the log be by way of the CFC and a user-defined signal)

2.5

### Data Acquisition and Recording



(div\_data\_SIP5C\_1\_en\_US)

**Figure 2.6/1** SIPROTEC 5 Compact – Functional Integration – Data Acquisition and Recording

The recorded and logged bay data is comprehensive. It represents the image and history of the bay. It is also used by the functions in the SIPROTEC 5 device for monitoring, substation automation, and multibay automation tasks. Thus, they represent the basis both for the functions available today and for future applications.

#### Measurement and PMU<sup>1</sup>

A large number of measured values is derived from the analog input variables, which supply a current image of the process.

Depending on the device type, the following basic measured values are available:

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

Besides the basic measured values, synchrophasor measured values can also be activated in the devices (application as PMU, Phase Measurement Unit)

Synchrophasor measured values support a range of applications for monitoring grid stability. For this purpose, SIPROTEC 5 devices acquire the necessary PMU data. These high-

precision, time-stamped phasors indicate power frequency and the change in the power frequency. They can be transmitted to central analysis systems via the high-performance communication systems.

Measured values are displayed as primary and secondary values and as reference values. These values are also available for other applications, for example, transmission to the systems control or automation tasks.

Up to 8 analog inputs can be supplied for each device.

All analog inputs are factory-calibrated and thereby ensure maximum accuracy.

Separate measuring transducers (analog inputs) are therefore unnecessary. The high-precision measured data enables extended energy management and makes commissioning much easier.

SIPROTEC 5 thus provides the following measured values for analysis and further processing:

- The basic measured values with high dynamic range and high accuracy (protection-class current transformer)
- The basic measured values with very high accuracy (instrument transformer)
- Synchrophasor measured values with high-precision time stamping for subsequent tasks such as grid stability monitoring.
- Detection of current and voltage signals up to the 50 th harmonic with a high accuracy for selected protection functions (for example thermal overload protection, peak over-voltage protection for capacitors) and operational measured values.

#### Recorder

In SIPROTEC 5 Compact devices, recorders are able to record large volumes of data. They feature a large number of analog and binary inputs, and a high sampling frequency. An extremely wide range of records can be converted, either continuously or via various trigger criteria.

Besides storing the data on internal mass storage, a transmission to central analysis systems is possible. Consequently, you are able to monitor systems regarding typical characteristics.

#### Fault Recorders

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

<sup>1</sup> Under development

# SIPROTEC 5 Compact – System

## Data Acquisition and Logging

Features of the fault recorders:

- Recording of all analog channels
  - Sampling frequencies from 1 kHz to 8 kHz
  - High recording capacity for individual records of 20 s for 24 channels at an 8 kHz sampling frequency
  - Storage capacity for up to 128 fault records
  - The recording duration for all records is limited by the available storage capacity of the device, and depends on the number of configured channels and sampling frequency.
- Example
- Line protection with 8 analog channels (4 I, 4 V),
  - Sampling frequency 1 kHz, 6 measured value and 20 binary channels: Resulting recording capacity of the device about 890 s!
- Up to 100 freely configurable binary and 50 additional measured value tracks

### Time Synchronization

In order to compare the measured values and recordings of devices at different locations to each other, a very exact time synchronization of all devices is required. Thus, the time synchronization is an important property and must be done with a high degree of accuracy.

The time synchronization can be done using 1 or 2 timers. Depending on time source, an accuracy from 1 ms to 1 μs is attained. Events are logged with a date and time with 1 ms resolution.

The time synchronization is optionally realized via:

- IRIG B signal
- SNTP protocol
- Substation automation protocol (for example, IEC 61850)
- IEEE 1588 protocol (accuracy: 1 μs)<sup>2</sup>
- DIGSI 5 protocol (not cyclical)
- Internal time with integrated quartz crystal

Time synchronization in the device has a battery back-up. Thus, the internal clock continues to run with the quartz accuracy of the device even in case of outage of the auxiliary voltage.

### GPS Time Signal Receiver for IRIG B

The recommended GPS receiver from Meinberg synchronizes the internal time of all connected protection devices. The internal clock of the protection devices is updated using the IRIG B telegram. SIPROTEC 5 devices generally support redundant time synchronization. The time information can be provided by 2 external timers. One timer functions as the primary time source. If it fails, a switchover to the second (secondary) timer is performed.

### Event-Log Buffer

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

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

### Convenient, Complete Analysis

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

### Maintainability

Hardware and software are constantly monitored and irregularities are detected immediately. In this way, extremely high levels of security, reliability, and availability are achieved at the same time. Important information about essential maintenance activities (for example, battery supervision), hardware defects detected by internal monitoring, or compatibility problems are recorded separately in the device-diagnosis log. All entries include specific instructions. The following table provides an overview of the typical logs.

The log entries and fault records are retained even in case of an auxiliary-voltage and battery-voltage failure.

Type of Log	Number of Messages	Property
Operational log	2000 messages	Cyclical logging of operational indications (for example, control processes)
Fault log	1000 messages per fault	Event-driven recording of faults. A maximum of 128 faults can be stored. A maximum of 1000 messages can be recorded for each fault.
User-specific buffer	200 messages	Option of cyclical or event-driven recording of user-defined signals
Ground-fault log	100 messages per ground fault	Event-driven recording of ground faults. A maximum of 10 ground faults can be stored. A maximum of 100 messages can be recorded for each ground fault.
Parameterization history log (cannot be deleted)	200 messages	Logging of all parameter changes and configuration downloads
Communication log	500 messages	Logging the status of all configured communication links (such as disturbances that arise, testing and diagnostic operation, and communication loads)

<sup>2</sup> Under development

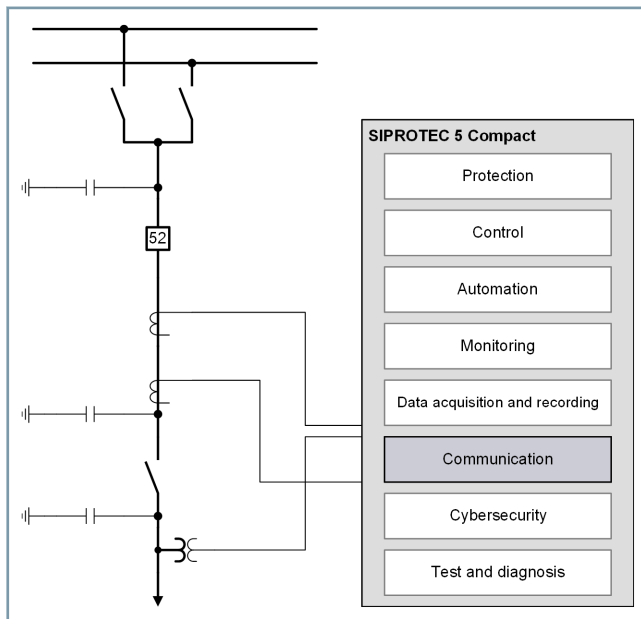
Type of Log	Number of Messages	Property
Security log (cannot be deleted)	500 messages	Logging the successful and unsuccessful attempts to access restricted areas of the device
Device-diagnosis log	500 messages	Logging and display of specific instructions in case of necessary maintenance (for example, battery supervision), detected hardware defects, or compatibility problems

**Table 2.6/1** Overview of Typical Logs

# SIPROTEC 5 Compact – System

## Communication

### Communication



[dw\_Communication\_SIP5C\_1\_en\_US]

**Figure 2.7/1** SIPROTEC 5 Compact – Functional Integration – Communication

2.7

SIPROTEC 5 Compact devices are equipped with high-performance communication interfaces. These are integrated interfaces to provide a high level of security and flexibility. The interface is independent of the protocol used. This can be loaded according to the application.

Particular importance was given to the realization of full communication redundancy:

- Ethernet-based protocols (for example, Modbus TCP, DNP3, IEC 60870-5-104, PROFINET IO, IEC 61850 Ed1 and Ed2)
- IoT interface via GridEdge for integration in cloud systems such as MindSphere
- PRP and HSR uninterruptible Ethernet redundancy protocols (seamless redundancy), in particular for high-availability station communication, as well as RSTP and point-to-point communication.



### Communication Interfaces of the Device

The protection device has an electrical serial interface on the rear panel and a redundant Ethernet interface, which – depending on the device variant – is optically or electrically designed.

#### Ethernet Interface

The redundant Ethernet interface is used for Ethernet-based protocol applications, such as IEC 61850, Modbus TCP, DNP3, IEC 60870-5-104, PROFINET IO, time synchronization via SNTP, DIGSI 5 via TCP. Several applications can run in parallel, whereby unused applications can be switched off for security reasons.

#### Optical Ethernet Interface

The optical Ethernet interface has 2 optical duplex LC 1300 nm interfaces. It can be configured with or without an integrated switch. The maximum optically permitted distance via 50/125- $\mu\text{m}$  or 62.5/125- $\mu\text{m}$  multimode optical fibers is 2 km. The optical transmission and receiving level is measured in the module and can be displayed with DIGSI 5.

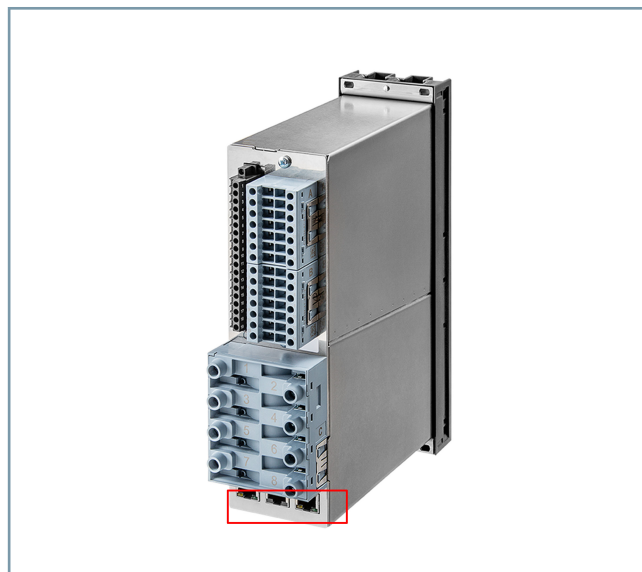


[dw\_SIP5Comp\_rear\_optical\_interface, 1, --]

**Figure 2.7/2** Rear Panel with Optical Ethernet Interface

#### Electrical Ethernet Interface

The electrical Ethernet interface has 2 RJ45 interfaces. It can be configured with or without an integrated switch. The maximum electrically permitted distance via CAT 5 patch cables is 20 m.



[dw\_SIP5Comp\_rear\_electrical\_interface, 1, --]

**Figure 2.7/3** Rear Panel with Electrical Interfaces

#### Serial interface

The serial RS485 interface features 1 RJ45 interface. It is used for serial protocol applications such as IEC 60870-5-103, DNP3 serial, or Modbus RTU.

# SIPROTEC 5 Compact – System

## Communication – Interfaces

### Communication Interfaces

Port or Integrated Interface	Front Interface	Serial Interface or Time Synchronization	Electrical Ethernet Interface	Optical Ethernet Interface
<b>Physical Connector</b>				
USB	■			
1 x electrical serial RS485, RJ45		■		
2 x electrical Ethernet 10/100 Mbit/s, RJ45, 20 m			■	
2 x optical Ethernet 100 Mbit/s, 1300 nm, LC connector, 2 km via 50/125 µm or 62.5/125 µm multimode optical fiber				■
<b>Applications</b>				
DIGSI 5 protocol	■		■	■
IRIG B		■		
IEC 61850-8-1 server (including GOOSE, reporting to 6 clients)			■	■
IEC 60870-5-103		■		
IEC 60870-5-104			■	■
DNP3 serial		■		
DNP3 TCP			■	■
Modbus TCP			■	■
PROFINET IO			■	■
SUP serial (Slave Unit Protocol) for connecting external temperature or 20-mA measuring devices		■		
SUP Ethernet (Slave Unit Protocol) for connecting external temperature gages or 20-mA measuring devices			■	■
Diagnostics homepage			■	■
<b>Additional Ethernet Protocols and Services</b>				
DHCP, DCP (automatic IP configuration)			■	■
Line Mode			■	■
PRP (uninterruptible Ethernet ring redundancy (Parallel Redundancy Protocol))			■	■
HSR (uninterruptible Ethernet ring redundancy (High Availability Seamless Redundancy Protocol))			■	■
RSTP (uninterruptible Ethernet ring redundancy (Rapid Spanning Tree Protocol))			■	■
SNTP (time synchronization over Ethernet)			■	■
SNMP V3 (network management protocol) <sup>3</sup>			■	■
IEEE 1588v2 <sup>3</sup> (PTP protocol over Ethernet – microseconds accuracy)			■	■
IEEE 802.1q (VLAN)			■	■

Table 2.7/1 Communication Applications and Integrated Interfaces

## Protocols

Communication interfaces are supplied without a protocol application. According to the [Table 2.7/1](#), an integrated interface can be initialized via DIGSI 5 with a protocol application. Every interface is assigned the desired application via DIGSI 5. Assignments can be erased and reconfigured. This enables a high degree of flexibility when configuring the interface.

### DIGSI 5 Protocol

The DIGSI 5 protocol works with TCP services, which can be routed via IP networks. Worldwide remote access to devices via secure connections is an integral component of the communication concept. The protocol is available on the USB interface and the Ethernet interface.

### IEC 61850-8-1 Client-Server Communication

Messages, measured and metered values can be transferred to a maximum of 6 clients (substation controllers) via the client-server communication in static and dynamic reports. Dynamic reports are created and read by the client without changing the parameters of the device. The static reports are created via the IEC 61850 System Configurator and are permanently saved in the device as indication lists. Fault records can also be retrieved in binary COMTRADE format. Extensive control functions are available from the client, for example, for the safe switching of a circuit breaker. The setting parameters of the device can be read and also changed via the IEC 61850 protocol. The devices can be integrated in interoperable, intelligent Smart Grids without difficulty. Changing the device parameterization during operation is possible through substation-controller equipment in order to adapt selected setting parameters to the operating conditions.

### IEC 61850-8-1 GOOSE

GOOSE has been established as a worldwide standard for cross communication between devices in order to transmit messages and measured values between devices. In addition to GOOSE between devices within switchgear, GOOSE is also supported between devices in different switchgears. The exchanged information is described in data terms via standard-conforming SCL files, which were defined in Edition 2 of IEC 61850. The exchange itself occurs via high-performance IP network connections or Ethernet network connections.

GOOSE messages can be used to exchange time-critical information that must be transmitted in a few milliseconds. In this case, GOOSE connections replace transmission via contacts and binary inputs; for protection signals, transmission times under 10 ms are required, and under 20 ms for switch positions and interlockings. Measured and metered values are transmitted in less than 100 ms. GOOSE applications are generated in the system configurator for this purpose. This data is exchanged by the devices in a high-performance manner via GOOSE messages.

Receivers of GOOSE messages can constantly monitor the receipt of indications and measured values for an outage of the connection. The state of missing indications is automatically updated at the receiver in order to attain a secure state. This allows a constant, high-quality monitoring of GOOSE communication to be realized. GOOSE messages transmitted during the

test mode of a device are ignored by the receivers if these are in normal operation. A test of a device can be performed without disconnection from the communication network.

### IEC 60870-5-103

The serial protocol is transmitted via the RS485 interface. Compatible and specifically extended for Siemens, it is the IEC 60870-5-103 protocol that is supported. The implementation is compatible with existing solutions, for example with SIPROTEC 4 or SIPROTEC 5 devices, which will enable a trouble-free exchange and extension of devices even in the very long term. In addition to indications, measured values, and fault records, metered values, and customer-specific defined indications of systems control are also available in protocol extensions. Control commands for switching devices can also be transmitted via the protocol. Setting values in the device can also be read or changed via the generic services of the protocol. Information about the device can be routed to the protocol interface by the user with DIGSI 5. Information types and function numbers can be freely configured here. This enables adaptation to existing solutions and the interchangeability of devices without changes in the systems control. This is an important contribution to investment security.

### IEC 60870-5-104

The station and network control protocol IEC 60870-5-104 is supported via the electrical or optical Ethernet module. Besides the transmission of messages (single and double-point indications), as well as measured values and metered values to 1 master or 2 (redundant) masters, 3 masters (controlling stations) which are sent the same information are also possible. Furthermore, IEC 60870-5-104 data transmission is supported and fault records can be read from the device in the COMTRADE format. In command direction, secure switching of switching objects is possible via the protocol. Time synchronization can take place via the IEC 60870-5-104 master or via SNTP via the network, redundant time servers being supported.

### SUP – Slave Unit Protocol

This Siemens-specific protocol is used temperature measuring devices (RTD unit 7XV5662-\_AD10) in series or via Ethernet. These devices are available as accessories for extension of SIPROTEC 5 devices with analog interfaces. The measured values of these devices can be further processed in the SIPROTEC 5 device or are used for protection functions such as overload protection or transformer hotspot calculation.

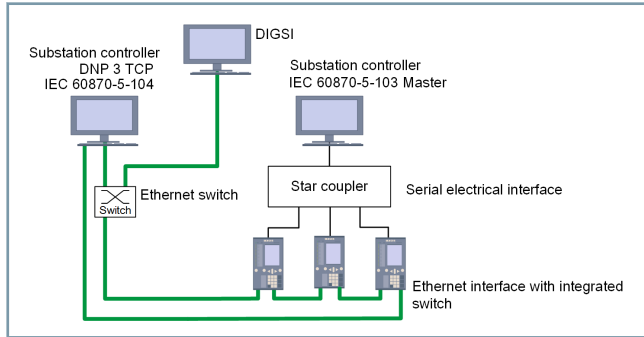
### Serial DNP3 or DNP3 TCP

DNP3 is supported as a serial protocol via RS485 and as an Ethernet-based TCP variant via the integrated electrical or optical Ethernet interface. A redundant optical or electrical ring can be implemented simply by means of the switch integrated in the Ethernet interface. Information about a device, and the fault records of the device, can be routed and transferred using the DNP3 protocol. Switching commands can be executed in control direction. DNP3 TCP can support up to 2 masters ([Figure 2.7/4](#)).

# SIPROTEC 5 Compact – System

## Communication – Protocols

Setting values in the device cannot be read or changed via the protocol.



[dw\_SIP5C-0057\_1\_en\_US]

**Figure 2.7/4** DNP3 TCP/IEC 60870-5-104 Communication with Further Serial Connection with an IEC 60870-5-103 Master

### Modbus TCP

The Modbus TCP communication protocol is supported via the the integrated electrical and optical Ethernet interface. Modbus TCP and Modbus RTU are very similar to one another. However, Modbus TCP uses TCP/IP packets for data transmission.

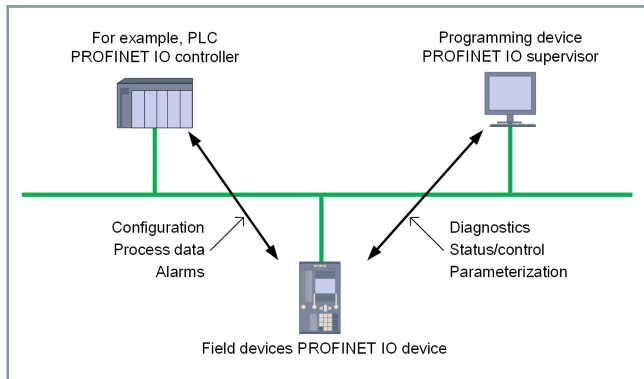
Modbus TCP can be used to transmit messages (single-point and double-point indications), measured values, metered values to 1 or 2 (redundant) masters. In command direction, switching of switching objects is possible via the protocol.

Time synchronization can take place via SNTP or IEEE 1588<sup>4</sup> via the network, redundant time servers being supported.

### PROFINET IO

PROFINET IO is an Ethernet-based communication protocol that can be used in all areas of communication automation.

The data exchange of PROFINET IO follows the Provider/ Consumer model. A configured PROFINET IO system has the same look and feel as in PROFIBUS.



[dw\_COM\_PRO\_IO\_2\_en\_US]

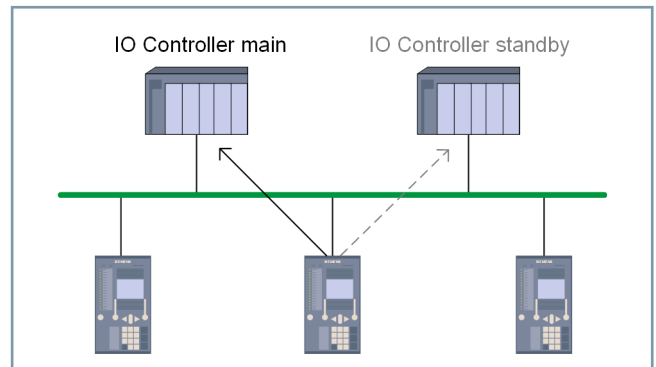
**Figure 2.7/5** Communication Paths for PROFINET IO

The following device classes are defined for PROFINET IO:

- **PROFINET IO controller**  
A PROFINET IO controller is typically the programmable logic controller (PLC) on which the automation program runs. The PROFINET IO controller provides output data to the configured IO devices in its role as provider and is the consumer of input data of IO devices.
- **PROFINET IO supervisor**  
A PROFINET IO supervisor can be a Programming Device (PD), a personal computer (PC), or a human-machine interface (HMI). It serves for commissioning or diagnostic purposes and corresponds to a class-2 master in PROFIBUS.
- **PROFINET IO device**  
A PROFINET IO device is a distributed IO field device that is connected to one or more IO controllers via PROFINET IO. It is comparable to the function of a slave in PROFIBUS. The PROFINET IO device is the provider of input data and the consumer of output data. The SIPROTEC 5 device works as the IO device.

### PROFINET IO S2 Redundancy and SOE (Sequence of Events)

The integrated Ethernet interface supports the redundancy on the system level for the PROFINET IO protocol. System redundancy is the redundancy of the IO controller or of the communication interface of the input/output device. *Figure 2.7/6* shows an example in which 1 input/output device is connected to 2 different IO controllers. The input/output device maintains the active communication with one of the IO controllers as the primary controller and with the other as the standby controller.



[dw\_Profinet-IO-S2-redundancy\_1\_en\_US]

**Figure 2.7/6** Connection of an Input/Output Device to 2 Different IO Controllers

The Ethernet interface also supports SOE functionality in which the digital signals can be queried from the input/output device (SIPROTEC 5 or SIPROTEC 5 Compact) and can be relayed to the IO controller with accurate time stamps and a FIFO buffer having a capacity of 500 signals.

### VLAN as per IEEE 802.1q

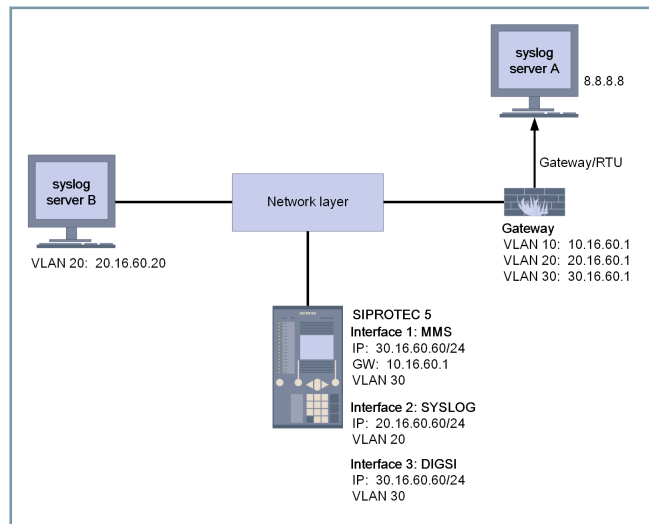
VLAN as per IEEE 802.1q is the standard in which various applications on the same physical Ethernet network can be discon-

<sup>4</sup> Under development

nected or isolated. This improves the security, availability and performance in the network and, at the same time, ensures cost efficiency.

In a VLAN-capable network, you mark the Ethernet frames that belong to the different application domains so that the other switches or receivers either transmit a packet with the desired priority or discard the packet due to security policy.

The SIPROTEC 5 Compact family supports VLAN on the integrated Ethernet interface. As shown in the example figure above, the SIPROTEC 5 device uses only one single physical medium for 3 different applications with 3 different IP interfaces. The switches control the telegrams to be transmitted in accordance with their setting. Devices can only receive those telegrams for which they are configured.



