SIPROTEC 5 Devices and Fields of Application

Generator Protection – SIPROTEC 7UM85

Description

The generator protection device SIPROTEC 7UM85 has been designed specifically for the protection of generators and power units. It contains all necessary main protection functions and a large number of other protection and monitoring functions. With its modular structure, flexibility, and the high-performance DIGSI 5 engineering tool, SIPROTEC 7UM85 offers future-oriented solutions for protection, control, automation, monitoring, and Power Quality – Basic.

For motors in explosive environments, the SIPROTEC 7UM85 is also available with EN 60079-14 or VDE 0165, Part 1, ATEX (Verband der Elektrotechnik, Elektronik und Information-stechnik) certification.

Main function	Typical generator protection functions
Inputs and outputs	5 predefined standard variants with up to 16 current transformers and 8 voltage transformers, 7 to 15 binary inputs, 9 to 20 binary outputs
	4 fast measuring transducer inputs (10 V or 20 mA)
Hardware flexibility	Flexibly adjustable and expandable I/O quantity structure within the scope of the modular SIPROTEC 5 system; 1/6 expansion modules can be added, available with large or small display, or without display
Housing width	1/3 × 19 inches to 2 × 19 inches

Benefits

- Safe and reliable automation and control of your systems
- Purposeful and easy handling of devices and software thanks to a user-friendly design
- Cybersecurity in accordance with NERC CIP and BDEW White-paper requirements
- Highest availability even under extreme environmental conditions by standard coating of the populated printed circuit boards

Functions

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

- Short-circuit protection (overcurrent protection, impedance protection, differential protection)
- Stator ground-fault protection (90 % non-directional or directional, 100 % with 3rd harmonic, real 100 % protection with 20-Hz voltage interference)
- Rotor ground-fault protection with different measuring methods (ground-current or ground-resistance monitoring)
- High-precision reverse-power protection and universal power protection
- Underexcitation and overexcitation protection
- Unbalanced-load protection
- Overload protection and temperature supervision via external RTD unit (with PT 100, for example)
- Out-of-step protection

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Figure 2.13/2   SIPROTEC 7UM85 Generator Protection (Width: 1/3 x 19" to 2 x 19")

- Rotor and stator overload protection with cold-gas consideration (coolant temperature)
- Power-plant disconnection protection
- Shaft-current protection (in particular with hydropower applications)
- Universal overvoltage and undervoltage protection with different measuring methods
- Overfrequency and underfrequency protection, frequency change protection, and supervision of duration time in frequency bands as turbine protection (protection against abnormal frequencies)
- Protection functions for network decoupling (voltage and frequency protection, directional reactive-power undervoltage protection (QU protection), and vector-jump protection)
- Inadvertent energization protection to detect incorrect activation of the circuit breaker
- Circuit-breaker failure protection (CBFP)
- Circuit-breaker reignition monitoring
- Single-channel parallel connection function (synchronization) with adjustment commands for speed (frequency) and voltage
- Graphical logic editor to create high-performance automation functions in the device
- Fixed integrated electrical Ethernet RJ45 interface for DIGSI 5 and IEC 61850 (reporting and GOOSE)
- Optional, pluggable communication modules, usable for different and redundant protocols (IEC 61850-8-1, IEC 61850-9-2 Client, IEC 60870-5-103, IEC 60870-5-104, Modbus TCP, DNP3 serial and TCP, PROFINET IO, PROFINET IO S2 redundancy)
- Virtual network partitioning (IEEE 802.1Q - VLAN)

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- Secure serial protection communication, also over great distances and all available physical media (optical fiber, two-wire connections, and communication networks)

- PQ – Basic: Voltage unbalance; voltage changes: overvoltage, dip, interruption; TDD, THD, and harmonics

- Reliable data transmission via PRP and HSR redundancy protocols

- Certification for use in environments at risk of explosion (EN 60079-14 or VDE 0165, Part 1, ATEX)

- Extensive cybersecurity functionality, such as role-based access control (RBAC), logging of security-related events, signed firmware, or authenticated IEEE 802.1X network access.

- Simple, fast, and secure access to the device via a standard Web browser to display all information and diagnostic data, vector diagrams, single-line and device display pages

- Phasor Measurement Unit (PMU) for synchrophasor measured values and IEEE C37.118 protocol

- Time synchronization using IEEE 1588

- Detecting operational measured variables and protection-function measured values to evaluate the system, to support commissioning, and to analyze faults

- Frequency tracked protection functions over a wide frequency range (10 Hz to 80 Hz) and the option to assign the protection functions in a single device to different **frequency tracking groups**.