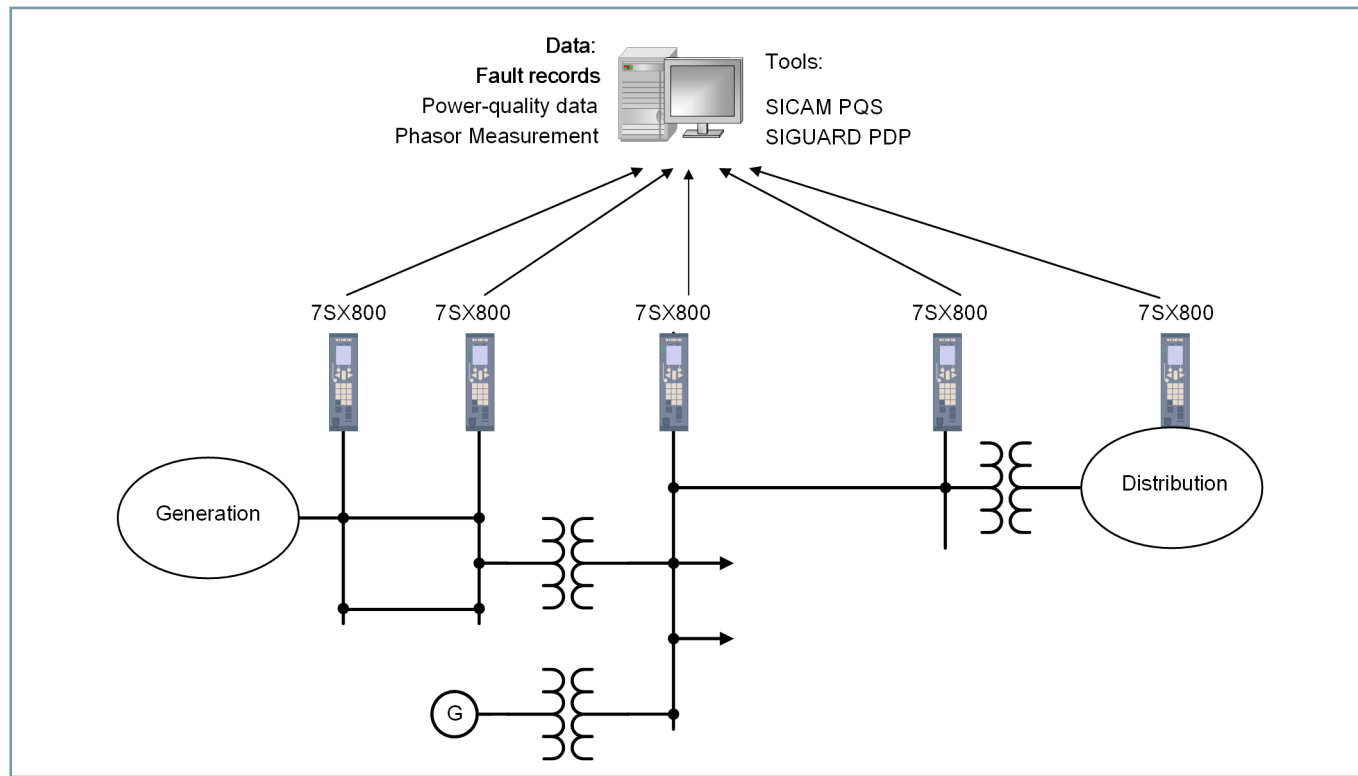
[dw\_SIP5\_IEEE802-1q\_VLAN\_1\_en\_US]

Figure 2.7/7 1 Physical Medium for 3 Applications

### IEEE C37.118 (Synchrophasor)

Under development

SIPROTEC 5 devices optionally calculate synchrophasors and work as a Phasor Measurement Unit (PMU). These measured values, which are synchronized across large geographic areas with high precision, allow for assessment of power system stability. These values are transmitted via an Ethernet network with the IEEE C37.118 protocol to a data concentrator. The transmission occurs via an optical or electrical Ethernet interface (Figure 2.7/8).



[dw\_central\_SIP5C\_1\_en\_US]

Figure 2.7/8 Central Evaluation of Fault Records and Phasors

# SIPROTEC 5 Compact – System

## Communication – Protocols

### Further Ethernet-Based Protocols and Services

Besides the actual protocol application, these services can run in parallel on an integrated Ethernet interface. They can be switched on and off by the user with DIGSI 5.

#### Ethernet Redundancy with RSTP, PRP, HSR

The electrical and optical Ethernet interface supports the building of redundant ring structures in Ethernet with the redundancy protocol (RSTP, HSR). With HSR, an uninterrupted ring redundancy is achieved with up to 50 devices in the ring. PRP can be used to communicate without interruption via parallel networks. These procedures can be activated by means of parameters. They are independent of the substation automation protocol or the selected additional services.

#### Time Synchronization with SNTP Protocol

The device can poll the absolute time from 1 or 2 time servers via an SNTP server. In redundant operation, both servers are read and the time of the 1st server is used for setting the device clock with an accuracy of 1 ms. If this server fails, the time is synchronized by the second server.

#### Time Synchronization with IEEE 1588 (Under Development)

The IEEE 1588 protocol is available for greater time synchronization accuracy via Ethernet. High accuracy of  $1\mu\text{s}$  is required to synchronize measured values for process bus applications, PMU data synchronization, and to stabilize unsymmetrical protection communications for line differential protection applications. It can be activated on the electrical or on the optical Ethernet interface. A prerequisite is that the network components (for example, switches) also support the protocol and special IEEE 1588 time servers are available in the network. With IEEE 1588, a runtime measurement for the time synchronous telegrams in the Ethernet network is carried out so that the terminal devices (for example SIPROTEC 5) receive time information corrected by the runtime, which is more precise than with SNTP. Both the Power Utility Profile (IEC 61850-9-3) and the Power Profile IEEE C37.238 are supported with the devices working as ordinary slave clocks (terminal devices) in the network.

For the high-precision time synchronization via Ethernet IEEE 1588, a suitable router, for example, from Ruggedcom, is used.

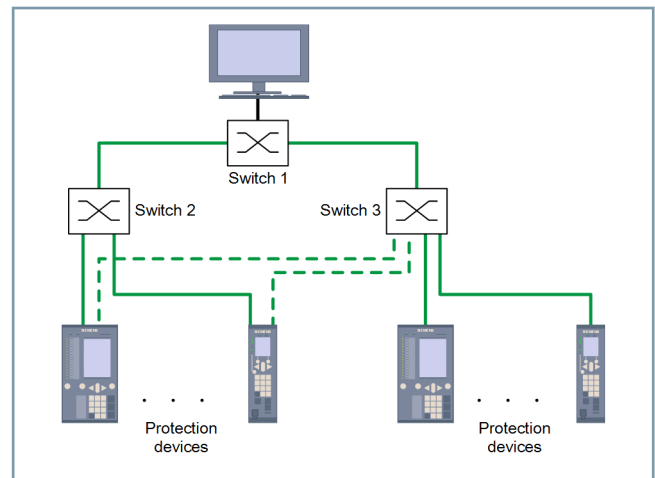
#### Network Monitoring with SNMP

The device can be integrated in network monitoring or power-management systems via the SNMP protocol V3. Extensive monitoring variables, for example the state of the Ethernet interfaces, their data throughput etc. can be made known to the monitoring system via MIB (Management Information Base) files. These variables are described in data-specific terms in MIB files and can be cyclically read out and monitored by the monitoring system. No values can be changed in the device via SNMP. It serves exclusively as a diagnosis interface.

### Ethernet Redundancy – Network Topologies

Regardless of the selected protocol (IEC 61850, DNP3 TCP), the electrical and optical Ethernet interface supports different network topologies.

If such an interface operates without an integrated switch that can be switched off through DIGSI 5, it is connected to external switches individually or redundantly. In the case of a double connection, only one interface processes the protocol applications (for example, IEC 61850). The second interface works in hot standby and the connection to the switch is monitored. In the case of an outage of interface 1, a switch is made to interface 2 within just a few milliseconds ([Figure 2.7/9](#)).

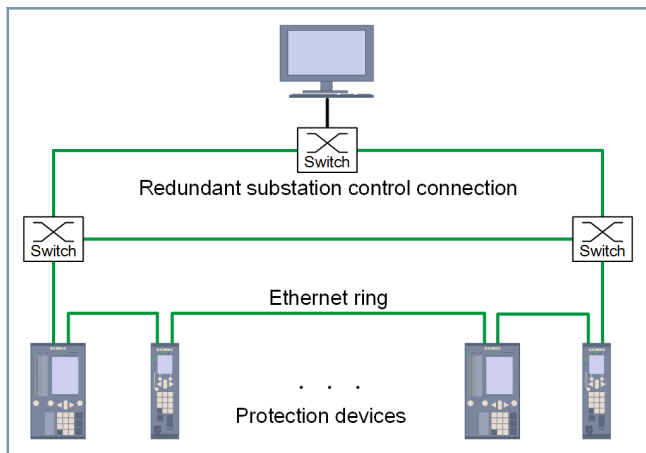


[dw\_SIP5C-0031; 2\_en\_US]

Figure 2.7/9 Single or redundant connection to external switches

Electrical or optical ring feeders with a maximum of 40 devices can be established with an integrated switch (RSTP) ([Figure 2.7/10](#)). Both channels of the interface transmit and receive simultaneously. Mixed operation with SIPROTEC 4 devices is possible in the ring feeder with a maximum of 30 devices. A special ring redundancy process, based on RSTP, ensures short recovery times in the event of the outage of a device, so that the protocol applications continue running nearly interruption-free. This configuration is also independent of the protocol application that runs on the Ethernet interface.





[dw\_SIP5C-0032, 2, en\_US]

**Figure 2.7/10** Ring operation with integrated switch and ring redundancy

### Seamless Redundancy with PRP and HSR

New technologies decisively shorten the time for the reconfiguration of communication networks in the event of interruptions.

These technologies include:

- PRP = Parallel Redundancy Protocol
- HSR = High Available Seamless Ring Redundancy

Both systems operate according to the same principle and conform to IEC 62439-3 standard.

The same information is thus transmitted via 2 different information routes. The receiver utilizes the first telegram to arrive and discards the second. If the first telegram does not arrive, the second one is still available and is used. This mechanism is based on the Ethernet stack, which assigns the same MAC address to the two telegrams.

- The PRP protocol uses 2 networks that are physically separate to transmit 2 identical telegrams. Although this doubles the effort and cost for the network equipment, the PRP protocol provides greater availability of the Ethernet system compared to the HSR protocol.
- HSR operates on the same principle but the 2 identical information telegrams are distributed in 2 directions on one Ethernet ring feeder. The cost for the Ethernet network infrastructure is less but HSR handles N-1 errors – however, evolving faults result in a communication outage in parts of the HSR ring feeder.

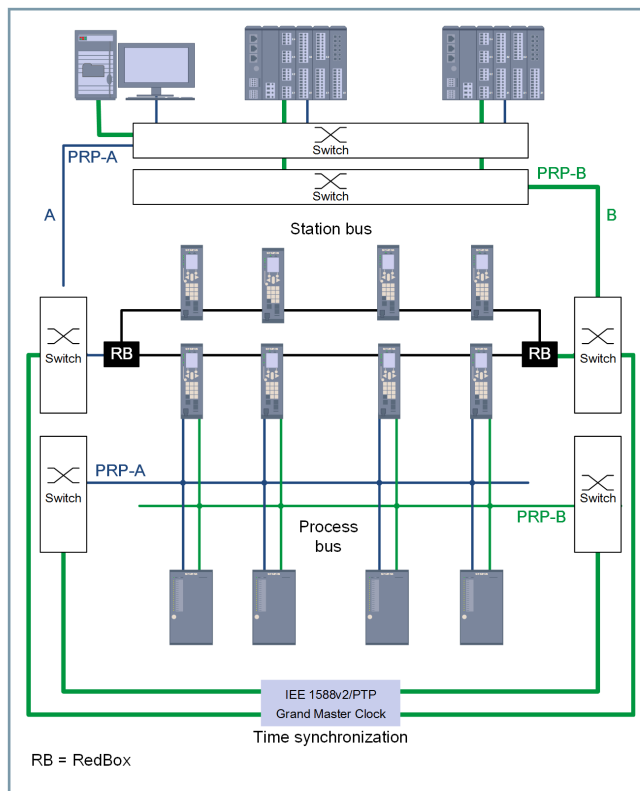
The procedures can be activated via setting parameters and do not have any other parameters. They are therefore easy to set up. The number of network users is limited in both procedures to a maximum of 512.

HSR and PRP can be combined using so-called RedBox units (redundancy boxes).

This cost efficient solution according to IEC 62439-3 can be designed in the following manner:

- 2 switches in the control center
- 2 switches in the bay

- 2 RedBox units (RB) per HSR ring
- Up to 50 devices per HSR ring
- Simple extension by 2 two additional PRP switches.



[dw\_SIP5C\_stossfreie-n-1-struktur, 1, en\_US]

**Figure 2.7/11** Economical Seamless n-1 Structure with 1 Time Source

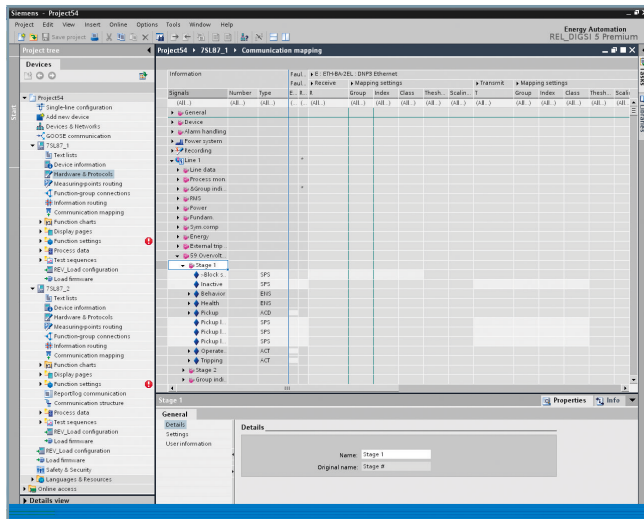
### Integrated Setting of Communication in DIGSI 5

A communication protocol is configured with DIGSI 5. According to the interface type, DIGSI 5 offers the user the selection of the respective, permissible protocols/applications. The protocol parameters are set (for example baud rate, IP address). Then the interface is initialized with the protocol application and, for example, the serial interface with the IEC 60870-5-103 protocol and the communication settings are loaded.

For an application template of a device there is an appropriate communication mapping (Figure 2.7/12). In a communication matrix, the user modifies this mapping and erases and completes his own information. This mapping file is finally loaded by DIGSI 5 into the device, and determines the scope of information that is provided via the protocol. Protocol mappings can be copied between devices, if they contain the same functions, and can be exported into substation control applications.

# SIPROTEC 5 Compact – System

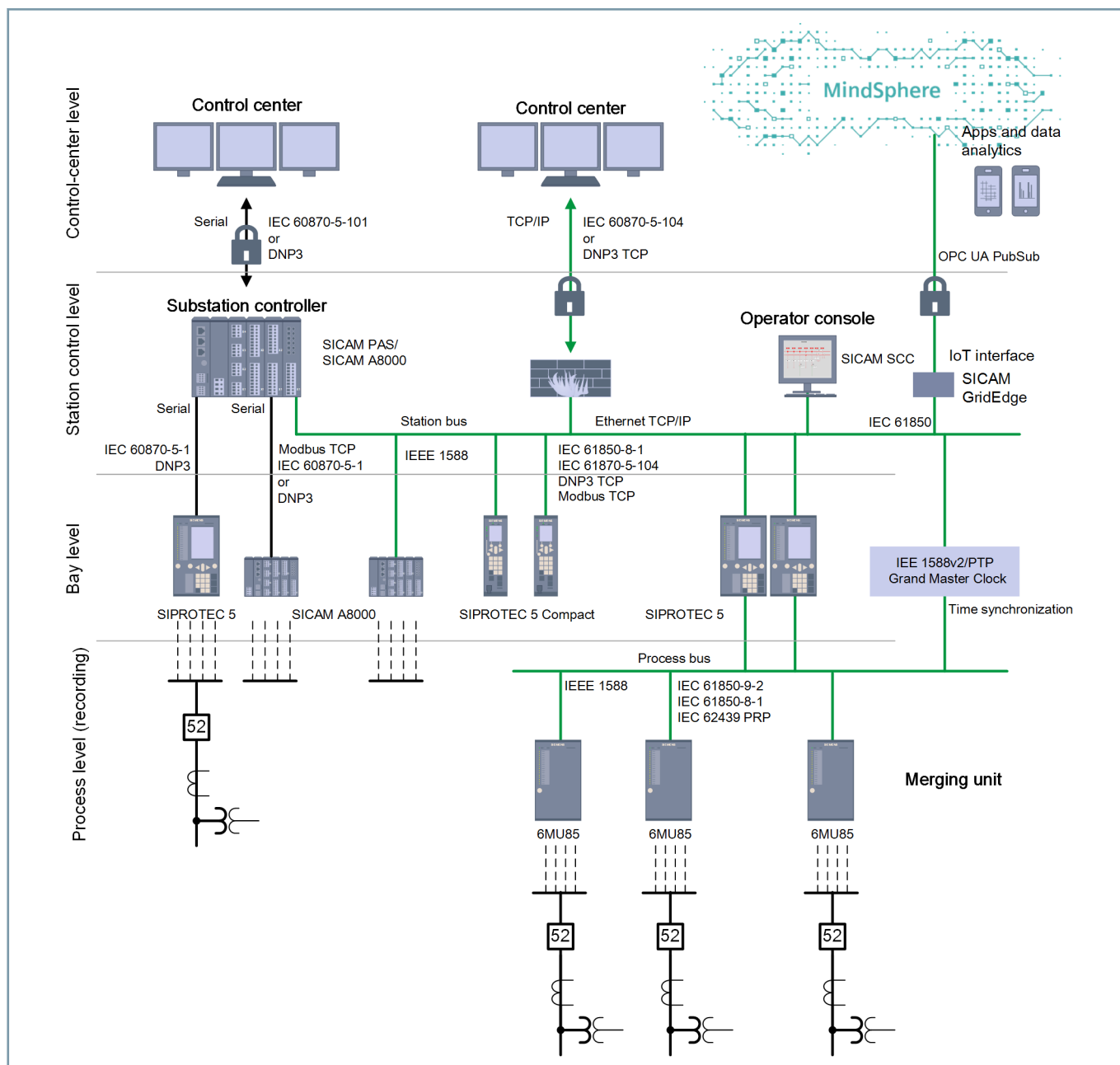
## Communication – Protocols



[Kom\_Communication Mapping\_en-US\_W\_1\_...]

Figure 2.7/12 Assignment of Communication with DIGSI 5





2.7

[dw\_example protection\_substation\_com\_SIP5C\_2\_en\_US]

Figure 2.7/13 Communication protocols in the substation automation technology and in network control systems

**Design to communicate means:**

- High-availability redundancy PRP, HSR
- Secure data transmission as per cybersecurity standards
- Communication with IoT applications via GridEdge
- Adaptation to the topology of your communication structure using settings (ring, star or network)
- Extensive routines for testing connections, functions and operating workflows.

# SIPROTEC 5 Compact – System

## Safety and Security Concept

Safety for personnel and equipment are first priority, but availability is also critically important. As the plant landscape becomes more open and complex, conventional security mechanisms are no longer adequate.

For this reason, a security concept has been implemented in the SIPROTEC 5 device architecture that is designed to address the multidimensional aspects of security in a holistic approach.

Multilayer safety mechanisms in all links of the system security chain provide you with the highest possible level of safety and availability.

Safety and cybersecurity includes:

- Security concept in device design
- Information security against IT attacks (IT threats from outside)

### Safety

#### Multilayer Safety Mechanisms

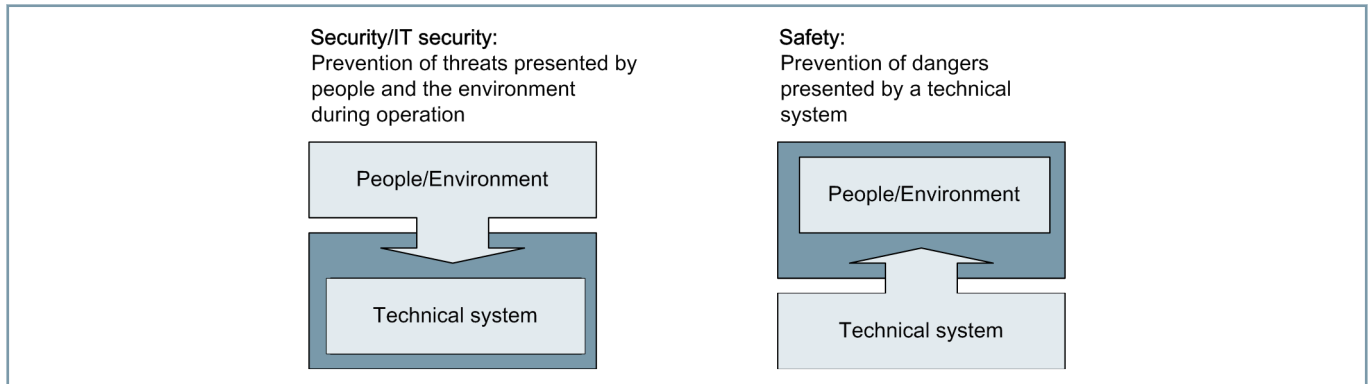
Safety comprises all aspects of protection for personnel and primary equipment installations. The devices and DIGSI 5 support this from the functional standpoint. Cybersecurity measures ensure secure operations in networks. The manufacturer can support the user with these measures. The responsibility to implement a comprehensive cybersecurity

concept lies with the operator of the system. The concept must consider all system components with regard to all technical aspects of cybersecurity.

#### Safety in the Hardware Design

- The cooling system, reduces thermal load, prolongs service life, and enables error-free operation in a wide ambient temperature range.
- High availability is achieved with the auxiliary power supply concept. Central wide range supply ensures the provision of a common voltage to all components. Individually required voltage levels are created in the modules concerned.
- Storage of calibration data in the analog capture modules enables completely safe exchange or extensions within the module unit.
- Fully pluggable terminals mean that when devices or modules are replaced.
- Now that the current transformer is integrated into the terminal block (Safety CT-Plug), open-circuited secondary current circuits cannot occur anymore during replacement of a device. When the terminal is pulled out, the transformer is always opened on the safe, secondary circuit.
- The device does not need to be opened to adjust binary input thresholds or adapt them to the rated current of the transformer (1 A, 5 A). The device does not need to be opened for battery replacement

2.8



[dw\_safety-security, 1, en\_US]

Figure 2.8/1 Differentiation of Safety/Security

#### Monitoring Functions

Comprehensive monitoring functions ensure secure operation by fast detection of irregularities and automatic initiation of appropriate measures to avert incorrect responses. Depending on the severity of the irregularity detected, a warning may be issued, the functions concerned may be blocked, or the entire device may be isolated by opening the life contact. In all cases, the device-diagnosis log outputs the cause and appropriate take-action instruction.

#### Hardware Monitoring

All hardware in the device is continuously monitored.

This includes for instance the CPU, the auxiliary voltage, the battery status, the internal clock, the memory chips, the analog inputs, the bus connections and communication interfaces.

#### Monitoring Analog Inputs

As a data source for the protection functions, monitoring of the analog inputs is assured in multiple stages. Some monitoring functions are primarily dedicated to the commissioning (incorrect or missing connections) and only generate a warning indication.

These include:

- Current and voltage balance
- Current and voltage sum
- Phase-sequence supervision

Other monitoring functions detect outages during operation and rapidly initiate blocking of the affected functions:

- Measuring-voltage failure detection (loss of voltage)
- Fast current-sum supervision and broken-wire detection for the circuits.

In addition, the proper working method of all analog/digital transformers is assured by a plausibility check at the sampling level.

### Trip-Circuit Supervision (ANSI 74TC)

The circuit breaker coil and its lines are monitored via 2 binary inputs. If the trip circuit is interrupted, and alarm indication is generated.

### Communication Connections

Telegrams are monitored for correct transmission. Failures are reported via warning messages. Data associated with protection and control is transmitted via protection interfaces and IEC 61850 GOOSE messages. The transmitted information is also monitored constantly on the receiving side.

### Monitoring of Protection Interfaces

- 32-bit Cyclic redundancy check checksum monitoring compliant with CCITT/ITU for detecting corrupted telegrams
- Invalid telegrams are flagged and not used by the protection system
- Sporadic failures are ignored, persistent failures trigger blocking of the affected protection and control functions.
- Propagation times are measured and taken into account for purposes of differential protection communication.
- The topology of the protection zone is monitored. Outages in the communication connections automatically trigger switching to other communication routes (ring to chain operation or hot standby), or blocking the entire protection zone. The same applies if outage of a device in the topology is detected.

### Monitoring of IEC 61850 GOOSE Messages

- Cyclic redundancy check checksum monitoring, sequence number monitoring and repetition time monitoring, for detecting wrong or missing telegrams
- Applications consider the state of GOOSE messages that are corrupt or transmitted under test conditions and switch to safe operation mode.

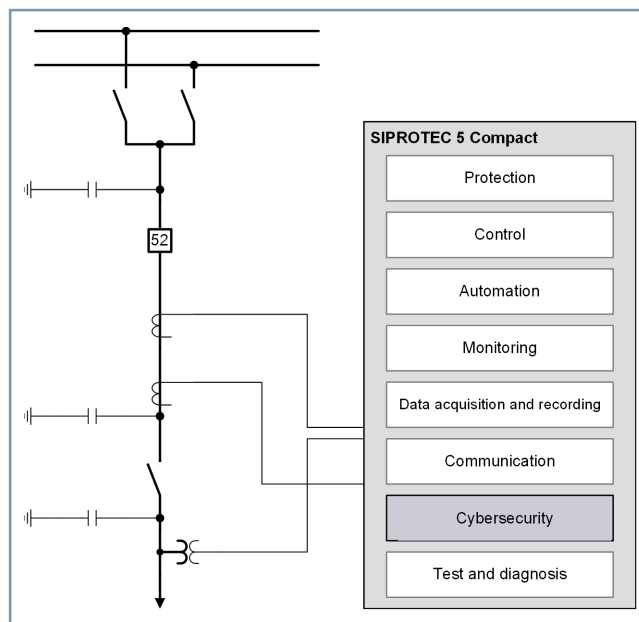
### **Load Management**

The free configurability of protection functions and function charts (CFC) enables them to be adapted to an enormous range of applications. During engineering with DIGSI 5, the integrated load model calculates the resulting device load. This ensures that only viable configurations can be loaded into the device.

### **Consistent Administration of Device Modes**

Test modes and the health status of information are forwarded and handled uniformly and consistently throughout the entire system. Analysis functions take the modes into consideration and warrant secure operation. This is particularly critical when protection and control-related data is transmitted via protection interfaces and IEC 61850 GOOSE messages. But it applies equally for signal processing in the function charts (CFC).

### **Cybersecurity**



**Figure 2.8/2** SIPROTEC 5 Compact – Functional Integration – Cybersecurity

With the increasing integration of bay devices in Ethernet-based communication networks, communication must be secured against internal disturbances and attacks from outside. Standards and directives such as IEC 62443, IEC 62351, NERC CIP (North American Electric Reliability Corporation – Critical Infrastructure Protection), and the BDEW Whitepaper (Requirements for Secure Control and Telecommunications Systems of the Bundesverband der Energie- und Wasserwirtschaft e.V) contain requirements for the secure operation of devices in the critical communications infrastructure, and are addressed to at both manufacturers and operators.

Cybersecurity must be incorporated into the design of devices right from the start. This has been carried out systematically in the case of SIPROTEC 5. Measures in the hardware ensure that key material for protecting the communication and datasets of a device is stored in absolute security. Communication stacks that are hardened against cyberattacks, a multistage role-based access concept in operation, and logging of events relevant to cybersecurity provide the operator with a high degree of cybersecurity when the devices are integrated in the network of the operator.

By default only the connection of DIGSI 5 is enabled in the device. All other Ethernet services and their ports are deacti-

# SIPROTEC 5 Compact – System

## Safety and Security Concept – Cybersecurity

vated by default in the device and can be enabled with DIGSI 5. If, for example, only the ring redundancy protocol RSTP is used, then you as the user enable this with DIGSI 5 (Figure 2.8/4). The secure standard configuration provides no open interfaces to a potential attacker and only services that are really in use are activated in a network.

### Cybersecurity at communication level

Secure authentication takes place between the device and the communication partner (for example DIGSI 5, Web monitor or cloud). This prevents an unauthorized program accessing the devices and reading or writing data there. Through this transmission protocol secured by Transport Layer Security (TLS), the integrity and confidentiality of the transmitted data are ensured. This prevents manipulation and unauthorized access of the data. TLS security is the basis for future communication routes and certificate management, both across stations (for example IEC 61850-MMS) and in the direction of cloud systems (for example, IoT connectivity to MindSphere).

### More operational security (safety) by means of confirmation ID

If Role-Based Access Control (or RBAC) is not activated, confirmation ID entering the confirmation ID is required for safety-critical actions (safety), such as changing parameters, in order to obtain write access to the device. These confirmation IDs can be configured by the user and may be different for different fields of application.

### Establishing connection after password verification

Optionally, if RBAC is not activated, a connection password can be set up on the device. Remote access via the Ethernet does not take place until the user enters the predefined password. The user has read and write access to the device only after the connection has been established. This connection password conforms to the cybersecurity requirements for assigning passwords defined in NERC CIP. It has 8 to 30 characters and must include upper-case and lower-case letters, digits, and special characters. Through this secure transmission protocol, the integrity and confidentiality of the transmitted data are ensured. This prevents manipulation and unauthorized access of the data.

### Establishing of the connection after central authentication and authorization of the user

As a new option, the device supports role-based access control (RBAC). With this option, the device can authenticate and authorize the users by means of centrally managed login data and user accounts. Authentication means that the device checks with the central user management system whether the user name and password combination entered by the user is valid. After successful authentication, the device tests the permitted roles of the user (authorization). Depending on the role assigned to the user, he can only perform authorized operations on the device.

The main advantages of this option for power utilities are:

- Central maintenance of user accounts and roles in RADIUS/ Microsoft Active Directory Server
- Protection against unauthorized access to the device via DIGSI 5, Web browser, and on-site operation thanks to built-in RADIUS authentication and authorization option

- Support for standard roles and rights according to standards and directives such as IEC 62351-8, IEEE 1686, and BDEW Whitepaper
- Emergency-access options in the case of a RADIUS server connection outage

### Logging of events relevant to cybersecurity

Events relevant to cybersecurity, such as login attempts or device restarts, are recorded and optionally transmitted to a central server via the standardized Syslog UDP protocol. The device-internal log entries are secured to prevent deletion and protected against anonymous access with the RBAC option. The events can additionally be transmitted to the substation automation unit and archived there.

### Integrity assurance of firmware and cybersecurity settings

SIPROTEC 5 device-firmware files are digitally signed. In this way, corruption from outside by viruses or trojans, for example by manipulated firmware files, is reliably prevented. In addition, the cybersecurity settings of a device configured with DIGSI 5 are stored in an encrypted way and thus protected against manipulation and disclosure.

### Secure standard configuration

By default, only the connection of DIGSI 5 is enabled in the device. All other Ethernet services and their ports are deactivated by default in the device and can be enabled with DIGSI 5. If, for example, only the ring redundancy protocol RSTP is used, then you as the user enable this with DIGSI 5 (Figure 2.8/4). The secure standard configuration provides no open interfaces to a potential attacker and only services that are really in use are activated in a network.

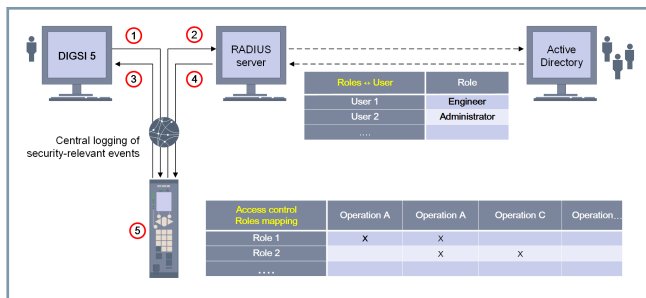
It is generally not desirable to have to enter login data, connection passwords, or confirmation IDs during the configuration and testing phase. During operation, however, the focus is on the reading of data. Complete access protection can be deactivated in the device until commissioning has been completed and can then be activated again for operation.

### Differentiation of the various network accesses

In SIPROTEC 5, the IP attack interface of the SIPROTEC 5 devices can be reduced effectively.

- Setting the IP-based access per device port (mainboard RJ45, slot F/E/P/N)
- Setting options: Full access, read access, or no access
- Adjustable for DIGSI 5 engineering, IEC 61850-MMS process communication, or Web monitor access

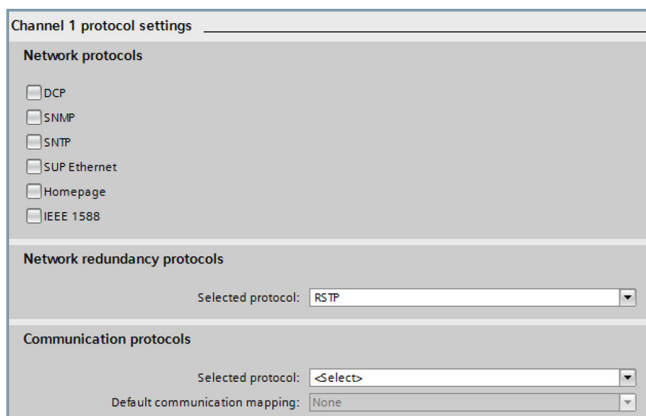
These settings function independently of RBAC.



[dw\_SIP5C\_cyber-security\_syslog\_protocol\_1\_en\_US]

**Figure 2.8/3** Role-Based Access Control (RBAC) with Central User Management

- (1) User requests device access (with user name & password)
- (2) Authentication request via RADIUS
- (3) Authentication & authorization (role) by RADIUS
- (4) Success/rejection response from device to user
- (5) Role-based user session initiated or rejected



[sc\_onlyRSTP\_de\_1\_en\_US]

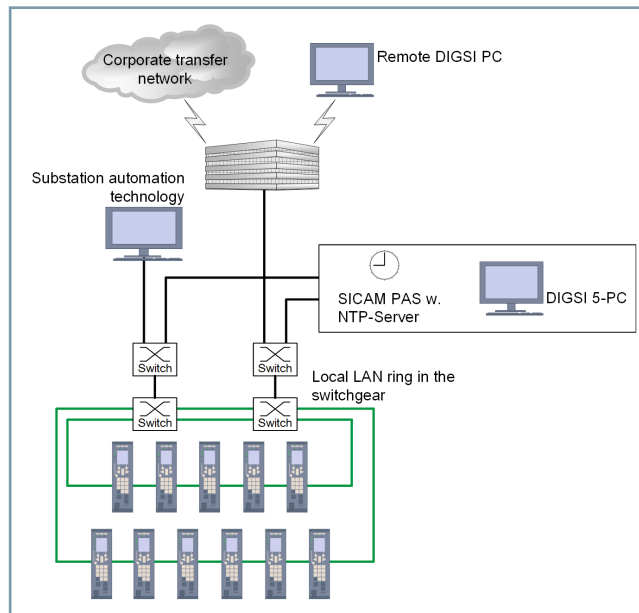
**Figure 2.8/4** Isolatable Communication Services during Access via Ethernet Networks

### Product Security Blueprint

You can find valuable hints on the integration and on secure operation of devices in your network in the Product Security Blueprint and in the **Application Note – SIP5-APP-009** for SIPROTEC 5 devices. An overall security concept should be drawn up and maintained in a **Spanning Security Blueprint**. This documents typical network configurations, the services used, and their ports. Measures for updating the components that are critical for cybersecurity, password protection, and anti-virus protection are also described.

**Figure 2.8/5** shows a recommendation of this kind for protecting switchgear. The SIPROTEC 5 devices are integrated in optical Ethernet rings via switches. In these rings, each Ethernet-based substation automation protocol, for example, IEC 61850 or DNP3 TCP, runs together with the systems control without loss of performance. Accesses from a non-secure external network are allowed via a gateway that is responsible for safeguarding the network. The accessing party is authenticated, for example, by DIGSI 5, in the gateway and the communication is encrypted

via VPN. This is fully supported by the communication services of DIGSI 5.



[dw\_SIP5C\_schaltanlage-mit-remote-zugriff\_1\_en\_US]

**Figure 2.8/5** Secure Operation of Devices within a Switchgear with Remote Access from an External Network

An extensive range of cybersecurity features have been integrated in SIPROTEC 5 and DIGSI 5.

### Security-Patch Management (Security Updates) for SIPROTEC 5 and DIGSI 5

According to the requirements for protecting power plants, **patch management** was introduced for SIPROTEC 5 and DIGSI 5. This means that regular security updates for the software components from third-party vendors integrated into SIPROTEC 5/DIGSI 5 or used by SIPROTEC 5/DIGSI 5 are tested for compatibility with SIPROTEC 5 and DIGSI 5. A corresponding list with the last Microsoft Windows Security Updates tested and hints on the compatibility with DIGSI 5 is provided for downloading from the [Internet](#) and is updated every month.

### Device Authentication Using IEEE 802.1x

IEEE 802.1x is the standard protocol that can be used to connect only to cryptographically authorized network devices as members of the IEEE 802.1x network. The standard defines 2 main roles where the terminal devices that are to be members of a network act as Supplicants and the basic network responsible for the switching procedure acts as the Authenticator.

In IEEE 802.1x-capable networks, supplicants (SIPROTEC 5 or other terminal devices) must provide their cryptographic identity which is then reported to the authenticators (normally switching devices). Then, the authenticator compares the requested login data to the centralized user directory (in this case, this is the RADIUS server) and activates or deactivates the access to this port according to the validity of the login data of the supplicant.

# SIPROTEC 5 Compact – System

## Safety and Security Concept – Cybersecurity

---

If you use IEEE 802.1x in your OT network, you can individually control which devices should be part of the network and block all undesired third-party devices through the use of certificate authorities or user certificates in the SIPROTEC 5 family.

### **Safety and Cybersecurity means:**

- Long-lasting, rugged hardware with regarding EMC immunity and resistance to weather and mechanical loads
- Sophisticated self-monitoring routines identify and report device faults immediately and reliably
- Compliant with the strict cybersecurity requirements in accordance with international cybersecurity standards and directives
- Effective and efficient role-based access control (RBAC) with central user management in the SIPROTEC 5 device
- Automatic logging of cybersecurity-critical events
- Reduction of the IP attack interface of the device



SIPROTEC 5 devices are equipped with extensive test and diagnostic functions. These are available to users in SIPROTEC 5 together with DIGSI 5, and they shorten the testing and commissioning phase significantly.

The DIGSI 5 Test Suite offers:

- Simulation of binary signals and analog sequences by integrated test equipment
- Hardware and wiring test
- Testing device functionality and protection functions
- Circuit-breaker test and automatic reclosing test functions
- Communication test including loop test
- Analysis of function charts

### DIGSI 5 Test Suite

The objective of the extensive test and diagnostic functions that are provided to the user with SIPROTEC 5 together with DIGSI 5 is to shorten testing and commissioning times. All test functions are integrated in DIGSI 5. This enables engineering including the device test to be carried out with one tool. The most important functions are listed as examples here. There are also other specific test functions depending on the device type.

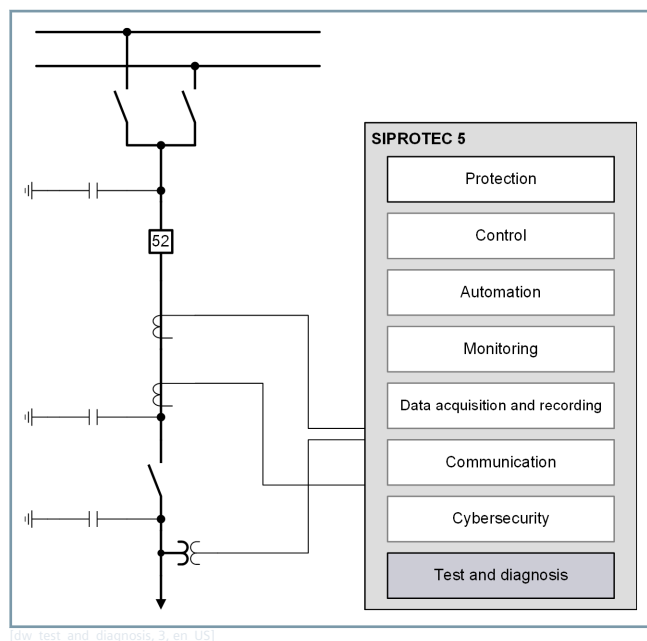


Figure 2.9/1 SIPROTEC 5 – Functional Integration – Test

### Integrated Test Sequencer

The integrated test sequencer enables functions to be tested via the test sequencer integrated in the device. Normally, the device receives analog and binary signals from the process or from an external secondary test equipment. Until now, the protection functions and communication were tested with variables such as these. With SIPROTEC 5 devices, in the simulation mode, these variables can now be substituted with values supplied

from an integrated test equipment. For this, the analog and binary inputs are decoupled from the process and connected to the integrated test sequencer.

The tester uses DIGSI 5 to create a test sequence, for example, a short-circuit sequence, loads it into the device, and runs it in simulation mode. The test sequencer in DIGSI 5 is capable of combining up to 6 test items in one test sequence. When loaded into the device, this test sequence is run in real time and simulates the functions of the device like a real process at binary and analog inputs. Protection functions, control, logic functions, and communication can thus be tested in real time without secondary test equipment.

The test sequence is started manually from DIGSI 5 or controlled via a binary input. This also makes it possible to test the interaction between several devices.

### Hardware and Wiring Test

In the hardware test, the state of the binary inputs can be read out by DIGSI 5 and contacts and LEDs can be switched or set through DIGSI 5 for test purposes.

The parameters measured at voltage and current inputs are represented in phasor diagrams – divided according to absolute value and phase angle (Figure 2.9/2). Thus it is easy to detect and check if the connections in the measurand wiring are inverted, as well as the vector group or the direction between current and voltage. In devices that are connected via operative connections, even analog measuring points of remote phasor ends can be represented as vectors. This makes it easy to check the stability of a differential protection.

In the wiring test, the wiring connections between devices are tested. If the devices are connected to a network via Ethernet, this test can be carried out with unprecedented ease. For this, the contact on a device is closed with the aid of DIGSI 5. This contact is connected to a binary input of one or more SIPROTEC 5 devices via a wire connection. These automatically send a report to DIGSI 5 to the effect that the binary input has been picked up by the closing operation of the contact. The tester can then log this test and check the wiring between the devices.

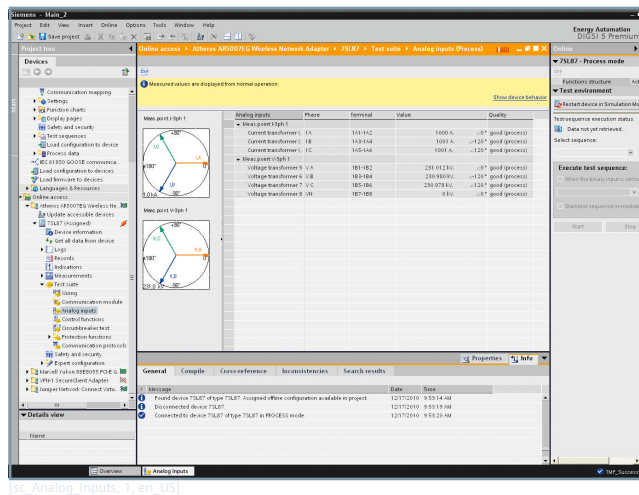


Figure 2.9/2 Display of Analog Measuring Points in Phasor Diagrams

# SIPROTEC 5 Compact – System

## Test and Diagnostics

### Testing Device Functionality and Protection Functions

The graphical representation of characteristic curves or diagrams of protection functions helps not only the engineer who parameterizes the test functions, but also the engineer who tests them (Figure 2.9/3). In this test, the operating point of a protection function is represented graphically in the diagrams. Additionally, messages relating to the protection function are logged, for example pickup or tripping. This test can be carried out with signals from the process or with the test equipment integrated in the device.

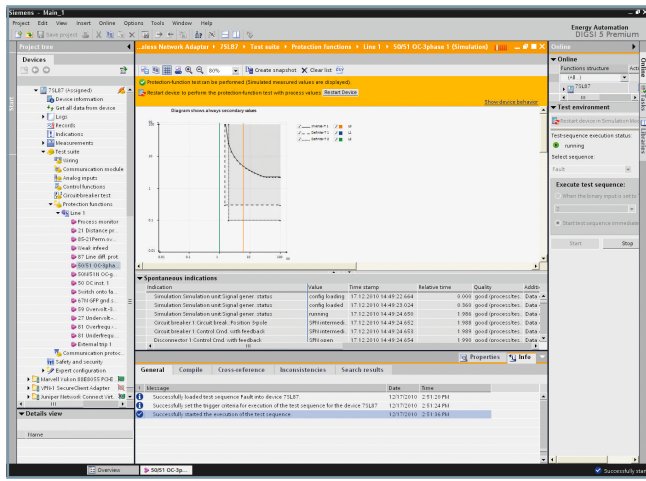


Figure 2.9/3 Test of Protection Function with Operating Point of the Protection Function in the Pickup Characteristic

2.9

### Circuit-Breaker Testing and Automatic Reclosing Test Function

Switching sequences can be initiated via DIGSI 5 to test the automatic reclosing (AREC). However, this is only possible if remote switching via the key switch is permitted. In addition, a security prompt (confirmation ID) must be entered for switching authorization via DIGSI 5. There are additional security prompts for non-interlocked switching. This provides protection against unauthorized use or inadvertent actuation during operation.

The test logs the closing operation of the switch including the interlocking and feedback signals at the binary inputs. A circuit-breaker test can also be deactivated and activated without an interlocking check.

### Communication Testing

Since communication is an integral component of the devices and they are connected either directly or via systems control, they must be thoroughly tested at commissioning and monitored continuously during operation. The integrated test tools support the user in the testing and monitoring of communication routes.

#### Loop Test for Communication Links (Loop Test)

This test is launched by DIGSI 5 for a communication module and a selected interface if a protection communication is configured at a remote line end. It is used to detect disturbances in subsections when inspecting the physical connection of the communication paths (Figure 2.9/4). Test telegrams are sent

from the transmitting side Tx of an interface, and these are measured again at the receiving Rx interface. The user thus has the capability to insert loops at various points in the communication network and to test the connection of the loop. The number of telegrams sent, received, and corrupted is displayed continuously in DIGSI 5, so that the quality of the connection can be monitored.

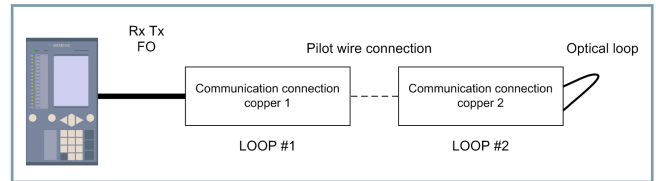


Figure 2.9/4 Loop Test for Operative Connections (Loop Test)

### Online Monitoring of Communication Links

The data flow at communication interfaces can be monitored constantly. To do this, the number of telegrams that are sent, received, and corrupted per time unit for serial connections and Ethernet interfaces during operation is measured and displayed constantly. If faults occur, an alarm can be issued. A network management and monitoring system performs detailed monitoring of Ethernet modules via the SNMP protocol.

For operative connections, the transmission time of the signals is also monitored, and it is calculated during synchronization by means of a high-precision second pulse in the transmit and receive directions. Additionally, the communication topology is also monitored constantly there and displayed in DIGSI 5. GOOSE connections can be monitored permanently at the receiving site during operation. This means that an outage is detected within a few seconds.

### Protocol Test

For the protocol test, specific signal values are set and reset using DIGSI 5 (Figure 2.9/5). The test mode itself is configurable. The device sends the selected value to the client using the configured communication protocol, for example IEC 61850. In this case, a report is generated or a GOOSE message is sent automatically when this information is routed correspondingly.

The device can be used to test systems control information for all protocols (for example, IEC 61850, IEC 60870-5-103, serial DNP3, DNP3 TCP) without the effortful generation of signal states with test equipment. Signals that are transmitted across operative connections can also be tested.