- High-performance fault recording (buffer for a max. record time of 80 s at 8 kHz or 320 s at 2 kHz)

- Auxiliary functions for simple tests and commissioning

- Flexibly adjustable I/O quantity structure within the scope of the SIPROTEC 5 modular system

Applications

- Protection of generators in busbar connection of different power, with directional stator ground-fault protection.

- Protection of generators in unit connection of different power (using the 100 % stator ground fault (20 Hz) with larger generators)

- Protection of power units with one device per protection group. In the generator transformer variant, the 7UM85 implements both generator and transformer protection.

- In more complex power units (unit connection with generator circuit breaker and several auxiliary transformers), additional SIPROTEC 5 devices are used, for example, 7UT8x, 7SJ82, or 7SJ85 and 7SA, SD, SL86, at the upper-voltage side of the generator transformer.

- Using motor and generator protection functions (for example, underexcitation protection) to protect synchronous motors

- Detection and recording of power-quality data in the medium-voltage and subordinate low-voltage power system

Application Templates

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

The following application templates are available:

- *Generator basis*
  - Basic protection functions (overcurrent protection, stator ground-fault protection, reverse-power protection, overexcitation protection, voltage protection, frequency protection, and unbalanced-load protection),
  - Rotor ground-fault protection (ground-current measurement)

- *Generator bus connection basis*
  - Basic protection functions
  - Generator differential protection
  - Underexcitation protection

- *Generator unit connection basis*
  - Basic protection functions
  - Transformer differential protection as overall protection (transformer + generator)
  - Underexcitation protection
  - 100 % stator ground-fault protection with 3rd harmonic

- *Enhanced generator unit connection*
  - Basic protection functions
  - Transformer differential protection
  - Generator differential protection
  - Underexcitation protection
  - Out-of-step protection
  - 100 % stator ground-fault protection with 20-Hz coupling
  - Synchronization function (without adjusting commands)
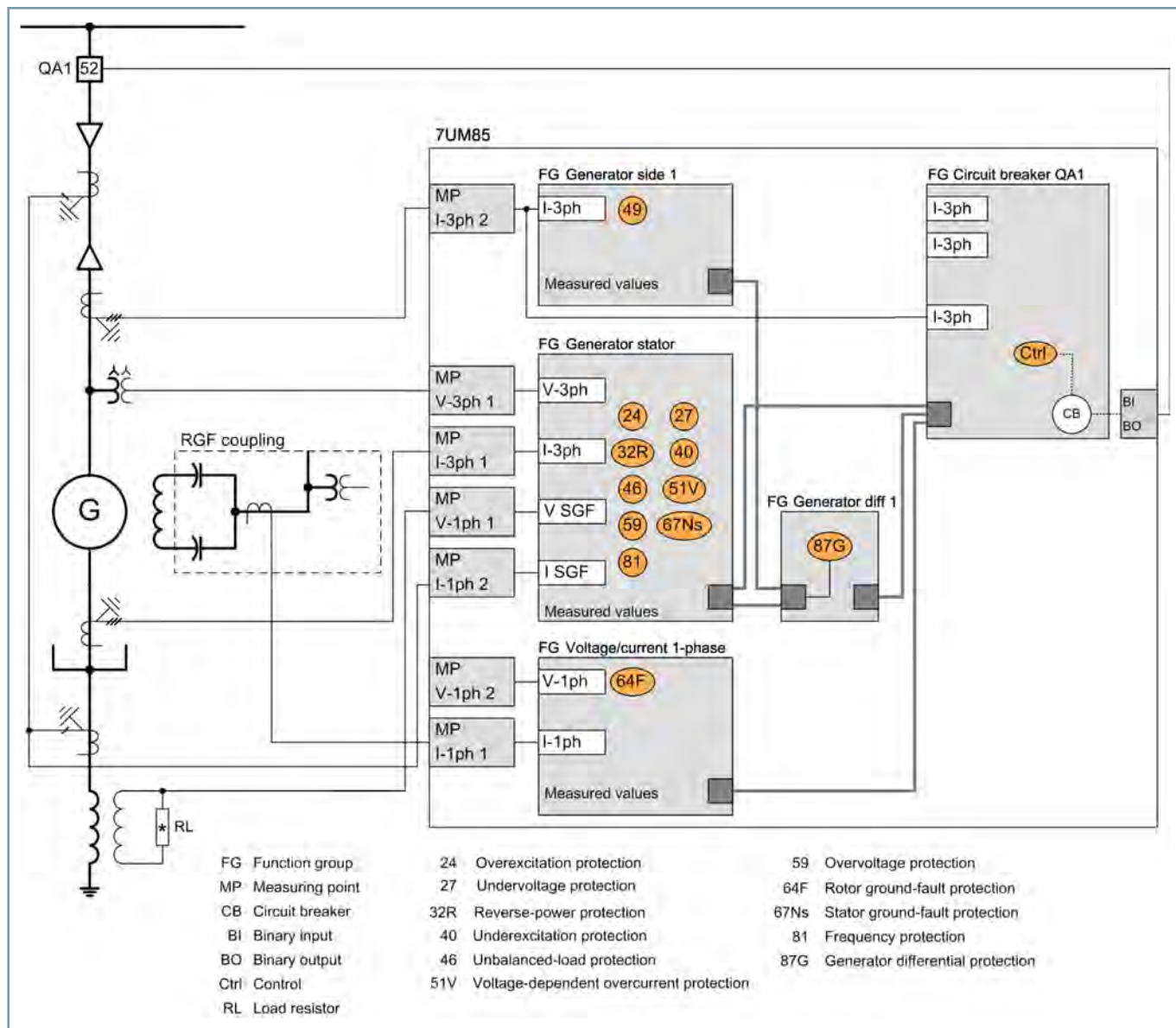 - Circuit-breaker failure protection