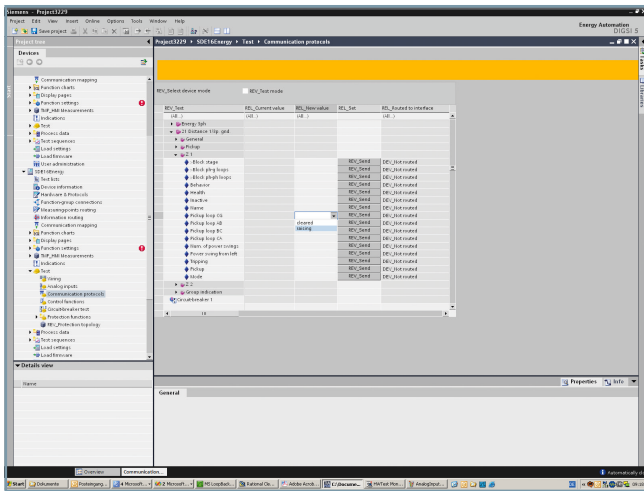


Figure 2.9/5 Protocol Test for Substation Automation Technology or for GOOSE and Operative Connections

### Test and Display of External Timers

If the system time of the device is set externally using 1 or 2 timers, this time can be read out in the device or with DIGSI 5. When the time protocol returns these values, it indicates which timer is setting the system time and issues a statement regarding the quality of the time source. Synchronization via external clocks can thus be monitored and displayed during operation (Figure 2.9/6).

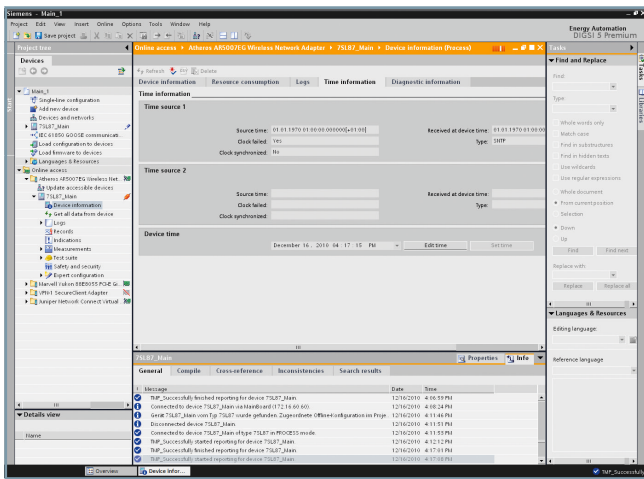


Figure 2.9/6 Test of External Timers

### Analysis of Function Charts (CFC Debugging)

Function charts generated in the form of function charts (CFCs) can be tested offline in DIGSI 5. To this end, test sequences can be generated with the DIGSI 5 sequencer that act on logical inputs of the function chart or on the analog and binary inputs of the device. This makes it possible to test not only the function chart but also its interaction with upstream and downstream functions. During this test, the values of variables are displayed and their changes over time are logged in records that can be analyzed at a later date, for example, with SIGRA. This enables even complex temporal dependencies to be analyzed with ease.

Function charts (CFC) can thus be created offline in the office and tested without needing a device.

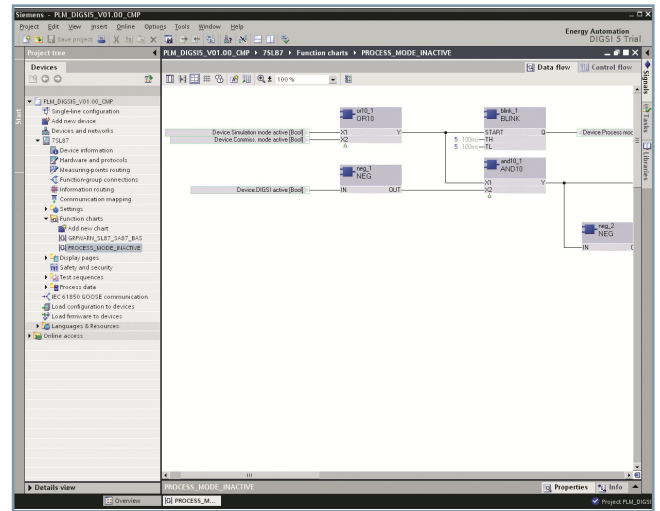


Figure 2.9/7 Easy Analysis of Function Charts

### Using the DIGSI 5 Test Suite means:

- Considerably shorter testing and commissioning time
- Having commissioning support personnel in the adjacent substation is not absolutely necessary
- All test routines performed are documented.
- Testing using secondary test equipment is for the most part dispensable.
- With the innovative SIPROTEC DigitalTwin solution, a virtual digital twin of a real SIPROTEC 5 Compact device, it is possible to use the full functionality of the DIGSI 5 Test Suite at any time, from anywhere, and also without any hardware.

# SIPROTEC 5 Compact – Hardware

## Hardware

### SIPROTEC 5 Compact Hardware

SIPROTEC 5 Compact hardware provides the entire experience of Siemens for digital protection devices.

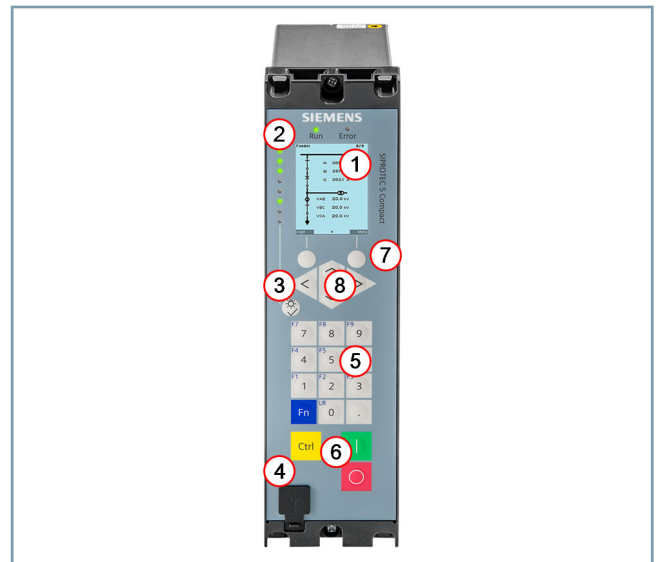
- **Durability and reliability**
  - Robust housing
  - Excellent EMC shielding in compliance with the most recent standards and IEC 61000-4
- **User-friendly operation panel**
  - 9 freely assignable function keys for frequently required operator control actions
  - Separate control keys for switching commands
  - Simple switchover of the switching authority
  - Context-sensitive keys with labeling in the display
  - Complete numerical keypad for simple input of setting values with navigation keys for easy navigation in the menu
  - 8 two-colored LEDs for signaling with labeling in the display
- **User-friendly design**
  - No opening of device necessary for installation and servicing
    - Integrated communication interfaces as standard
    - Electronically settable threshold for binary inputs
    - Rated current (1 A/5 A) of the current-transformer inputs configurable electronically
  - Removable terminal blocks
    - Prewiring of terminals is possible
    - Simple replacement of current transformers, for example with sensitive ground-current transformers in case of network conversions
    - Increased safety, since open current-transformer circuits are no longer possible (safety CT plug).

3.1

### SIPROTEC 5 Compact Design

The SIPROTEC 5 Compact device is 1/6 x 19 inches wide. The on-site operation panel features a graphical color display, keyboard, and 8 dual color LEDs.

### Operation Panel



[IE\_SIP5C\_operation panel\_2\_...]

Figure 3.1/1 SIPROTEC 5 Compact Operation Panel

- (1) Color display
- (2) LEDs (green or red, configurable)
- (3) Display of the LED labeling in the display
- (4) USB interface
- (5) Numerical keys and function keys
- (6) Control/command keys
- (7) Context-sensitive keys with labeling in the display
- (8) Navigation keys

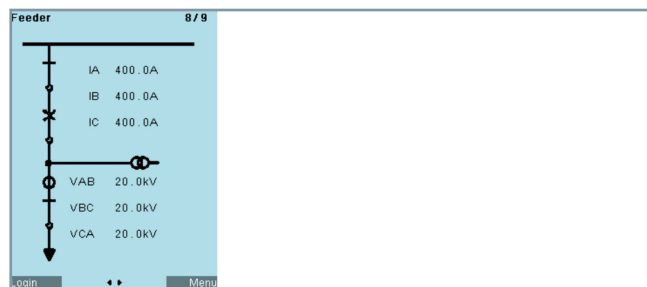
### On-site operation panel elements

The central element is the graphical color display. With its high resolution, it provides ample space for icons in graphical representations.

Below the display there is a 12-key block. In combination with 4 navigation keys and 2 context-sensitive keys, you have everything you need to navigate conveniently and quickly through all information that is shown in the display. 2 LEDs on the upper border of the operation panel inform you about the current device operating state.

8 additional LEDs, to the left of the keypad, ensure quick, targeted process feedback. The LED labeling is directly shown on the display. The USB interface enables fast data transmission. It is easily accessible from the front and well protected with a plastic cover.

The operation panel enables the illustration of a control display and provides space for measured values and to display event lists.



**Figure 3.1/2** Display – Control Display

The O and I keys (red and green) for the direct control of equipment, a key for displaying the LED labeling, and the CTRL key for activating the system diagram complete the operation panel.

You can order any SIPROTEC 5 Compact device in 2 different installation variants:

- As a flush-mounting device
- As a surface-mounting device with integrated on-site operation

### Surface Assembly Frame for Wall Installation

An assembly frame for the SIPROTEC 5 Compact device can be ordered as an accessory to install it on the wall. Depending on

the device wiring, the frame is turned accordingly and mounted on the switch panel. The SIPROTEC 7SX800 protection device is then pushed into the frame and the wiring is guided upwards or downwards.



[ph\_SIP5\_C\_Surface, 2, --, --]

**Figure 3.1/3** SIPROTEC 5 Compact with Surface Assembly Frame

Hardware Properties	7SX800
Hardware expandable (modular)	no
Binary inputs	4/14/17
Binary outputs	5/11/8
Current inputs	4
Voltage inputs	4
Housing (x 19")	1/6
Flush mounting device	yes
Surface mounting device with integrated on-site operation panel	Yes, with assembly frame
Display (pixels)	320x240
Function keys	9
LEDs	8
Power supply	DC 24 to 250 VIAC 100 to 230 V

**Table 3.1/1** Hardware Properties

# SIPROTEC 5 Compact – Hardware

## Integrated Interfaces

### Integrated Interfaces

#### USB Connection on the Front

The device can be accessed with the DIGSI 5 operating program by plugging a standard USB cable into the USB-B socket on the front side. The complete configuration and setting of the device can be carried out via this connection.

#### Integrated Interfaces on the Rear Panel of the Device

The device offers a permanently installed redundant Ethernet interface on the rear panel. For this, observe the connection plans in the Attachment.

tasks. In this way, devices can be precisely synchronized to the microsecond across stations. For this purpose, Siemens provides a prefabricated complete solution with time receiver, FO converters, and appropriate connecting cables.



[img\_SIP3Comp\_rear\_optical\_interface, 1, --]

**Figure 3.2/1** Rear View of the Device with Integrated Interfaces

#### Integrated Redundant Ethernet Interface (Port F)

The integrated Ethernet interface is available as an optical (2 x Duplex-LC 1300 nm) or electrical (2 x RJ45) variant and can be configured with or without integrated switch. It can be used for Ethernet-based protocol applications, for example, IEC 61850, Modbus TCP, DNP3, IEC 60870-5-104, PROFINET IO, time synchronization via SNTP, network management via SNMP<sup>5</sup>, DIGSI 5 via TCP. Several applications can run in parallel, whereby unused applications can be switched off for security reasons.

#### Serial Electrical RS485 Interface/Time-Synchronized Interface (Port E)

The serial RS485 interface features an RJ45 socket. It can be used for asynchronous serial protocols, for example, IEC 60870-5-103, DNP3. Alternatively, with this interface, the time in the device can be synchronized using IRIG B.

The time telegram IRIG-B005 (007) of a GPS receiver can be fed with the 5-V or 24-V levels. An additional, second pulse input enables microsecond-precise synchronization of the device from a highly precise time source, for example a special GPS receiver. This accuracy is needed for special protection and measuring

<sup>5</sup> in preparation

### Die SIPROTEC 5 Terminals

Innovative terminals were developed for the SIPROTEC 5 family. All terminals are individually removable (Figure 3.3/1). This enables prewiring of the systems and simple device replacement without costly rewiring.

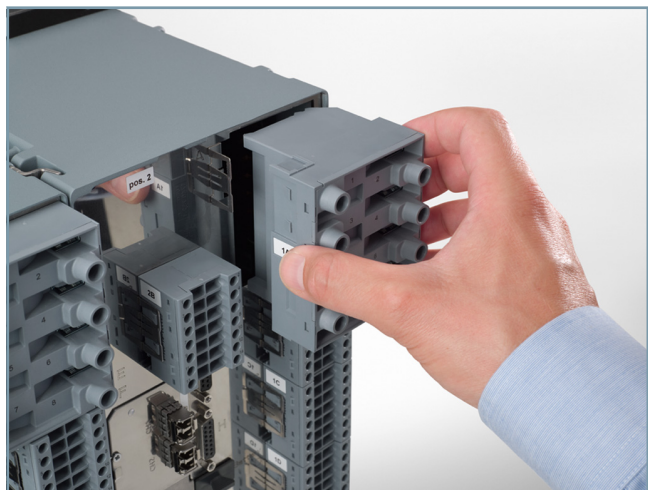


Figure 3.3/1 Removed Current Terminal Block

#### Current terminals

The 8-pole current terminal with 4 integrated current transformers is available in 2 variants:

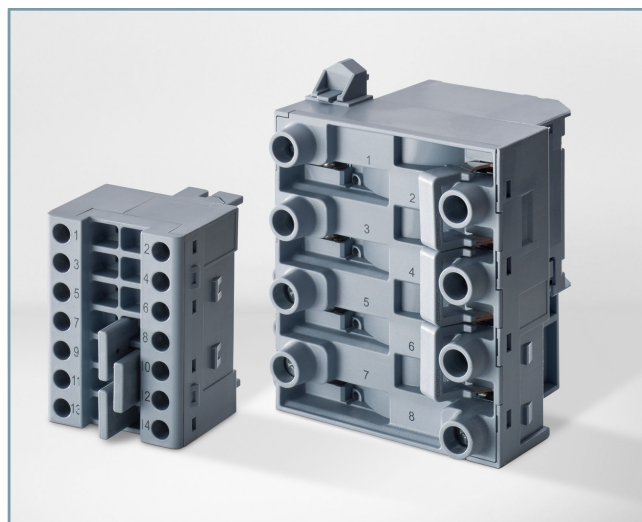
- 4 protection-class current transformers
- 3 protection-class current transformers + 1 sensitive protection-class current transformer

The terminal design provides the following advantages for the connection of currents:

- Exchange of the current-transformer type also possible retroactively on-site (for example, sensitive to normal ground-current transformers in case of network conversions)
- Additional safety during tests or device replacement since the secondary current-transformer circuits always remain closed.

#### Voltage terminal

The voltage transformers and the binary input and output signals are connected via the 14-pole voltage terminal. The cable route away from the device enables clear terminal wiring. Jumpers precisely matching the current and voltage terminals are available for connection to common potential of contacts (see spare parts and accessories, chapter Attachment).



[terminal blocks, 1, ...]

Figure 3.3/2 Voltage and Current Terminal Block with Jumpers

# SIPROTEC 5 Compact – Hardware

## Standard Variants


SIPROTEC 7SX800 Standard Variants		
V1	1/6, 4 BI, 5 BO, 4 I, 4 V Housing width 1/6 x 19" 4 binary inputs 5 binary outputs (1 life contact, 4 fast) 4 current transformer inputs 4 voltage transformer inputs	
V2	1/6, 14 BI, 11 BO, 4 I, 4 V Housing width 1/6 x 19" 14 binary inputs 11 binary outputs (1 life contact, 10 fast) 4 current transformer inputs 4 voltage transformer inputs	
V3	1/6, 17 BI, 8 BO, 4 I, 4 V Housing width 1/6 x 19" 17 binary inputs 8 binary outputs (1 life contact, 7 fast) 4 current transformer inputs 4 voltage transformer inputs	

Table 3.4/1 SIPROTEC 7SX800 standard variants

In project engineering with SIPROTEC 5 Compact, your workflow is in the center of interest – beginning with the single-line diagram of the primary system on to ordering, engineering, and parameter setting all the way through to testing and commissioning. For you, this means: less errors, higher quality, and higher efficiency.

Holistic workflow means optimal, integrated support for all project phases:

- Project specification
- Device engineering
- System engineering
- Commissioning
- Operation and service

## All Functions from the Library

SIPROTEC 5 Compact devices always have a basic functionality, depending on the device type. You can extend this functionality flexibly with any desired functions from the library. Additional functions are paid with your credit balance, which is reflected in function points.

In the SIPROTEC 5 system, the main function is defined by the device-type selection. This means that the functionality does not have to be fixed in detail during product selection. In the later engineering phase, you can select any optional additional function from the device-specific function library. You must simply ensure that your balance of function-point credit ordered for the device is not exceeded. Extra function points can simply be reordered at any time.



# SIPROTEC 5 Compact – Engineering

## WEB Monitor

### Operation Using the Web UI

Apart from the use of an engineering tool such as DIGSI 5 for configuration and maintenance, SIPROTEC 5 Compact provides a Web front end that can be used with a standard Web browser.

The **browser-based user interface** is a comprehensive commissioning and monitoring tool that provides an easy-to-understand display of the most important measured data. You can operate the device remotely or locally using the **browser-based user interface** and a Web browser.

The **browser-based user interface** can be used via a communication network:

- During commissioning
  - Checking and adjusting the values of a specific setting
  - Comparing the values of 2 or more devices
  - Checking a setting value against a user-defined setting to verify whether the setting value differs from the default value specified by Siemens
- During an inspection
  - Querying a value in order to adjust a test case, for example to preset the tripping current
  - Viewing all types of measured values, for example functional measured values and derived values such as the minimum/maximum and mean values
  - Displaying the deviation of the expected measured-value quality.
- While operating the device

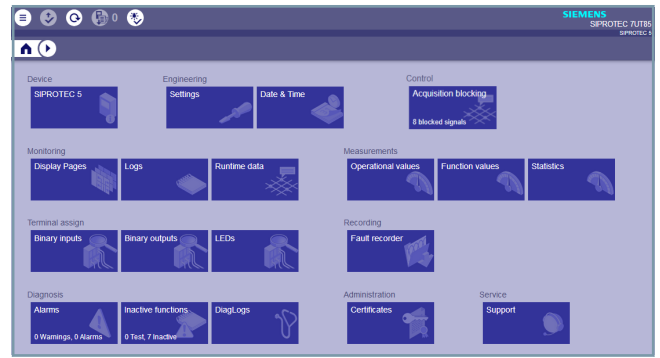
The **browser-based user interface** is especially optimized for the protection system and provides comprehensive support during testing and commissioning from the PC or laptop computer.

All relevant device information and setting options are displayed graphically on the screen.

### Application Options

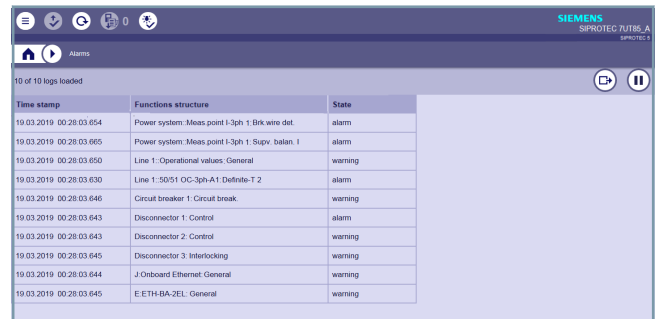
You can also use the **browser-based user interface** for the following applications, for example:

- Checking and adjusting the values of a specific setting
- Comparing the values of 2 or more devices
- Checking a setting value against a user-defined setting as to whether the setting value differs from the default value specified by Siemens
- Querying a value to adjust a test case, for example, to preset the tripping current
- Viewing all types of measured values, for example functional measured values and derived values such as the minimum/maximum and mean values
- Displaying the deviation of the expected measured value quality.



[swebmonitor], b, en\_US

Figure 4.1/1 Buttons for the Browser-Based User Interface



[sAlarmAndWarningList, 2, en\_US]

Figure 4.1/2 Alarm List

### Additional Information

For more information on **Operation with a browser-based user interface**, please refer to the latest system manual for **SIPROTEC 5 Operation** under [SIOS](#)



### Description

DIGSI 5 is the versatile engineering tool for parameterization, commissioning, and operating all SIPROTEC 5 devices. Its innovative user interface includes context-sensitive user instructions. Simple connection to the device via USB enables you to work with a device easily and efficiently. The full capabilities of DIGSI 5 are revealed when you connect it to a network of protection devices: Then you can work with all of the devices in a substation in one project. DIGSI 5 offers superior usability and is optimized for your work processes. Only the information you actually need to carry out your tasks is shown. This can be reduced further via expanded filter mechanisms. Consistent use of sophisticated and standardized mechanisms in the user interfaces requires less training.

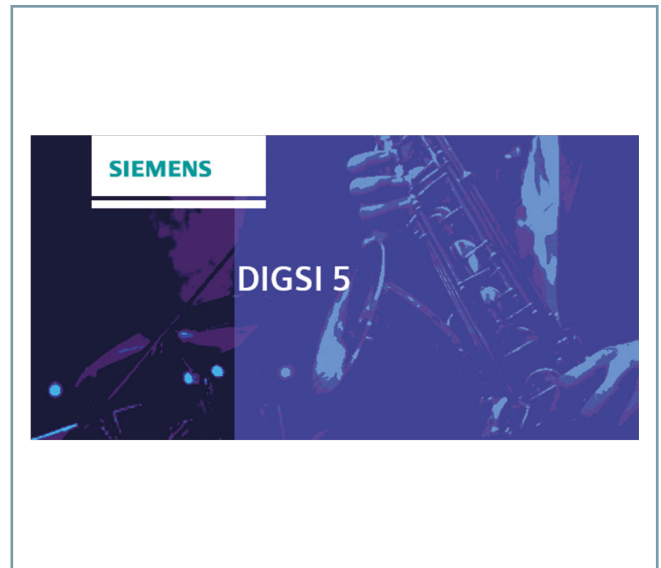
### Functions

Using a PC or laptop computer, you can set parameters for the devices using the interfaces and export the fault data.

DIGSI 5 is available in different variants (Compact, Standard, and Premium) with various functionalities:

- Using the Single-Line Editor, you can visually define a substation and the primary equipment. Connect these elements with the protection function of your protection devices.
- The visual display of the SIPROTEC devices can be configured and edited with the Display Editor or with a graphics program. Take your single-line diagram and convert it into a display image. You can also define your own icons.
- You can configure additional functions like interlocking of the devices graphically with the function block diagrams editor (CFC).
- Using the Siemens IEC 61850 System Configurator, you can configure and set parameters for IEC 61850 stations. Using this tool, you can administer subnetworks, network users and their IP addresses and link the information of various participants.
- The DIGSI 5 test suite provides extensive test tools, which accelerate commissioning and support you with operation. One of the test functions enables you to compile and execute test sequences, to test devices without external test equipment.
- SIGRA for simple, fast, and convenient analysis of fault records, such as those recorded during faults in power plants by fault recorders.

**Languages:** English, German, French, Italian, Portuguese, Spanish, Turkish, Czech, Polish, and Russian (selectable)



DIGSI 5 is available in 3 different functional scopes:

#### • DIGSI 5 Compact

Software for configuring and operating smaller projects with up to 8 SIPROTEC 5 Compact (7x800) or non-modular SIPROTEC 5 devices (7x82). Contains graphical editors for Continuous Function Charts (CFC) and device display pages. Integrated test and commissioning functions, including the possibility of creating test sequences and their execution in the protection device without external test equipment. Projects may only contain a single SIPROTEC 5 protection device.

#### • DIGSI 5 Standard

Like DIGSI 5 Compact, but without constraint with regard to the number of supported SIPROTEC 5 devices per project, incl. IEC 61850 System Configurator. Contains additional graphical editors for single-line diagrams and the network topology. SIGRA for professional fault-record analysis is available as an option.

#### • DIGSI 5 Premium with SIGRA

Same as DIGSI 5 Standard, but with enhanced functionality for IEC 61850, for example, flexible engineering and functional naming. Contains SIGRA for a professional analysis of fault records.