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Application Examples

SIPROTEC 7UM85 – Generator Protection in Bus Connection

(*Figure 2.13/3*) is based on the application template **Generator busbar connection, basis** and shows the single-line diagram, the connection to the 7UM85, and the logic structure in the device. The ground current for the stator ground-fault protection is generated via a neutral-point transformer. Sensitive ground-fault detection must be implemented via a different connection to the ground-current transformer (same transformation ratio). The rotor ground-fault protection is implemented as a power-frequency coupling and is based on the rotor ground-current measurement. 7XR61 + 3PP1336 must be provided as accessories. A base module and an expansion module (such as standard variant AA2 + IO201) are required as minimum device hardware.

The figure also shows the internal functional structure of the device. The measuring points are connected with the function groups. The function groups are also interconnected. Functions are routed to function groups and interconnected automatically. The **FG Generator stator** is the main function group. The differential protection requires additional function groups. The rotor ground-fault protection runs in the **FG VI 1ph**. The circuit-breaker function group controls the entire interaction with the circuit breaker. Additional functions, such as activating quick stop and actuating de-excitation, are activated via a direct routing of the tripping signal to the relay contacts. Alternatively, you may use additional circuit breaker FGs. All connections are preset in the application template. 100 function points are required for the application template. To use additional functions, the number of function points may need to be increased.

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| Abbr.	Description				
FG	Function group	24	Overexcitation protection	59	Overvoltage protection
MP	Measuring point	27	Undervoltage protection	64F	Rotor ground-fault protection
CB	Circuit breaker	32R	Reverse-power protection	67Ns	Stator ground-fault protection
BI	Binary input	40	Underexcitation protection	81	Frequency protection
BO	Binary output	46	Unbalanced-load protection	87G	Generator differential protection
Ctrl	Control	51V	Voltage-dependent overcurrent protection		
RL	Load resistor				

[dw_appl-02_legend, 2, en_US]

Figure 2.13/3   Generator Protection in a Bus Connection (Application Template: Generator Bus Connection Basis)