# SIPROTEC 5 Compact – Engineering

DIGSI 5

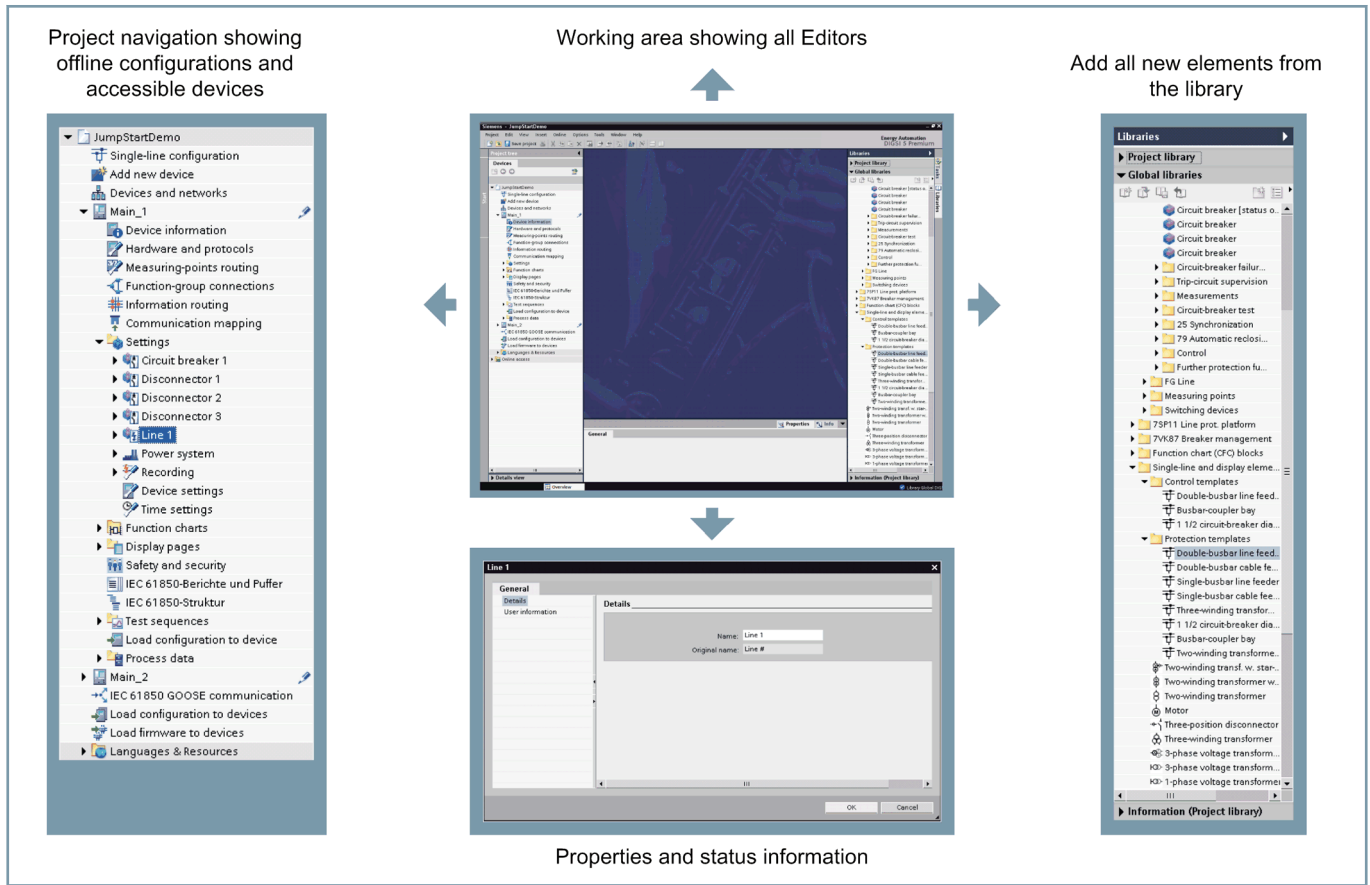


Figure 4.2/1 Structure of the DIGSI 5 User Interface

## MLFB Number

The device MLFB number can be adopted directly into the engineering program DIGSI 5. In this way, you create your selected devices directly in DIGSI 5. Since all device characteristics are unambiguously specified via the MLFB number, engineering work with DIGSI 5 starts on a consistent basis without the need to reenter the device characteristics which would take much time.

## From Planning to Engineering up to Testing – DIGSI 5

The engineering tool DIGSI 5 assists you in your workflow from planning to operation of your systems with SIPROTEC 5 devices. With DIGSI 5, you have full control over the engineering. The functional scope of the tool covers all tasks – from device configuration and device setting to commissioning and evaluation of fault data.

This is how a modern, efficient engineering process looks in short form:

In the rough planning, the system layout is documented using CAD. This system layout is prepared as the basis for the detail planning in the Single-Line Editor. Depending on the application, the required functionality (protection functions, control and automation scope as well as auxiliary functions) is defined and a device is selected. In the next step, the device is assigned an appropriate application template. You can use your own personally created, exactly matching applica-

tion templates or standard application templates here. Function adaptations are possible at any time after the selection of the application template. The high-performance copy functions with consistency checks allow fast project engineering. Then, you must configure the system (routings, implementation of corresponding logic into function charts (CFC)) and set the parameters.

The new program structure of DIGSI 5 is designed to support the required work steps during a project optimally. The application-oriented engineering approach guarantees that you are always aware of the workflow. DIGSI 5 makes you more productive – from design to engineering and even with installation, commissioning, and operation.

## The Project View Guides You Through the Entire Workflow

In DIGSI 5, processing and maintenance of all components of IEDs and of all associated data is carried out in a project-oriented way. This means that the topology, devices, parameter values, communication settings, process data, and much more are stored in one project.

All devices are available in one central location. Just open the device in the project tree and the entire content is provided. When you begin with a device, you can edit your tasks in a simple and intuitive way.

The user interface of DIGSI 5 is divided into several sections (Figure 4.2/1). The project tree on the left displays every-

4.2

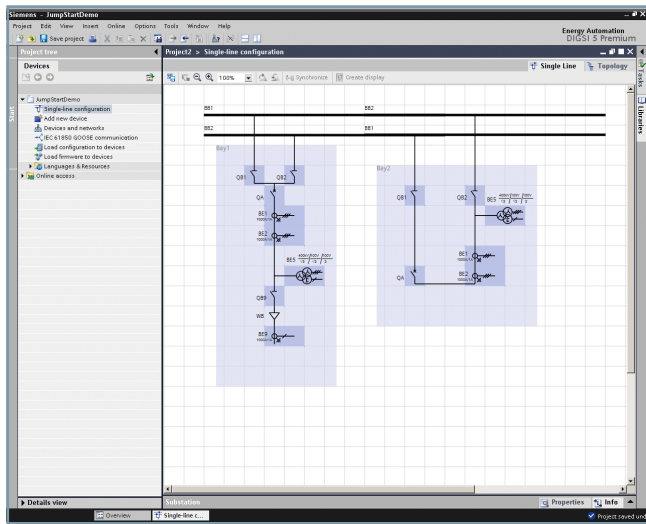
thing that belongs to your project, for example, devices and global settings. Double-clicking an entry opens an Editor in the main window section. This can be, for example, an editor for changing protection parameters, for configuring communication mappings, or for creating function charts (CFC).

In the lower section of the screen view, you can access the properties of all elements (for example, for circuit breakers or signals) quickly and conveniently. This section also contains lists with warnings and errors.

The libraries are particularly important in DIGSI 5. They are located on the right and contain everything that is used in the editors. Here, you select the required scope and insert it into your project. When configuring the hardware, you can select different hardware components. On the other hand, if you are working with function charts (CFC), you select the corresponding logical building blocks and select the required functionality while configuring the protection scope. For this purpose, you drag the elements to the position of the editor where you need them.

### Visual Definition of the Primary Topology in Single Lines

The single-line diagram describes the primary topology of your system (*Figure 4.2/2*). For this, simply select the correct single-line template from the library. Further processing, for example, an extension, is possible without difficulty. DIGSI 5 contains a library with elements that are familiar to you from the ANSI and ISO standards.



**Figure 4.2/2** Graphical Definition of the Topology of a Substation in the Single-Line

### From the Application to the Solution: Application Templates and Their Modification

After the topology has been defined, the next step is to add the required device. You simply use the ordering code from the configurator in DIGSI 5 and your device specification is already known. In the next step, you select the application template appropriate for your application and adapt it according to your requirements. Remove functions that are not needed and add the desired functions. The library offers you an extensive selection that you can use for this. The consistency of the device

configuration is continually checked. Finally, you can connect the application template with the primary elements of the single-line diagram (voltage and current transformers as well as circuit breakers) graphically. Thus, a topological reference is created. Setting values of the transformers (primary and secondary rated values, as well as the neutral-point formation for current transformers) can then be adopted from the single-line diagram.

If you have created a suitable device type, you can save it as your own application template and use it in other devices of the same device family. To do this, export the application template with DIGSI 5 in UAT format (User-defined Application Template).

### Design of User-Defined Control Displays

With the Display Editor, you can create or change the factory-set displays, known as control displays. The editor assists you in a typical workflow. You simply decide which fields of the single-line diagram you already created are to be used for the display pages – and that is all. Of course, the displays can also be completely newly created or imported. To do this, drag a signal from the library to a dynamic element in the display and the connection is created. Besides the use of icons in accordance with the IEC and ANSI standards, you can create your own static or dynamic icons in an icon editor.

### Routing and Assignment

The routing matrix is one of the most important functionalities of DIGSI 5. It is conveniently divided between 2 editors: **Information routing** and **Communication mapping**. Both views are designed in such a way that you can complete your task quickly. With pre-defined or user-defined filters, you reduce the displayed information to a minimum. As in Excel, you can select which information is to be displayed for each column (*Figure 4.2/4*).

In the matrix, all signals are sorted according to function and function groups. Sources and targets are displayed as columns. The scope reaches from the compressed form of representation to a detailed representation of information in which you can view and change each piece of information (routing to binary inputs and outputs, LEDs, buffers, etc.) in different columns. In this way, all information can be configured very simply.

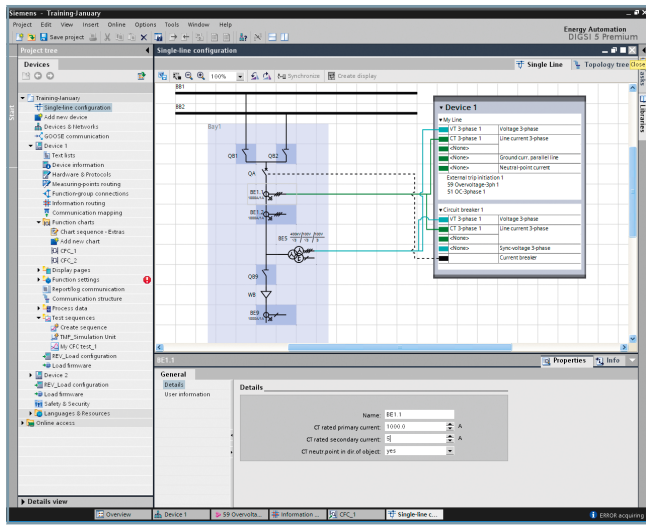
For communication mapping, all necessary settings are already predefined for the selected protocol. You can adapt these to your needs in a fast and simple way.

With a large selection of filters and the option to open and close rows and columns, you will find it easy to display only the information you need.

Saving time is a priority with DIGSI 5. All table-based data displays provide the functionality to fill adjacent cells with a single mouse-click – in the same way you know from Excel.

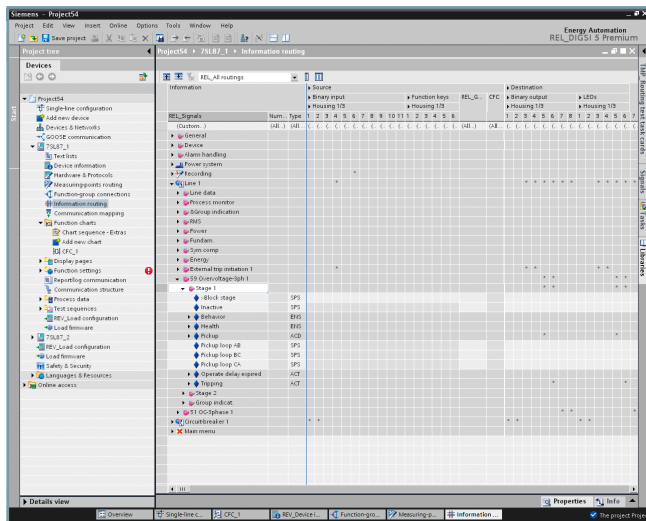
# SIPROTEC 5 Compact – Engineering

## DIGSI 5



sc\_change CT ratio, 1, en\_US

Figure 4.2/3 Graphical Linkage of Primary and Secondary Equipment



sc\_information\_routing\_fong, 1, en\_US

Figure 4.2/4 The Entire Flexibility of the Information Routing Editor

### Automation and Switchgear Interlocking Protection

A PLC (Programmable Logic Controller) is integrated in SIPROTEC 5 devices. In this PLC, automation functions, logic for switchgear interlocking protection, and lots more can be executed. If you want to change or adapt these, use the function-chart (CFC) editor that is included as a component in DIGSI 5 Standard and Premium. Thanks to the fully graphical user interface, even users without programming knowledge can fully utilize the functional scope and thus adapt the functionality of the device (Figure 4.2/5) flexibly.

For this, an entire library is available to you with building blocks that are compatible with IEC 61131-3. This library contains simple logical operators, such as AND, but also complex functions such as timers, command chains for switching sequences, and much more.

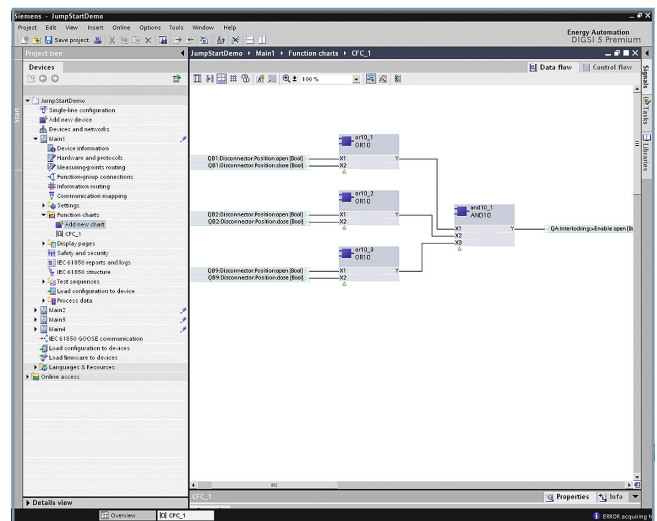
The use of the editor is more efficient than ever before. You thus need less building blocks in order to achieve your objec-

tives. This improves the readability of the function-chart (CFC) decisively. New display modes also increase clarity. The new modes offer you a compressed view of the building blocks and connection points, so that you can see all the information you need without having to scroll through it.

Use macros (chart in chart) to reuse recurring tasks clearly and in a pre-checked manner.

Even the use of signals in a function-chart (CFC) is designed to be simpler. Drag a signal via drag and drop from the signal library to the input or output port of a building block – and you are finished. Created logic plans can be tested even without devices (offline) with DIGSI 5. This ensures the necessary quality for commissioning and saves time.

The logic sequence with DIGSI 5 can be monitored and analyzed online in the device as well.



sc\_cfc\_01, 1, en\_US

Figure 4.2/5 Simple Creation of Automations with the CFC Editor

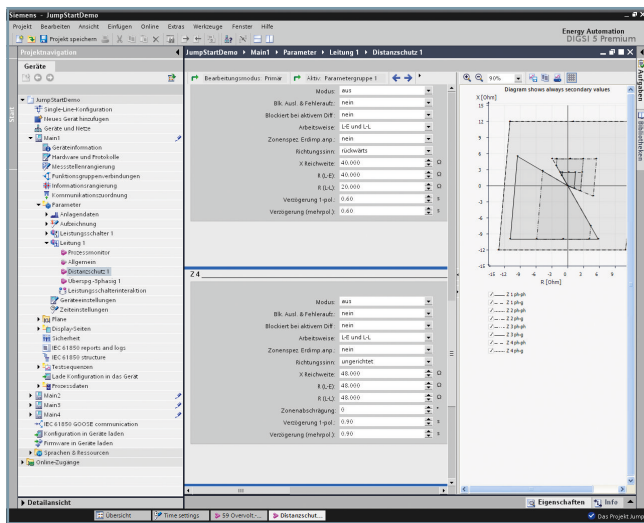
### Setting the Parameters of the Device

All parameter settings are represented in the same way. This occurs in the parameter editor, which displays all parameters of a function. Here, you can select between different views of the settings. On the one hand, there is a primary view where you can directly enter the primary setting values.

In this way, you can avoid using transformer ratios which can lead to setting errors. The same applies for the "per unit" view where setting parameters refer to object rated values. If you opt for the secondary view, the setting parameters must be converted to secondary values.

For setting special protection characteristics, the graphical representation of the characteristics is advantageous. In the parameter editor, all characteristic variants of the function are represented. In this way, you can check the effects of changes in the settings immediately in the graphic. Setting values of different settings groups can be compared in a common window in a fast and easy way, differences can be detected and compensated (Figure 4.2/6).

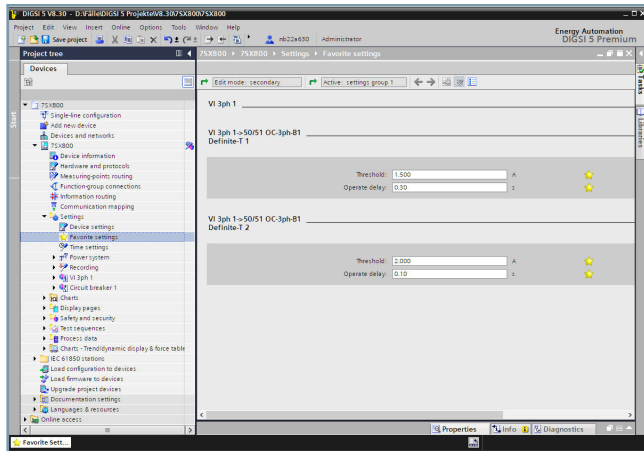




[sc\_Function Settings\_with\_diagram, 1, en\_US]

Figure 4.2/6 Easy Parameter Setting

Frequently used parameters can be marked as favorites. These favorites are displayed in a transparent favorites view so that you always keep an overview of everything essential (Figure 4.2/7)



[sc\_favorite\_settings, 1, en\_US]

Figure 4.2/7 Favorites View

## Cooperating in Teams

Improve your engineering performance by cooperating in teams. Using extensive export and import functions, one team can define the protection parameters and work on the routing settings while others set system-interface parameters. The individual sections can be updated at any time with the new input of colleagues. For example, when the protection-parameter crew has updated its data, this data can be adopted into the project.

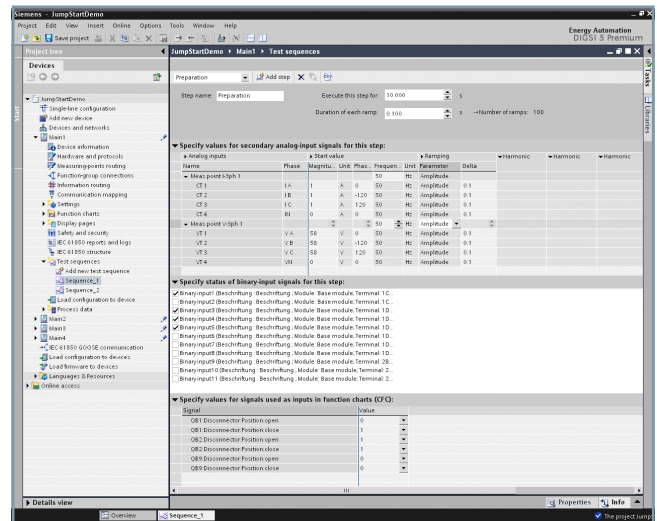
## Comprehensive Testing Support During Commissioning and Operation

The testing and diagnostic functions support you in the commissioning phase. You can thus quickly and simply test the wiring or observe the effect that a message transmitted via the system interface has in the superordinate station. The error messages

that are recorded in the relay in case of a disturbance of the protected object are listed in DIGSI 5 and can be displayed, saved, and printed for documentation purposes.

The new testing options are an innovation. Multi-level test sequences can be defined (even for phasor factors) via a sequence functionality. These are loaded into the device with DIGSI 5 and simulate the physical inputs there. These are then executed in the device via the integrated test sequencer, which simulates the analog process values. In this way, you can define and execute complex checks for testing your project engineering and logic at an early stage.

With the test and diagnostic functions, extensive test equipment is no longer necessary or its tests are reduced to a minimum. You can find processes that were developed for testing special protection principles, for example, for line differential protection, in the appropriate device manual. The function-chart (CFC) editor also offers new analysis functions. DIGSI 5 thus allows offline debugging of logic plans as well as tracing of measured values – both in the representation of the logic chart and in the representation of lists. This reduces overall testing effort during commissioning. The results of the function-chart (CFC) analysis can also be represented after completion of the test sequence, for example, with SIGRA. Thus, even complex runtime relations can easily be analyzed.



[sc\_Test sequence, 1, en\_US]

Figure 4.2/8 Definition of Test Sequences for Comprehensive Tests of Device Configurations

# SIPROTEC 5 Compact – Engineering

## DIGSI 5

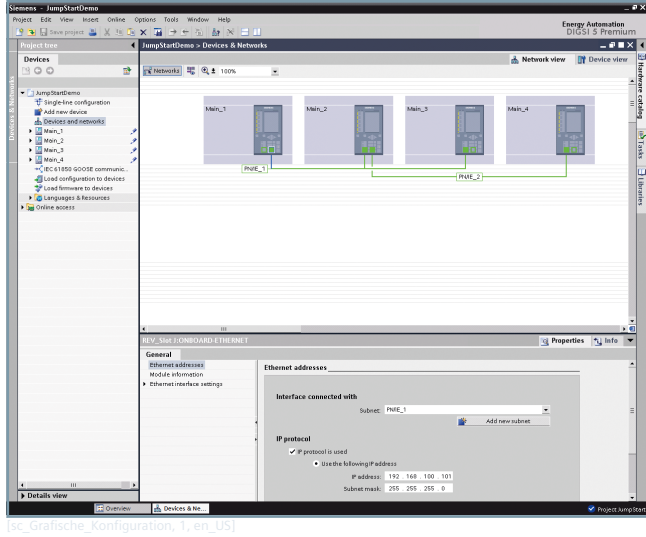


Figure 4.2/9 Graphical Configuration of Network Connections between Devices

### Direct Online Access of all Accessible Devices

DIGSI 5 also assists you in your workflow if your devices engineered offline are connected to the devices in your plant in your system. In DIGSI 5, all devices accessible via communication interfaces are displayed immediately next to your offline devices. The preferred communication in networks is Ethernet. Of course, you can individually access devices via a USB interface. In order to work with a physical device, connect the online device and offline configuration via drag and drop, and you are done.

Besides transmitting the device configuration to individual devices, you can also transmit all device configurations to your devices automatically.

Besides online access, in addition to reading fault records and logs, you can also display measured values and messages. You can save snapshots of measured values and messages in archives for subsequent analysis or for documenting tests of temporary operating states or commissioning.

### Openness Through Import and Export

DIGSI 5 offers a broad spectrum of exchange formats. These include the standard formats of IEC 61850 as well as the uniform data exchange format TEA-X of Siemens tools. This XML-based format is the basis for all import-export scenarios and ensures efficient workflows in the engineering process. Since data must only be entered once, engineering effort is reduced and you profit from consistent data quality at all levels of automation.

Besides efficient data exchange for the levels of power automation, the XML data format also supports easy exchange of data with other applications.

Via the import interface, you can read data from other applications into DIGSI 5. Thus, this enables external project engineering of the devices. Similarly, you can export the settings data to other applications for further processing. It is therefore easy to exchange data with other power-distribution applications: for example, network calculation, protection-data administration/evaluation, and data for the protection-function test.