SIPROTEC 7UM85 – Generator Protection in Unit Connection
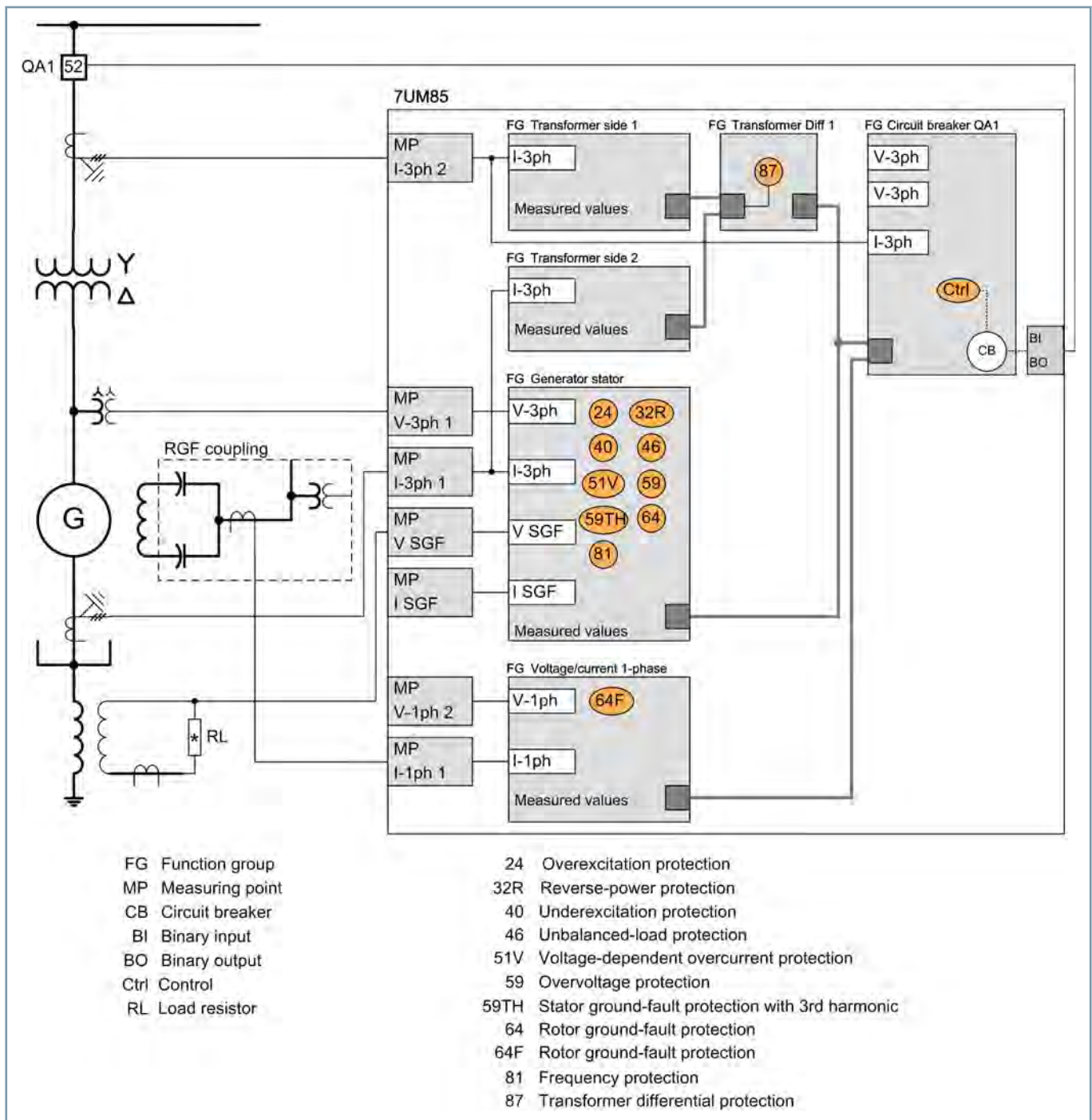
[dw_appl-03_legend, 2, en_US]

Figure 2.13/4   Generator Protection in Unit Connection (Application Template: Generator Unit Connection Basis)

Figure 2.13/4 shows the typical implementation of a plant for small to medium-sized generators (1 MVA to 50 MVA, for example) in unit connection. The generator feeds power into the power system via the generator step-up transformer. The figure shows the single-line diagram, the connection to the 7UM85, and the logic structure in the device. The protection range of the 90 % stator ground-fault protection is guaranteed by the neutral-point transformer with load resistor. The rotor ground-fault protection is implemented as a power-frequency coupling and is based on the rotor ground current measure-

ment. A 7XR61 + 3PP1336 must be provided as accessory. A base module and an expansion module (such as standard variant AA2 + IO201) are required as minimum device hardware. The example also shows the internal functional structure of the device. It is almost identical to the busbar version. The differential protection was changed. It is to protect the generator and the transformer. The transformer differential protection must therefore be used with the associated function groups.