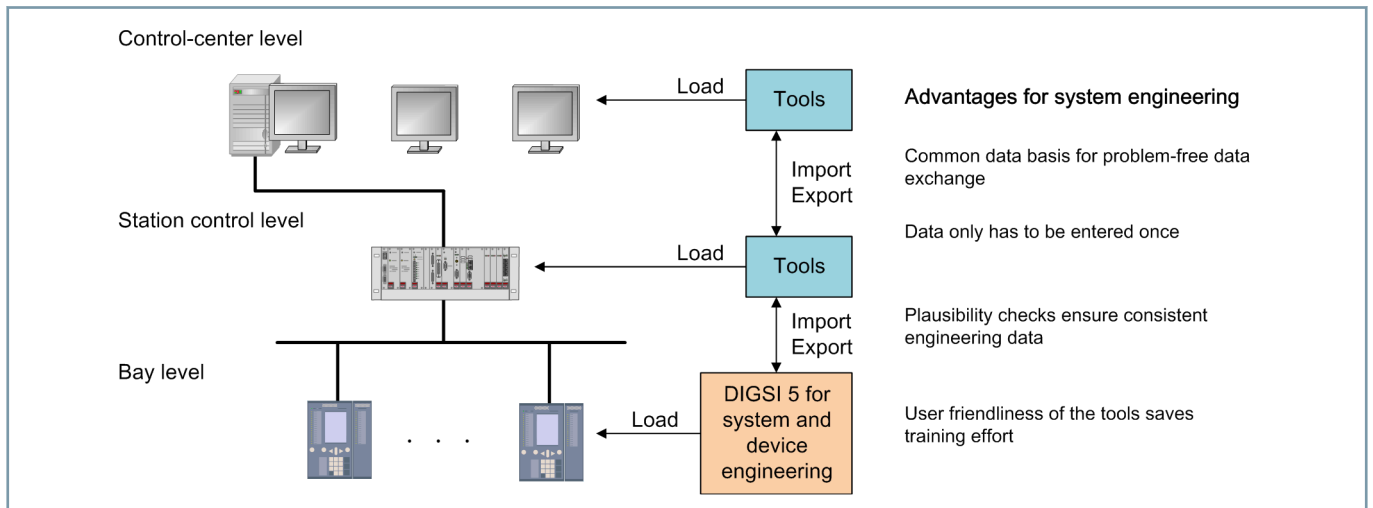


Figure 4.2/10 Open Exchange Formats Allow Reuse of Data at all Tiers

## Overview of Functions

	Compact	Standard	Premium
<b>Project processing</b>			
Maximum number of devices per project	8 or 1 <sup>6</sup>	Unlimited	Unlimited
Copy and paste	■	■	■
Multilingualism is supported	■	■	■
<b>Single-line diagrams and device displays</b>			
Single-Line Editor with ANSI and IEC standard icons available	–	■	■
Device Display Editor permits creation of user-defined displays and icons	7	■	■
<b>Setting parameters and routing</b>			
Information routing including filtering and sorting	■	■	■
Graphical visualization of protection parameters	–	■	■
Comparison of devices (offline/offline – offline/online)	■	■	■
<b>Continuous function charts (CFC)</b>			
Graphic continuous function chart editor (CFC) available	■	■	■
<b>Communication</b>			
Assignment of communications to system interface	■	■	■
Assignment of communications to various logs	■	■	■
Graphical network view of devices	–	■	■
Inter-device communication (via IEC 61850 System Configurator)	–	■	■
<b>IEC 61850</b>			
IEC 61850 Edition 2 fully supported	–	■	■
IEC 61850 structure editor for flexible engineering and functional naming	–	–	■
<b>Access and communication</b>			
Via USB and Ethernet	■	■	■
Access to communication partners via system interface	■	■	■
<b>Online</b>			
Measured values (current values, minimum, maximum, average values) and storage in the project as snapshots	■	■	■
Messages (and storage in the project as snapshots)	■	■	■
Logs and records	■	■	■
Display fault records	■ COMTRADE Viewer	■ COMTRADE Viewer <sup>8</sup>	■ SIGRA
Loading settings for the selected device	■	■	■
<b>Commissioning and testing</b>			
Creating and running multistage test sequences, no external equipment necessary	■	■	■
Test views for testing the device configuration	■	■	■
Analysis/debugging of continuous function charts (CFCs) in offline and online mode	■	■	■
<b>Export and import</b>			
SCL formats (IEC 61850– ICD/IID/MICS)	–	■	■
Device configurations (full and partial)	■	■	■
Single-line diagrams/topology	■	■ <sup>9</sup>	■
Display pages	■	■	■
Test object definition (RIO)	■	■	■
<b>Documentation</b>			
Printing and exporting project documentation	■	■	■
Creation of user-defined print formats	■	■	■

<sup>6</sup> 8 SIPROTEC 5 Compact (7SX800) or non-modular SIPROTEC 5 devices (7xx82); alternatively 1 modular SIPROTEC 5 device

<sup>7</sup> For SIPROTEC 5 Compact (7SX800) or non-modular SIPROTEC 5 devices (7xx82)

<sup>8</sup> SIGRA available as optional package

<sup>9</sup> WMF export only

# SIPROTEC 5 Compact – Engineering

## DIGSI 5

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	Compact	Standard	Premium
<b>Safeguarding and security</b>			
Authorization of access to devices with NERC CIP-compatible password	■	■	■
Secure connection to the device	■	■	■
Configuration data protected from alteration	■	■	■
Confirmation IDs for safeguarding critical activities (for example switching)	■	■	■



## DIGSI 5 Order Variants

	DIGSI 5 Compact	DIGSI 5 Standard	DIGSI 5 Premium with SIGRA
<b>Description</b>	<ul style="list-style-type: none"> <li>• Software for the configuration and operation of smaller projects including transmission of process data from the device</li> <li>• Includes graphical editors for Continuous Function Charts (CFC) and device display pages.</li> <li>• Integrated test and commissioning functions, including the possibility of creating test sequences and executing them in the protection device without external test equipment</li> <li>• Projects can contain up to 8 SIPROTEC 5 Compact (7x800) or non-modular SIPROTEC 5 devices (7x82). Alternatively, it is also possible to create 1 individual modular SIPROTEC 5 device.</li> </ul>	<ul style="list-style-type: none"> <li>• Like DIGSI 5 Compact, but without constraint with regard to the number of supported SIPROTEC 5 devices per project, incl. IEC 61850 System Configurator</li> <li>• Contains additional graphical editors for single-line diagrams, device display pages, and the network topology</li> <li>• SIGRA for professional fault-record analysis is available as an option</li> </ul>	<ul style="list-style-type: none"> <li>• Same as DIGSI 5 Standard, but with enhanced functionality for IEC 61850, for example, flexible engineering and functional naming</li> <li>• Contains SIGRA for a professional analysis of fault records</li> </ul>
<b>Product features</b>	All features are listed in the <a href="#">Overview of Functions, Page 67</a> table.		
<b>Authorization</b>	No license key necessary	Authorization required using the license key; can be used on one computer per license.	
<b>Available interface languages</b>	German, English, Portuguese, Spanish, Italian, French, Russian, Polish, Czech, and Turkish (selectable)		
<b>Contained in the scope of delivery of the DVD version</b>	<ul style="list-style-type: none"> <li>• Program, device drivers, and online documentation on DVD-ROM</li> <li>• USB stick including a 30-day test license for a free test of DIGSI 5 Premium</li> <li>• Product information</li> <li>• USB cable for connecting a PC/laptop computer and all SIPROTEC 5 device types</li> </ul>	<ul style="list-style-type: none"> <li>• Program, device drivers, and online documentation on DVD-ROM</li> <li>• USB stick with the number of licenses ordered. The program can be used on one computer per license.</li> <li>• Includes a 30-day test license for a free test of DIGSI 5 Premium</li> <li>• Product information</li> <li>• USB cable for connecting a PC/laptop computer and all SIPROTEC 5 device types</li> </ul>	<ul style="list-style-type: none"> <li>• Program, device drivers, and online documentation on DVD-ROM</li> <li>• USB stick with the number of licenses ordered. The program can be used on one computer per license.</li> <li>• Product information</li> <li>• USB cable for connecting a PC/laptop computer and all SIPROTEC 5 device types</li> </ul>
<p>DIGSI 5 can also be ordered and delivered via online software delivery (OSD). The delivery of the DVD and USB cable is unnecessary. The program is offered for downloading. The license can be loaded online on the Automation License Manager.</p>			

# SIPROTEC 5 Compact – Engineering

## DIGSI 5

### Selection and Ordering Data

Versions	Number of licenses	Delivery form	Order no.
DIGSI 5 Compact	Unlimited	DVD/USB <sup>10</sup>	7XX8002-0CA00
DIGSI 5 Standard without SIGRA (with COMTRADE viewer)	1 single license	Download	7XX8002-0SA01
	5 single licenses	Download	7XX8002-0SA05
	10 single licenses	Download	7XX8002-0SA10
DIGSI 5 standard with SIGRA	1 single license	Download	7XX8002-1SA01
	5 single licenses	Download	7XX8002-1SA05
	10 single licenses	Download	7XX8002-1SA10
DIGSI 5 Premium with SIGRA	1 single license	Download	7XX8002-1PA01
	5 single licenses	Download	7XX8002-1PA05
	10 single licenses	Download	7XX8002-1PA10
DIGSI 5 Premium Trial (Premium full version for 30 days)	Unlimited	DVD/USB <sup>10</sup>	7XX8002-1PT00
DIGSI 5 Premium Scientific (only for technical colleges)	10 single licenses	Download	7XX8002-1PC10
DIGSI 5 Premium Sales (only for Siemens sales and distribution Dept.)	10 single licenses	Download	7XX8002-1PS10
Upgrade from DIGSI 5 Standard to Premium	1 single license	Download	7XX8002-1UP01
	5 single licenses	Download	7XX8002-1UP05
	10 single licenses	Download	7XX8002-1UP10
Upgrade from DIGSI 4 professional to DIGSI 5 standard	10 single licenses	Download	7XX8002-0US10
Upgrade from DIGSI 4 professional to DIGSI 5 premium	10 single licenses	Download	7XX8002-1US10
Upgrade from DIGSI 4 Professional + IEC 61850 to DIGSI 5 Standard	10 single licenses	Download	7XX8002-0UC10
Upgrade from DIGSI 4 Professional + IEC 61850 to DIGSI 5 Premium	10 single licenses	Download	7XX8002-1UC10
SIGRA option package for DIGSI 5 Standard	1 single license	DVD/USB <sup>10</sup>	7XS5412-2AA00
	5 single licenses	DVD/USB <sup>10</sup>	7XS5413-2AA00
	10 single licenses	DVD/USB <sup>10</sup>	7XS5414-2AA00

**Table 4.2/1** DIGSI 5 Selection and Ordering Data

<sup>10</sup> Exclusively physical delivery (DVD/USB)

### Description

The IEC 61850 System Configurator is the manufacturer-independent solution for the interoperable engineering of IEC 61850 products and systems. It supports all devices with IEC 61850, not just Siemens products – like SIPROTEC 5, SIPROTEC 4, SIPROTEC Compact, Reyrolle, SICAM RTUs, SICAM IO/AI/P85x/Q200 – but also devices from other Siemens divisions (such as SITRAS PRO) or from third parties.

The IEC 61850 System Configurator supports the SCL configuration files (substation configuration language) from the IEC 61850-6 through import or export of all formats (ICD/IID/CID/SCD/SSD/SED). Thus, IEC 61850 devices can be added and a complete IEC 61850 station is available for substation automation technology.

IEDs from the IEC 61850 standard of Edition 1, 2.0, or 2.1 are supported. The possible engineering therefore includes not only GOOSE communication and client-server configuration via MMS reporting, but also system topology, process bus communication with SMV (sampled measured values) and IEC 60870-5-104 addresses for the gateway to the network control center via IEC 61850-8-1.

Simple engineering thanks to customer-friendly workflows and the universal display of IEC 61850 addresses as well as customer description texts. Users with basic or expert IEC 61850 knowledge find the desired level of detail. For documentation purposes, the engineering can be displayed in the Web browser in a customer-friendly form. Harmonized interfaces of the tool, such with DIGSI 4 and DIGSI 5, reduce the engineering effort for Siemens plants even more.

### Benefits

- Comprehensive – one tool for configuring all digital IEC 61850 devices
- Simple extension and adaptation of plants by using IEC 61850 Edition 1 and 2 in a project
- Customer-specific IEC 61850 structures (flexible engineering) permit the implementation of customer standards
- Easy to understand by using application-oriented signal names instead of the specific IEC 61850 language (logical nodes, etc.)



[sc\_IEC 61850 SysConf, 2, ...]

Figure 4.3/1 Splash Screen for the IEC 61850 System Configurator

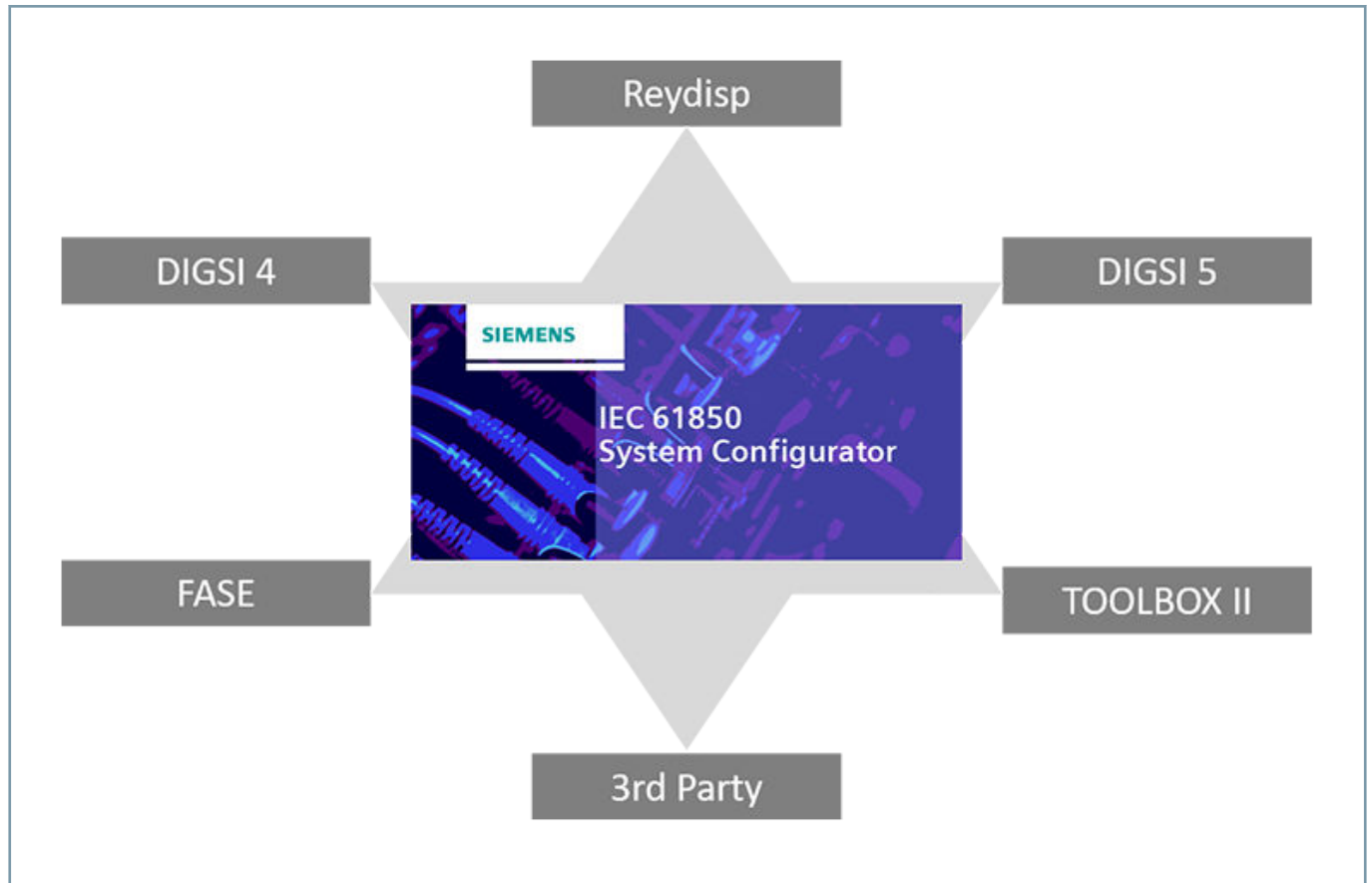
- Proven by experience from worldwide standardization activities and engineering of more than 500 000 devices
- Facilitated engineering by means of integrated interfaces to DIGSI, SICAM SCC, SICAM PAS, SICAM protocol test system and IEC 6150 browser

### Applications

- Interoperable engineering of IEC 61850 (MMS; GOOSE; SMV)
- Import and export of all SCL formats, such as ICD, IID, CID, SCD, SSD or SED
- Supporting of Editions 1, 2.0, and 2.1 of IEC 61850
- Engineering with IEC 61850-80-1
- Engineering independent from manufacturers

# SIPROTEC 5 Compact – Engineering

## IEC 61850 System Configurator



[One IEC 61850, 3, ...]

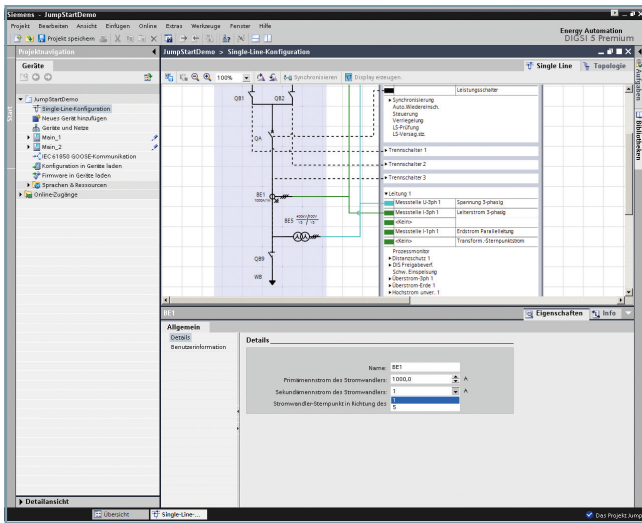
**Figure 4.3/2** One IEC 61850 System Configurator for all Devices in the Station

### IEC 61850 – Ethernet-Based Substation Automation Protocol

IEC 61850 is more than just a substation automation protocol. The standard comprehensively defines data types, functions, and communication in station networks. In Edition 2, the influence of the standard is extended to more sectors of the energy-supply industry. Siemens actively participated in designing the process of adapting Edition 1 to Edition 2 for the purposes of the standardization framework. Edition 2 fills in certain omissions and defines additional applications. As a global market leader with Edition 1 SIPROTEC 4 devices, Siemens has resolved the issues of interoperability, flexibility, and compatibility between Editions 1 and 2: Cooperation with Edition 1 devices is possible without difficulties.

- Converting the complexity of the IEC 61850 data model into your familiar user language
- Integrated, consistent system and device engineering (from the single line of the plant to device parameterization on the basis of the IEC 61850 data model)
- Flexible object modeling, freedom in addressing objects, and flexible communication services warrant the highest possible degree of interoperability and effective exchange and expansion concepts.
- Full compatibility and interoperability with IEC 61850 Editions 1, 2.0, and 2.1

The internal structure of SIPROTEC 5 devices conforms to IEC 61850. The result is that for the first time, an integrated, consistent system and device engineering, from the single line of the plant to device parameterization, conforming to the guiding principles of IEC 61850 is possible.

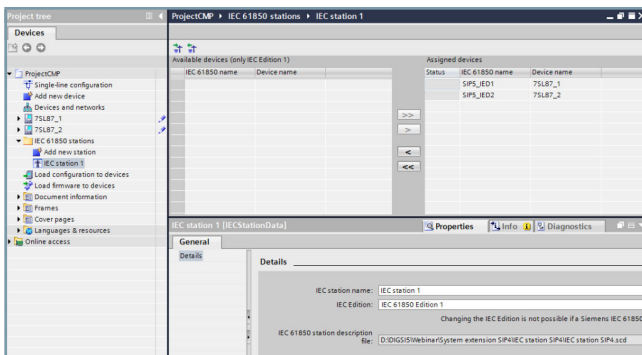


IEC\_Change\_CT\_ratio\_1\_...-1

**Figure 4.3/3** System Specification and Configuration in DIGSI 5 – the Complexity of IEC 61850 is Transparent

DIGSI 5 with integrated IEC 61850 engineering covers the complexity of the standard with a sophisticated user interface. In standard engineering, you as the user will not be required to deal with the details of IEC 61850; you get to use your user language.

In the user language, distance protection is distance protection with zones and dependent functions, not a collection of logical nodes. Reports are message lists in which information about the systems control is configured. In the system configurator, GOOSE connections are simply configured in a table with source and target information. You work in your language, with functions and messages associated with a device. If you wish, you can view the assigned IEC 61850 objects in the IEC 61850 protocol language. This bilingualism is supported throughout the user interface by DIGSI 5 and the export files on the systems control. As the user, you can even add helpful notes to the data points you define in your language and then export them for data purposes in the ICD and SCD description.



IEC\_DIGSI\_catalog\_1\_en\_US

**Figure 4.3/4** Creating an IEC 61850 Station

Flexible engineering offers IEC 61850 experts a wide range of freedom to design their own IEC 61850 structure, including with user-defined functions and objects. Flexible object modeling, freedom in addressing objects, and flexible communication serv-

ices warrant the highest possible degree of interoperability and effective exchange and expansion concepts.

The name of the logical device (IdName) is freely editable. For example, the standard-conforming name CTRL can be changed to CONTROL. Structural changes can also be made by changing the logical device (LD), so that the interface structure can be adapted flexibly to the requirements of the user. Rigid manufacturer specifications are a thing of the past. Prefix and instance (inst) of the logical node (LN) can also be edited.

The standard defines the length and rules that are checked by DIGSI 5 when they are entered.

Stages of functions of a device, which the standard maps to logical nodes (LN), can be deleted, copied, and extended with objects of the user. Messages can be added to a switching object such as the LN XCBB, for example, monitoring messages for a circuit breaker that have not been defined in the original LN. You as a user, you can route all of the information associated with a given switching object into a logical node (LN).

Logical nodes (LN) can be added from a library. These instructions can be supplemented with your own objects. You can also define and create generic nodes. For example, there are logical nodes (LN) whose functionality you as the user create for yourself through logic functions. These user-defined functions can be loaded into the device and run there. Monitoring functions can be created and expanded as required.

A high degree of flexibility in communication is offered for configuration of GOOSE messages and reports.

Addresses, dataset names, etc. can be set by you, the user.

Flexible engineering offers a high degree of design freedom on many levels, enhancing interoperability for more complete communication interchangeability. This in turn safeguards investments in model devices in accordance with IEC 61850.

With the single-line diagram, you as the user can view the topological structure of the system. DIGSI 5 has been prepared so that it can export this topological structure of a system to the SSD file conforming to the standard. This description, as an extension of the SCD file, represents the primary system for technical data purposes. In the future, the objects of the device with which processes of the primary system are controlled can be adapted flexibly to reflect the specifications of the customer. Flexible engineering is the key to bringing the system view into harmony with the IEC 61850 structure of the device.

# SIPROTEC 5 Compact – Engineering

## IEC 61850 System Configurator

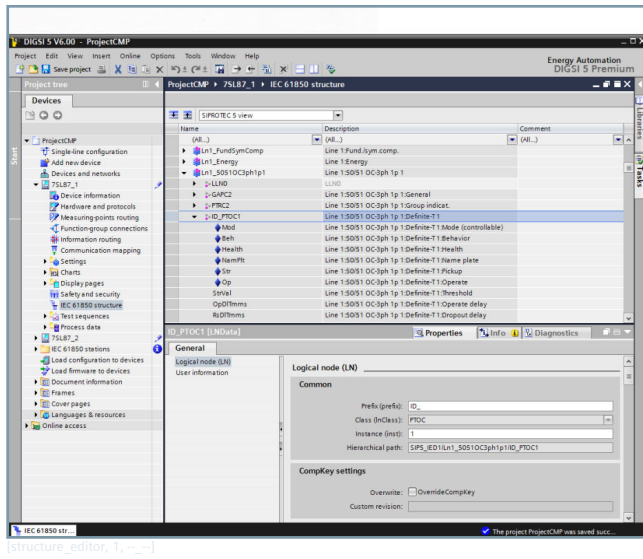


Figure 4.3/5 Editor for Adapting the IEC 61850 Structure in the SIPROTEC 5 View

### Description

The SIPROTEC DigitalTwin is the virtual, digital twin of a real SIPROTEC 5 device, including the algorithms, functions, and communication interfaces.

The new, innovative, cloud-based SIPROTEC DigitalTwin offers a comprehensive test of your SIPROTEC 5 devices as part of the power automation system with high levels of efficiency, power, security, and 24/7 availability from anywhere and without any hardware.

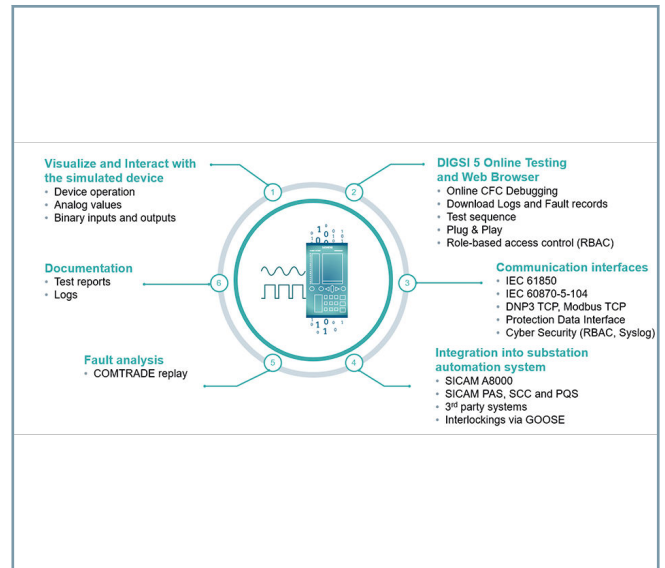
### Application Areas

- Visualization and operation of the device (navigation, function keys, etc.)
- Infeed of currents, voltages, binary inputs, etc. to simulate setting values
- Testing the protection functions, the automation logics, and the customer-specific applications
- Integration into SICAM A8000, SICAM PAS/SCC substation automation systems, and SCADA third party systems with the Ethernet protocols IEC 61850, DNP3, Modbus TCP, IEC 60870-5-104
- PMU and power-quality systems, such as SICAM PQS, SIGUARD PDP, or PQ Advisor Compact
- SICAM GridEdge, SIPROTEC Dashboard, or PQ Advisor Premium IoT applications
- IEC 61850 GOOSE communication between devices, for example, for interlocking
- Error analysis, for example, fault-record playback
- Cybersecurity functions (Syslog, RADIUS)
- Individual and intuitive SIPROTEC 5 training

### Customer Benefit

Saves time and boosts the quality throughout your systems entire lifecycle.

- Testing the power-automation system in minutes 24/7 without any hardware, without any additional expenditure, and regardless of location.
- The new systems can be added more quickly due to shorter project lead times.
- Reduced OPEX with shorter downtimes ensure high availability due to improved pretesting (incl. patches)
- Reduced investment costs (CAPEX) in test devices
- Quick and realistic error analysis due to easy reproducibility of the product and system behavior
- Flexible, continuous, and personalized training in a virtual testing environment based on real system conditions



[sc\_SIPROTEC DigitalTwin energy aut, 1, en\_US]

Figure 4.4/1 SIPROTEC DigitalTwin within the Power Automation System



# SIPROTEC 5 Compact – Engineering

## SIPROTEC DigitalTwin –

### Testing the Device

- Infeed of static currents and voltages
- Simulation of binary inputs and analog values
- Device operation (display, LED)



[sc\_SIPROTEC-DigitalTwin-Analog-Values, 1, ...]

Figure 4.4/2 SIPROTEC DigitalTwin – Analog Value

### Testing the Protection Function

- With static values
- With COMTRADE output
- With State Sequencer



[sc\_SIPROTEC-DigitalTwin-Analog-Values-Vector, 1, ...]

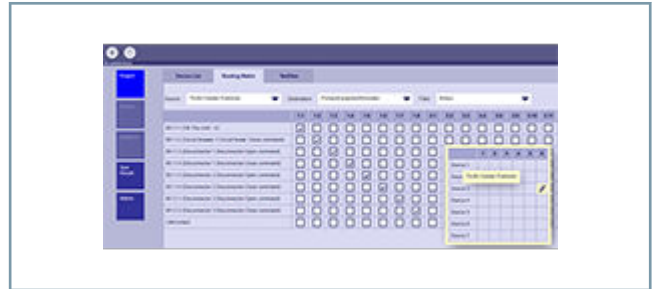
Figure 4.4/3 SIPROTEC DigitalTwin – Vector Analog Values

### Cybersecurity

- Windows Server
- Security Logs
- Role-based access control (RBAC)

### Communication

- SCADA systems
- Ethernet-based station protocols
- Protection-data transfer
- Telecontrol interfaces
- Web-based interfaces (SIPROTEC 5 Web UI)
- IoT connectivity/GridEdge

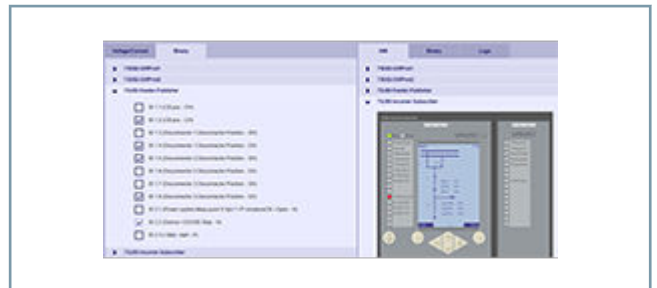


[sc\_SIPROTEC-DigitalTwin-Binary-Inputs, 1, ...]

Figure 4.4/4 SIPROTEC DigitalTwin – Binary Input

### IEC 61850 communication

- GOOSE, MMS, and interlocking
- SCADA systems
- Process bus



[sc\_SIPROTEC-DigitalTwin-Binary-Outputs, 1, ...]

Figure 4.4/5 SIPROTEC DigitalTwin – Binary Output

### Transparency Increases Efficiency

Protection relays sit at the very heart of our power grid infrastructure. They operate silently inside substations and listen to the AC 50 Hz or AC 60 Hz heartbeat of the power lines. Once they come into action however, literally every millisecond counts to initiate switching operations to avert disaster and alert the grid operator about a specific fault situation. This is where the SIPROTEC Dashboard comes into play.

As part of our Grid Diagnostic Suite, the cloud-based SIPROTEC Dashboard application benefits from a new communication architecture. SIPROTEC 5 devices communicate not only to the substation automation level but also to the new SICAM GridEdge node, and from there to the MindSphere cloud. This way we can unlock the best of two worlds: Full data transparency on the Edge level and a grid-wide data overview in the cloud while adhering to state-of-the-art cyber security standards through the decoupling of field devices from the cloud.

### Empowerment of Maintenance Crews

The SIPROTEC Dashboard empowers operational crews in their task to troubleshoot faults in the power grid. Instead of waiting for information from the control center they can now directly access key data like fault logs and fault records of a given protection relay that initiated a trip – even before going on-site. The new SIPROTEC Dashboard enables different views for all relays in the grid, including a map view, station view and device view.

Furthermore, the Dashboard offers additional insights into compact condition monitoring parameters like the switched fault current ( $I^2t$ ) or temperature hotspots of transformers or switchgear – all very helpful indications for an early assessment of the situation on the ground.

One source of complexity when troubleshooting the behavior of protection relays is related to firmware versions. Are all devices on the same version? Is the latest version deployed everywhere? Through our new firmware cross-check functionality, firmware versions can be analyzed at a glance within the context of a substation or even across the entire grid.

In summary the SIPROTEC Dashboard is an innovative new offering for our SIPROTEC devices and offers insightful views on your protection fleet at a glance.

#### Advantages at a Glance

- Simplifies workflows for faster response times
- Increases grid availability and service quality
- Full support for SIPROTEC and Reyrolle relays as well as cross-vendor support for IEC 61850 enabled protection devices
- Highest cybersecurity standards

### Main Features

Monitor the status of your protection relay fleet:



[IoT, 1, ...]

Figure 4.5/1 Grid Diagnostic Suite

#### Multiple Views

- Map view, substation view, device and measurement data views
- Drill down option for each event

#### Fault Analysis

- Automated fault record and fault log retrieval
- Fault record visualization

#### Device Management

- Firmware cross-check on station and grid-level
- Settings monitoring on station and grid-level

#### SICAM GridEdge

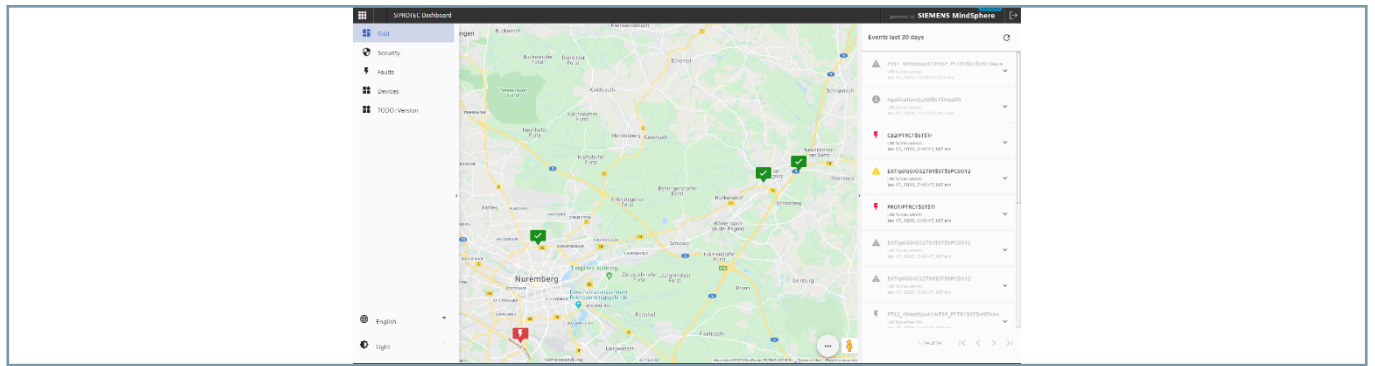
- Full data transparency via direct device access
- Cross-vendor compatible for IEC 61850 enabled protection relays
- Modular extensible functionality via containerized applications
- Secure decoupling from relays to the cloud

#### Condition Monitoring Views

- Circuit breaker  $I^2t$  statistics
- Hotspot measurements for transformers and switchgear
- Transformer tap position statistics

# SIPROTEC 5 Compact – Engineering

## SIPROTEC Dashboard



[sc\_SIPROTEC\_Dashboard, 1, \_-]

Figure 4.5/2 IoT Architecture for Power Automation Systems

## Description

The SIGRA user program supports you in analyzing failures in your electrical power system. The program graphically analyzes data recorded during the failure and calculates additional supplemental quantities such as impedances, powers, or RMS values, from the supplied measured values, making evaluation of the fault record easier.

The quantities can be shown as desired in the diagrams of the following views: **time signals**, **vector diagrams**, **locus diagrams**, **harmonic components**, and **fault locators** and represented in the **table** view.

After a system incident, it is especially important to quickly and completely analyze the error, so that the respective measures can be derived immediately from the cause analysis. This will enable the original network status to be restored and the down time to be reduced to an absolute minimum.

As well as the usual time signal display of the recorded measured quantity, the current version is also set up to display vector, pie and bar charts to show the harmonics and data tables. From the measured values recorded in the fault records, SIGRA calculates further values, for instance missing quantities in the 3-phase electrical power system, impedances, outputs, symmetrical components, etc. Using 2 cursors, the fault current can be evaluated easily and conveniently. Using SIGRA however, further fault records can also be added. The signals from another fault record (for example, from the opposite end of the line) are added to the current signal pattern using drag and drop.

SIGRA facilitates the display of signals from various fault records in one diagram as well as a fully automated synchronization of these signals on a common time base. As well as the precise determination of the individual factors of the line fault, the fault location is also of particular interest.

A precise determination of the fault location saves time which the user can use for an on-site inspection of the error. This function is also supported by SIGRA using the **Offline fault location** function. SIGRA can be used for all fault records in COMTRADE file format.

The functions and advantages of SIGRA can often only be best displayed on the product itself. Consequently, SIGRA is available as a 30-day test version.

## Functions

- 6 diagram types:
  - Time-signal representation (standard)
  - Pie chart (for example for R/X)
  - Vector diagram (reading angles)
  - Bar chart (for example for displaying the harmonics)
  - Table (list values for different signals at the same time)
  - Fault location (to display the location of faults)
- Additional-value calculation, for example positive-sequence impedances, RMS values, symmetrical components, vectors



[sc\_SIGRA\_Splash, 1, ...]

Figure 4.6/1 Fault-Record Analysis with SIGRA

- 2 cursors for for measured values are synchronized in all views
- Powerful zoom function
- User-friendly configuration via drag and drop
- Innovative signal configuration in a clear matrix
- User profiles that save time and can be assigned to individual device types or series
- Additional fault records can be added to the existing fault record
- Synchronization of different fault records to a common time base
- Simple documentation by copying diagrams into documents from other MS Office programs
- Offline fault-location determination

## Hardware Requirements

To work with SIGRA, you need a PC or laptop computer with the following minimum specifications, irrespective of the operating-system version you are using:

- Intel® Celeron® Dual Core 2.2 GHz (Ivy/Sandy Bridge) or equivalent
- 2 GB RAM (8 GB recommended)
- Graphic display with resolution of 1024 × 768 pixels (1280 × 1024 recommended)
- 5 GB of available hard-disk space

# SIPROTEC 5 Compact – Engineering

## SIGRA

Operating System	Version/Type	Updates	PC <sup>11</sup>	VM <sup>12</sup>	32-bit <sup>13</sup>	64-bit <sup>14</sup>
Windows 10	Professional	1803;1809;1903	+	+	+	+
Windows 10	Enterprise	1803;1809;1903	+	+	+	+
Windows 7	Professional	SP1 <sup>15</sup>	+	+	+	+
Windows 7	Enterprise	SP1 <sup>15</sup>	+	+	+	+
Windows 7	Ultimate	SP1 <sup>15</sup>	+	+	+	+
Windows Server 2019	Standard	–	+	–	–	+

Table 4.6/1 Supported und Tested Operating Systems

### Virtual Machines

SIGRA supports VMware virtual machines with the following versions and higher:

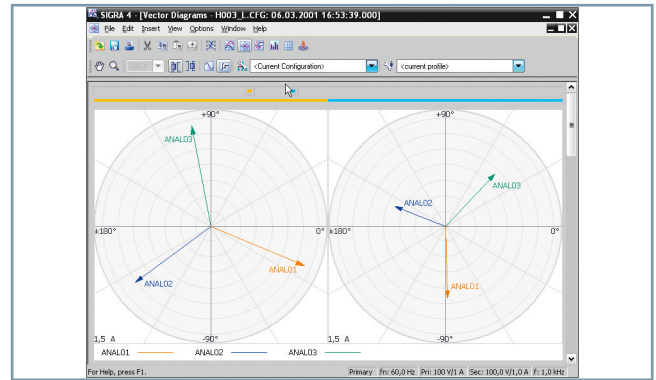
- VMware Workstation V6.5.0
- VMware Player V3.1.2
- VMware Tools for Windows V8.4.4

You can find more information on the Internet page: <https://www.vmware.com>

You use other Windows and older VMware versions at your own risk.

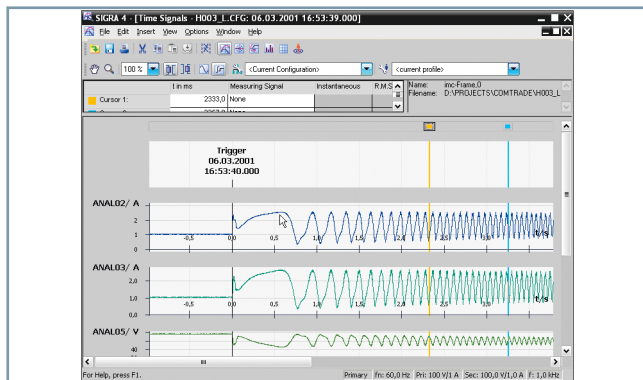
### Interface Languages:

German, English, French, Spanish, Italian, Chinese, Russian, Turkish (selectable)



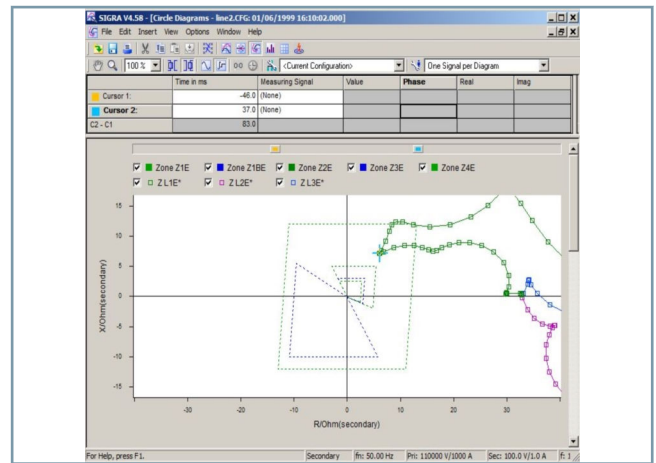
[sc\_VectorDiagram, 1, en\_US]

Figure 4.6/3 SIGRA Phasor Diagram



[sc\_TimeSignalsDiagram, 1, en\_US]

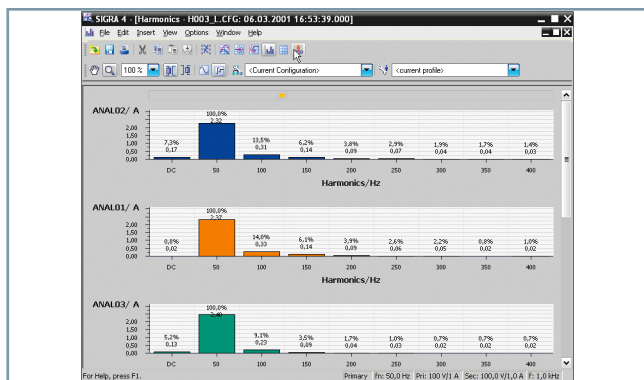
Figure 4.6/2 SIGRA Time Signals



[sc\_circle diagram, 1, en\_US]

Figure 4.6/4 SIGRA Locus Diagrams

11 PC: Windows computer  
 12 VM: Virtual machines (for example VMWare)  
 13 32 bit: Operating system with 32-bit support (DIGSI 5 cannot be installed or used on a 32-bit operating system)  
 14 64-bit: Operating system with 64-bit support  
 15 Including security update KB3033929 or other security patch incorporating this security update



[sc\_Oberschwingung\_1\_en\_US]

Figure 4.6/5 SIGRA Harmonics

DIGSI 5, IEC 61850, and SIGRA support you in an optimal and holistic manner for your SIPROTEC 5 project:

- Powerful and effective analysis of fault records
- Integrated system and device engineering
- Graphical user interface simplifies and accelerates project engineering
- Application templates and function groups as images of the primary application and the primary objects, such as the line or circuit breaker, warrant a user-oriented working method and perspective
- Test and simulations tools offer optimal plausibility checks

# Attachment

## Selection and Ordering Data

### Selection and Ordering Data

5.1

Description	Variants	Order no.																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
<b>Universal protection device</b>		7	S	X	8	0	0	0	-	3	□	□	5	□	-	1	□	A	0
											▲	▲		▲			▲		
Binary inputs/outputs																			
	4 BI, 5 BO (4 F, 1 life contact)										A								
	14 BI, 11 BO (10 F, 1 life contact)										B								
	17 BI, 8 BO (7 F, 1 life contact)										C								
Measuring inputs																			
	4 x Ip, 4 x U										A								
	3 x Ip, 1 x Iee, 4 x U										B								
Front view																			
	Standard												0						
	US												1						
Ethernet interface (port F)																			
	Ethernet electrical																	B	
	Ethernet optical																		C
Function point budget																			
	1 function point	7	X	X	8	1	5	2	-	1	A	A	□	□	-	□	□	□	□

**Table 5.1/1** SIPROTEC 7SX800 Selection and Ordering Data

Create SIPROTEC 5 license files (DAF) and manage your function-points budgets with the [SIPROTEC function-point manager](#). As a prerequisite, you must register in the function-point manager and create a budget account.

To order SIPROTEC function points, use the account-specific item number displayed in the function-point manager. Order function points from your regional sales partner or in the [SiePortal](#).

For more details, refer to [siemens.de/siprotec-funktionspunkte-manager](https://www.siemens.de/siprotec-funktionspunkte-manager).

By placing an order, you accept the following terms and conditions: [siemens.com/fpm-terms](https://www.siemens.com/fpm-terms).

Functions/function points see next page



ANSI	Function	Function points (FP)
	Protection functions for 3-pole tripping	Basis (0)
14	Locked rotor	
37	Undercurrent protection	
46	Negative-sequence system overcurrent protection	
46	Unbalanced-Load Protection	
49	Thermal overload protection	
49R	Thermal overload protection, rotor (motor)	
50/51	Overcurrent protection, phases	
	Switch-Onto-Fault Tripping (SOTF)	
50HS	Instantaneous high-current tripping	
50/51	Overcurrent protection with positive-sequence current I1	
50N/51N	Overcurrent protection, ground	
50N/51N	Overcurrent protection, 1-phase	
50Ns/51Ns	Sensitive ground current protection for grounded arc suppression coils and isolated power systems (3I0>, 3I0-harm>)	
	Sensitive ground-fault detection via pulse detection	
	Intermittent ground-fault protection	
50BF	Circuit-breaker failure protection, 3-pole	
50RS	Circuit breaker reignition monitoring	
59C	Peak overvoltage protection, 3-phase, for capacitors	
60C	Current-unbalance protection for capacitor banks (1-phase)	
74TC	Trip-circuit supervision	
74CC	Single circuit monitoring	
79	Automatic reclosing, 3-pole	
86	Lockout	
87N	Restricted Ground-fault Protection	
	Measured values, extended: Min, max, average	
	Switching statistics counter	
	Power quality – basics, measured values: THD (Total Harmonic Distortion) and harmonic (current)	
	CFC (standard, control, arithmetic)	
	Circuit-breaker wear monitoring	
	Switching sequence function	
	Inrush-current detection	
	External trip initiation	
	Control	
	Fault recording of analog and binary signals	
	Monitoring	
	Cybersecurity: Role-based access control	
	Cybersecurity: Authenticated network access using IEEE 802.1x	
SSR	Slow-scan recorder	
CR	Continuous recorder	
TR	Trend recorder	

Table 5.1/2 Standard Function Package (Current-Based Functions and Cybersecurity)

# Attachment

## Selection and Ordering Data – Functions/Function Points

5.1

ANSI	Function	FP
	Voltage measurement	30
24	Overexcitation protection	
25	Synchrocheck, synchronization function	
27	Undervoltage protection: 3-phase or positive-sequence system V1 or universal Vx	
27R, 59R	Voltage change protection	
	Directional reactive power undervoltage protection (QU protection)	
32.37	Power protection active/reactive power	
32R	Reverse-power protection	
46	Negative-sequence system overcurrent protection with direction	
47	Overvoltage protection: negative-sequence system V2 or negative-sequence system V1/positive-sequence system V1	
51V	Overcurrent protection, voltage dependent	
59, 59N	Overvoltage protection: 3-phase or zero-sequence system V0 or positive-sequence system V1 or universal Vx	
	Voltage protection according to the standard CEI 0-16	
60	Voltage-comparison supervision	
67	Directional overcurrent protection, phases	
67N	Directional overcurrent protection, ground	
67Ns	Sensitive ground-fault detection for systems with resonant or isolated neutral including a) $3I_0 > b) V_0 >$ , c) $\cos/\sin \varphi$ , d) Transient ground fault, e) $\varphi(V, I)$ , f) Admittance	
	Directional intermittent ground-fault protection	
81	Frequency protection: $f >$ or $f <$ or $df/dt$	
81U	Underfrequency load shedding	
	Vector-jump protection	
FL	Fault locator, single-side	
FL+	Fault locator plus, single-side	
	Power Quality – Basic, measured values: THD (Total Harmonic Distortion) and harmonics (voltage)	

**Table 5.1/3** Voltage-Based Function Package

ANSI	Function	FP
48	Motor-starting time supervision	5
50L	Load-jam protection motor	5
66	Motor restart inhibit	5

**Table 5.1/4** Motor Protection Functions

	Ethernet Protocols	FP
	IEC 61850-8-1	50
	Modbus TCP	
	IEC 60870-5-104	
	DNP3	
	PROFINET IO	
	Redundancy protocols RSTP/PRP/HSR	

**Table 5.1/5** Communication Package – Ethernet Protocols

Serial Protocols		FP
	IEC 60870-5-103	20
	DNP3	
	Modbus RTU	

Table 5.1/6 Communication Package – Serial Protocols

Measured Values		FP
	Voltage unbalance (required voltage-based protection functions)	20
	Voltage variations – supervision of voltage dips, swells, and interruptions (required voltage-based protection functions)	30
	TDD – Total demand distortion	10
	PQ-10/12 cycle values for continuous recorder	25
	PQ trend values for trend recorder	25
	PQ flicker values for trend recorder	25

Table 5.1/7 PQ – Basic

For countries in which the SIPROTEC function points manager is not yet available, you can order the devices pre-configured with function points. The following options are available:

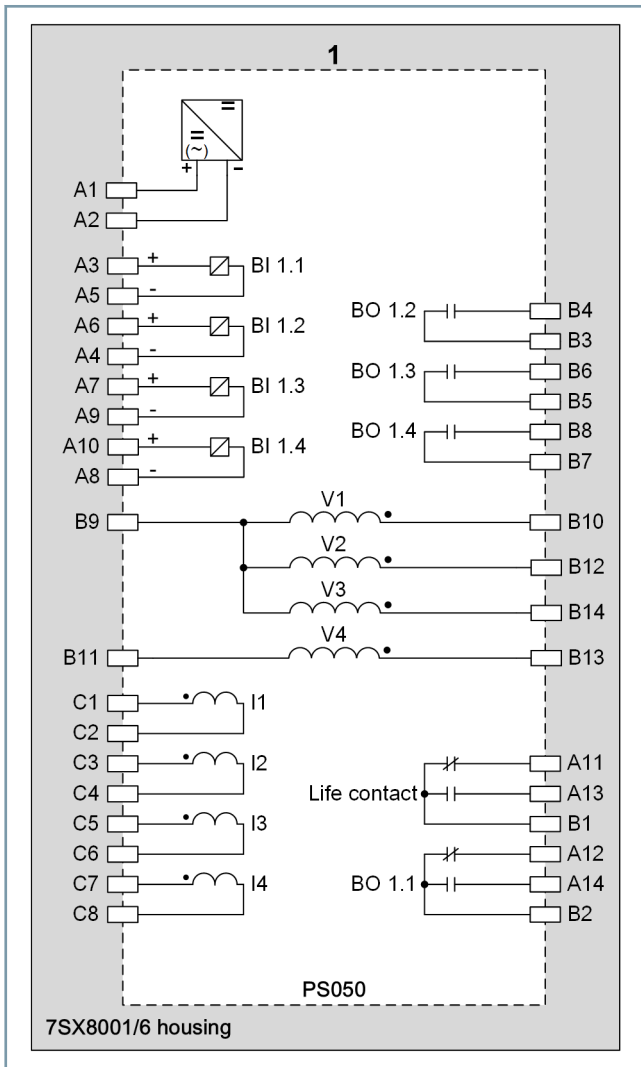
Pre-configuration	Short code
20 function points	ZP02
50 function points	ZP05
100 function points	ZP10
150 function points	ZP15
200 function points	ZP20

# Attachment

## Accessories

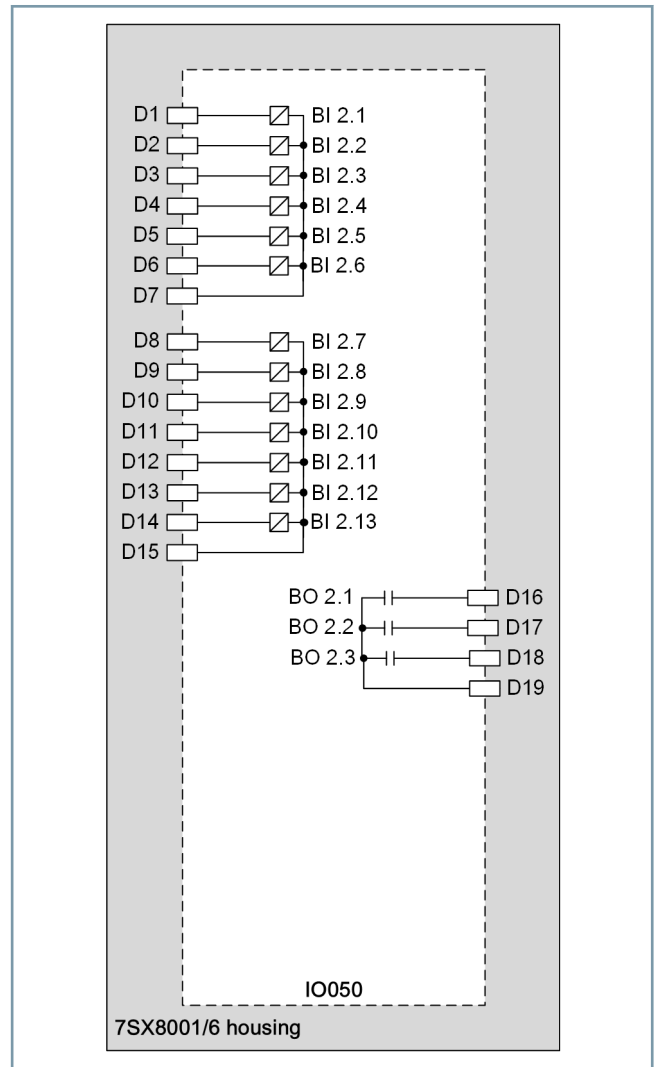
Group	Accessories	Articles per packaging unit	Order no.
Terminal	Voltage terminal, terminal block, 14-pole	8	7XX8400-0VA00
Terminal	Current terminal, 4 x protection	1	7XX8410-0CF00
Terminal	Current terminal, 3 x protection and 1 x measurement	1	7XX8410-0CG00
Terminal	2-pole cross connector for current terminal	3	7XX8400-0XA00
Terminal	Terminals for expansion module	2	7XX8410-0TE00
Terminal	2-pole cross connector for voltage terminal	6	7XX8400-0XB00
Terminal	Cover for current terminal block	1	7XX8400-0XC00
Terminal	Cover for voltage terminal block	8	7XX8400-0XD00
Terminal	Transport safety, current terminal	2	7XX8400-0XE00
Terminal	Transport safety, voltage terminal	10	7XX8400-0XF00
Terminal	Terminal for direct connection to 400 V low voltage	4	7XX8400-0TD00
Accessories	USB cover	10	7XX8310-0MK00
Accessories	Set of angle rails	2	7XX8300-0ME00
Accessories	Panel surface mounting assembly frame (for mounting a device in the panel surface mounting)	1	7XX8310-0MG00
Accessories	DIGSI 5 USB cable 2.0	1	7XX8300-0CE00
Accessories	SFP RJ45	10	7XX8300-0EB00
Accessories	Y-adaptor cable for serial communication	1	7XV5103-2CA00
Accessories	RS485 bus termination plug	1	7XV5103-5BA00
Accessories	IRIG B adaptor cable	1	7XX8310-0CG00

Table 5.2/1 Accessories



[sv\_PS050, 1, en\_US]

Figure 5.3/1 PS050 – Connection Diagram



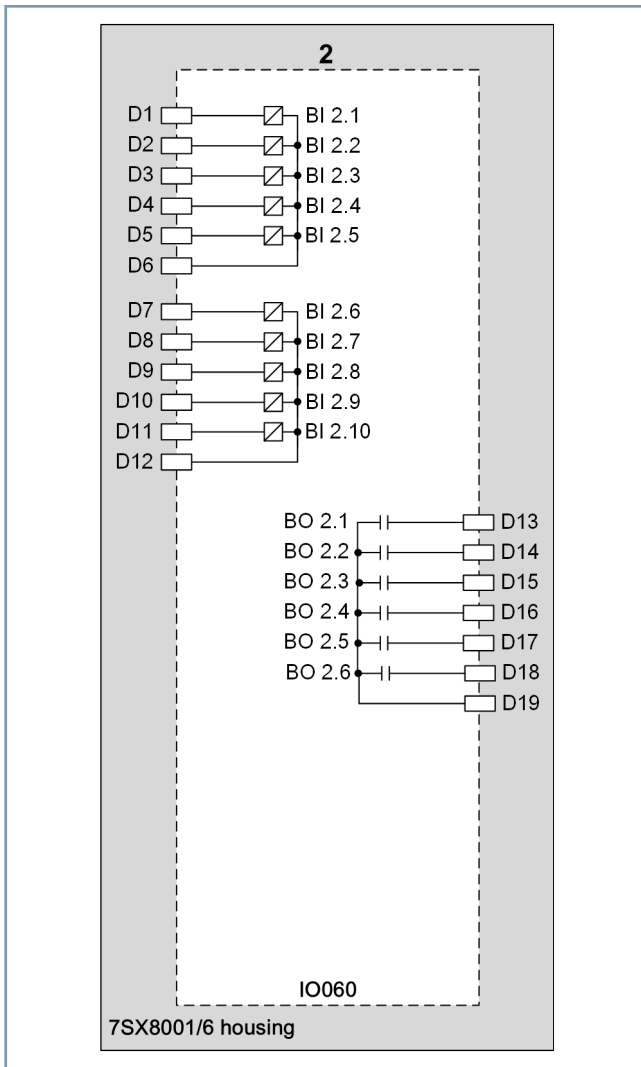
[dw\_IO050, 1, en\_US]

Figure 5.3/2 IO050 – Connection Diagram

# Attachment

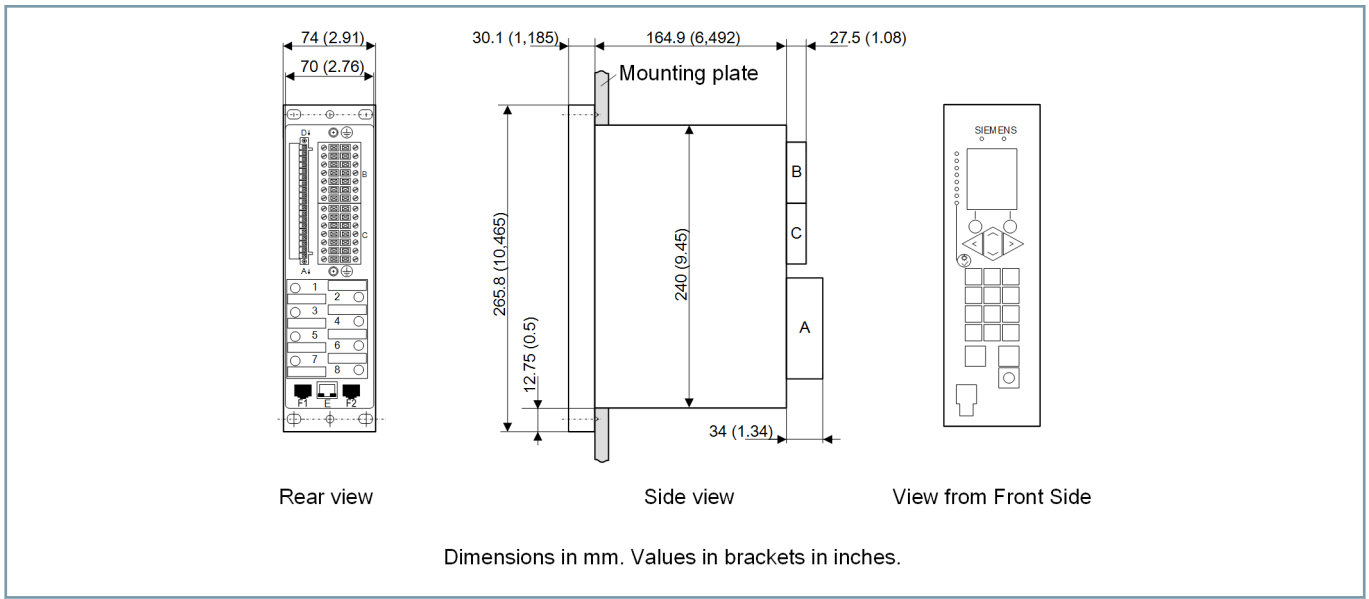
## Connection Diagrams

5.3

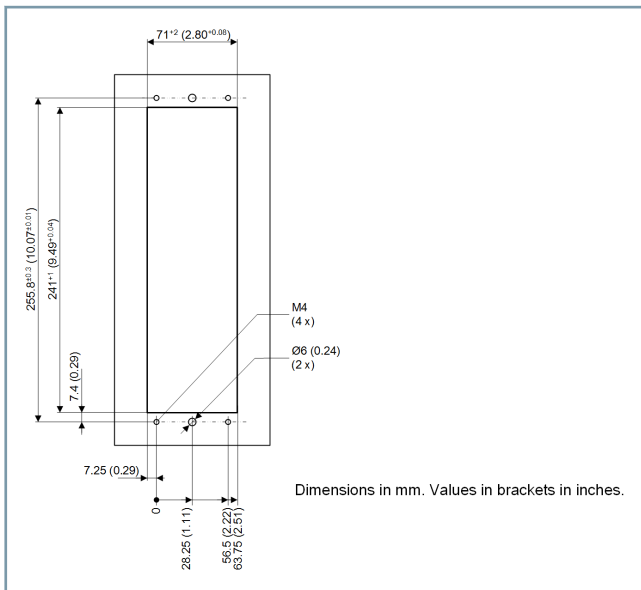


[dw\_IO060, 1, en\_US]

Figure 5.3/3 IO060 – Connection Diagram



[dw\_SIP5-compact\_dimensional\_drawing\_2\_en\_US]



[dw\_drilling\_source\_mounting\_in\_SIP5Comp\_1\_en\_US]



# Attachment

## Grouping Measured Values

5.5

Measured Value	Description
<b>Grouping of Base Measured Values</b>	
Operational measured values	<p>RMS value calculation and power calculation as per the definition</p> <p>Phase currents <math>I_A, I_B, I_C</math></p> <p>Ground current <math>I_N, I_{NS}</math> (sensitive)</p> <p>Phase-to-ground voltages <math>V_A, V_B, V_C</math></p> <p>Phase-to-phase voltages <math>V_{AB}, V_{BC}, V_{CA}</math></p> <p>Residual voltage <math>V_{NG}</math></p> <p>Frequency <math>f</math></p> <p>Power P, Q, S (3-phase and phase-specific)</p> <p>Power factor <math>f</math></p>
Fundamental and symmetrical components	<p>Calculation of phasor variables with Fourier filter or according to transformation rule</p> <p>Phase currents <math>\underline{I}_A, \underline{I}_B, \underline{I}_C</math></p> <p>Ground current <math>\underline{I}_N, \underline{I}_{NS}</math> (sensitive)</p> <p>Phase-to-ground voltages <math>\underline{V}_A, \underline{V}_B, \underline{V}_C</math></p> <p>Phase-to-phase voltages <math>\underline{V}_{AB}, \underline{V}_{BC}, \underline{V}_{CA}</math></p> <p>Residual voltage <math>\underline{V}_{NG}</math></p> <p>Symmetrical components <math>\underline{I}_0, \underline{I}_1, \underline{I}_2, \underline{V}_0, \underline{V}_1, \underline{V}_2</math></p>
Energy values	<p>Metered values are determined for active and reactive energy. Restore time, restore interval, and counting mode are adjustable. Restoring can also be initiated via a binary input. The following metered values are available:</p> <p>Active energy <math>W_{p+}</math> (release), <math>W_{p-}</math> (uptake)</p> <p>Reactive energy <math>W_{q+}</math> (release), <math>W_{q-}</math> (uptake)</p>
Statistical values	<p>The following statistical values are formed as follows:</p> <p>Total sum of primary breaking currents</p> <p>Total number of initiated trippings of the circuit breaker</p>
<b>Grouping of Advanced Measured Values</b>	
Mean values	<p>Mean values can be calculated on the basis of the operational measured values and the symmetrical components. The time slot for mean-value calculation and the output interval are parameterizable.</p>
Minimum values and maximum values	<p>The minimum/maximum values can be generated on the basis of operational measured values, symmetrical components, and selected measured values (for example, from mean values). The display of minimum and maximum values contains the time of their occurrence. The calculation is stabilized against smaller value fluctuations in currents and voltages.</p>

The following is an extract from the technical data for SIPROTEC 5 Compact. Refer to the current **SIPROTEC 5 Compact** manual under [www.siemens.com/siprotec](http://www.siemens.com/siprotec) or under **SIOS** for more information

### Voltage Input

All current, voltage, and power data are specified as RMS values.	
Rated frequency $f_{\text{rated}}$	50 Hz, 60 Hz
Measuring range	0 V to 200 V
Burden	< 0.1 VA
Thermal rating	230 V continuously

### Power supply

Power supply via integrated power supply			
Permissible voltage ranges		DC 19 V to DC 250 V AC 92 V to AC 265 V at 50 Hz, 60 Hz	
Auxiliary nominal voltage $V_H$		DC 24 V, 48 V, 60 V, 110 V, 220 V AC 100 V, 230 V at 50 Hz, 60 Hz	
Ripple voltage, peak-peak, IEC 60255-11, IEC 61000-4-17		$\leq 15\%$ of the DC auxiliary nominal voltage (applies to direct voltage only)	
Inrush current		$\leq 18$ A	
Recommended external protection		6 A miniature circuit breaker, characteristic C according to IEC 60898	
<b>Internal fuse</b>			
DC 24 V to DC 250 V AC 100 V to AC 230 V 4 A time-lag, AC 250 V, DC 300 V, UL recognized SIBA type 179200			
<b>Power consumption (life relay active)</b>			
–	DC	AC 230 V	AC 100 V
	12 W	42 VA, power factor $\geq 0.25$	28 VA, power factor $\geq 0.35$
Stored-energy time on outage or short circuit of the auxiliary voltage IEC 61000-4-11 IEC 61000-4-29		In each permissible AC and DC voltage range $\geq 50$ ms	

### Binary Input

Standard Binary Input	
Rated voltage range	DC 24 V to 250 V
Current consumption, picked up	Approx. DC 0.6 mA to DC 2.5 mA (independent of the control voltage)
Power consumption, max.	0.6 W

Standard Binary Input		
Pickup time	Approx. 3 ms	
Dropout time <sup>16</sup>	Capacitive load (supply-line capacitance)	Dropout time
	< 5 nF	< 4 ms
	< 10 nF	< 6 ms
	< 50 nF	< 10 ms
	< 220 nF	< 35 ms
Control voltage	Adapt the binary-input threshold to be set in the device to the control voltage.	
	Range 1 for 24 V, 48 V, and 60 V Control voltage	$V_{\text{low}} \leq \text{DC } 10$ V $V_{\text{high}} \geq \text{DC } 19$ V
	Range 2 for 110 V and 125 V Control voltage	$V_{\text{low}} \leq \text{DC } 44$ V $V_{\text{high}} \geq \text{DC } 88$ V
	Range 3 for 220 V and 250 V Control voltage	$V_{\text{low}} \leq \text{DC } 88$ V $V_{\text{high}} \geq \text{DC } 176$ V
Maximum admissible voltage	DC 300 V	
The binary inputs contain interference suppression capacitors. To ensure EMC immunity, use the terminals shown in the terminal diagrams/connection diagrams to connect the binary inputs to the common potential.		

5.6

### Relay Outputs

Fast relay (type F)	
Making capacity	Max. 1000 W (L/R = 40 ms)
	Max. 3600 VA (power factor $\geq 0.35$ , 50 Hz to 60 Hz)
Breaking capacity	Max. 30 W (L/R = 40 ms)
	Max. 360 VA (power factor $\geq 0.35$ , 50 Hz to 60 Hz)
AC and DC contact voltage	250 V
Permissible current per contact (continuous)	5 A
Permissible current per contact (switching on and holding)	30 A for 1 s (make contact)
Short-time current across closed contact	250 A for 30 ms
Total permissible current for contacts connected to common potential	5 A

<sup>16</sup> For time-critical applications with low-active signals, consider the specified dropout times. If necessary, provide for active discharge of the binary input (for example, a resistor in parallel to the binary input or using a change-over contact).

# Attachment

## Technical Data

5.6

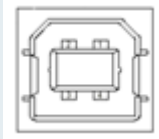
Fast relay (type F)	
Switching time OOT <sup>17</sup>	Make time: typical: 4 ms; maximum: 5 ms Break time: typical: 2 ms; maximum: 5 ms
Rated data of the output contacts in accordance with UL certification	DC 24 V, 5 A, General Purpose DC 48 V, 0.8 A, General Purpose DC 240 V, 0.1 A, General Purpose AC 120 V, 5 A, General Purpose AC 250 V, 5 A, General Purpose AC 250 V, 0.5 hp B300 R300
Interference suppression capacitors across the contacts	4.7 nF, ± 20 %, AC 250 V
Monitoring	2-channel activation

### Light-Emitting Diodes in the On-Site Operation Panel

Status	Color	Quantity
RUN	Green	1
ERROR	Red	1
Routable (adjustable with DIGSI 5) Only the defined color can be used in operation.	2-colored: red or green	8

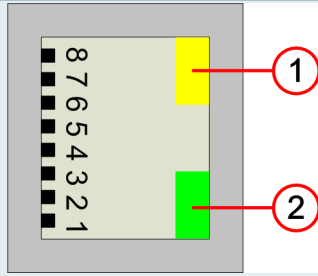
### User Interface, Front Side

You can find a USB connection of type B for the connection to a laptop computer or to a PC on the front side of the device. A protection cover protects this USB connection against pollution and humidity.

USB	User interface
Connection	USB type B 
Insulation class	PELV (Protective Extra Low Voltage) (according to IEC 60255-27)

### Integrated Ethernet Interface (Port F)

This connection is used to load the device with DIGSI 5 via Ethernet. This terminal also enables IEC 61850 Ethernet communication or communication with another protocol via Ethernet, for example, for connecting an external RTD unit.

Interface	Integrated electrical Ethernet interface
Connection	 (1) LED 1 Yellow (2) LED 2: Green
Connector type	2 x RJ45
Baud rate	100 Mbit/s
Protocol	DIGSI 5 protocol (secure Web service protocol) IEC 61850 (MMS and GOOSE) Modbus TCP DNP3 IEC 60870-5-104 PROFINET IO
Max. line length	20 m with Ethernet patch cable CAT 6 S/FTP, F/FTP, or SF/FTP
Insulation class	SELV (as per IEC 60255-27)
Interface design	Corresponds to IEEE 802.3, 100Base-TX

Interface	Integrated optical Ethernet interface
Connector type	2 x Duplex LC
Wavelength	$\lambda = 1300 \text{ nm}$
Baud rate	100 Mbit/s
Protocol	DIGSI 5 protocol (secure Web service protocol) IEC 61850 (MMS and GOOSE) Modbus TCP DNP3 IEC 60870-5-104 PROFINET IO You can switch on and off other network services such as SNMP, RSTP, PRP, HSR, SNTP, and SUP Ethernet.
Max. line length	2 km via 62.5/125 $\mu\text{m}$ multimode optical fiber

Transmit power	Minimum	Typical	Maximum
50 $\mu\text{m}/125 \mu\text{m}$ , NA <sup>18</sup> = 0.2	-24.0 dBm	-21.0 dBm	-17.0 dBm
62.5 $\mu\text{m}/125 \mu\text{m}$ , NA <sup>18</sup> = 0.275	-20.0 dBm	-17.0 dBm	-14.0 dBm

Receiver sensitivity	Maximum -12.0 dBm Minimum -31.0 dBm
Optical budget	Minimum 7.0 dB for 50 $\mu\text{m}/125 \mu\text{m}$ , NA <sup>18</sup> = 0.2 Minimum 11.0 dB for 62.5 $\mu\text{m}/125 \mu\text{m}$ , NA <sup>18</sup> = 0.275

<sup>17</sup> OOT (Output Operating Time): Additional delay of the output medium used, for example, 1 ms with electronic relays

<sup>18</sup> Numerical Aperture (NA =  $\sin \theta$  [launch angle])

Interface design	Corresponds to IEEE 802.3, 100Base-FX
Laser class 1 as per EN 60825-1/-2	With the use of 62.5 $\mu\text{m}$ /125 $\mu\text{m}$ and 50 $\mu\text{m}$ /125 $\mu\text{m}$ optical fibers

The integrated optical Ethernet interface offers the possibility of replacing the SFP modules (Small Form-Factor Pluggable) delivered as standard with electrical SFPs that can be separately ordered.

### Indication of Conformity



This product complies with the directive of the Council of the European Communities on harmonization of the laws of the Member States concerning electromagnetic compatibility (EMC Directive 2014/30/EU), restriction on usage of hazardous substances in electrical and electronic equipment (RoHS Directive 2011/65/EU), and electrical equipment for use within specified voltage limits (Low Voltage Directive 2014/35/EU).

This conformity has been proved by tests performed according to the Council Directive in accordance with the product standard EN 60255-26 (for EMC directive), the standard EN IEC 63000 (for RoHS directive), and with the product standard EN 60255-27 (for Low Voltage Directive) by Siemens.

The device is designed and manufactured for application in an industrial environment.

The product conforms with the international standards of IEC 60255 and the German standard VDE 0435.

5.7

### Disclaimer of Liability

Subject to changes and errors. The information given in this document only contains general descriptions and/or performance features which may not always specifically reflect those described, or which may undergo modification in the course of further development of the products. The requested performance features are binding only when they are expressly agreed upon in the concluded contract.

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