All connections are preset in the application template. 125 function points are required for the application template. To use additional functions, the number of function points may need to be increased.
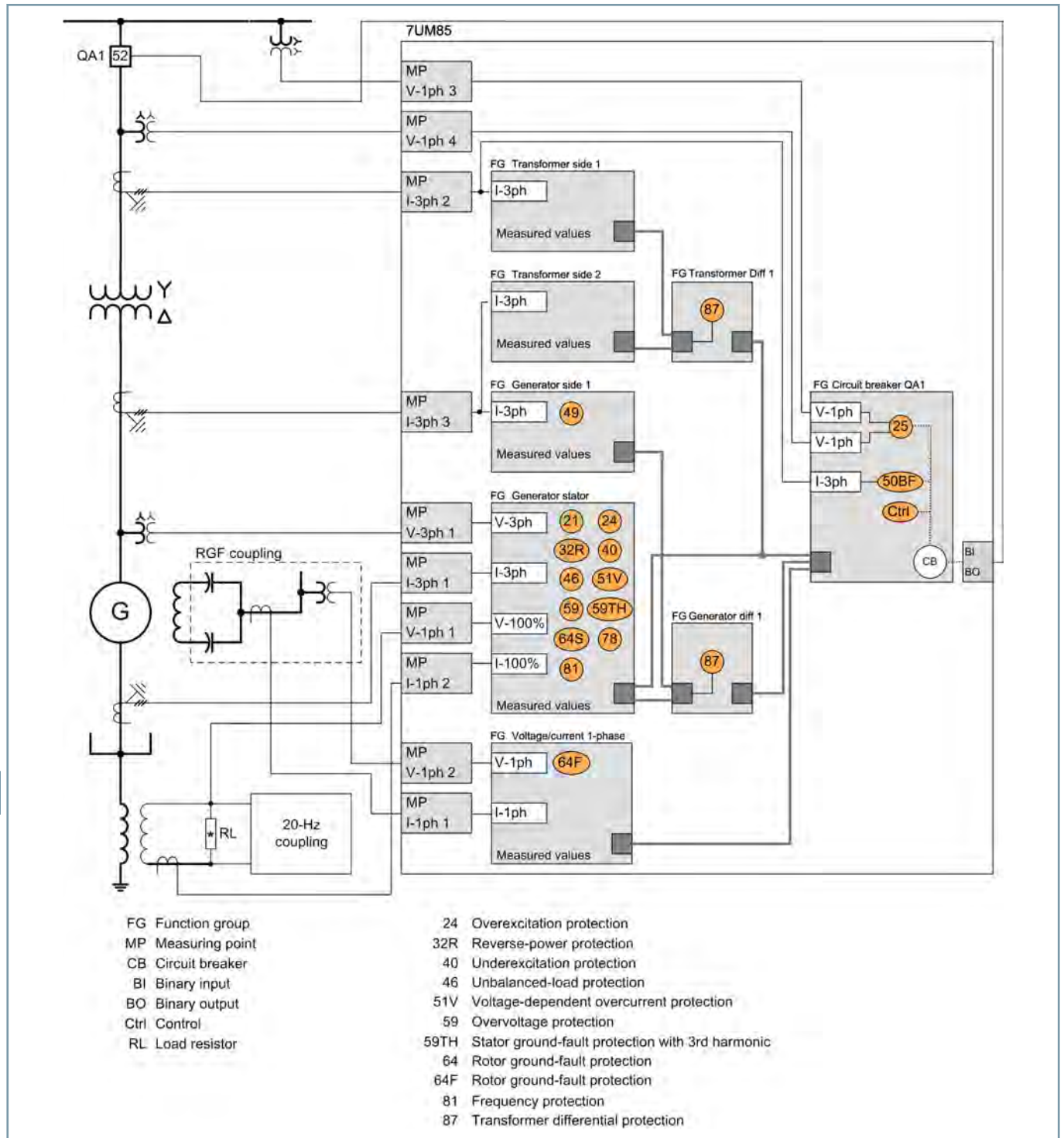
SIPROTEC 7UM85 – Protection of a Power Unit

Figure 2.13/5 shows a more complex version of a plant for medium-sized to large generators (for example, 20 MVA to 200 MVA) in unit connection. The auxiliary system is supplied via a separate infeed. This example is intended to demonstrate the performance of the system. An extension for plants with an auxiliary transformer is possible. If necessary, an additional transformer differential protection can be provided. The maximum number of differential protection functions is limited to 3. The example also shows the single-line diagram, the connection to the 7UM85, and the logic structure in the device.

The protection range of the 90 % stator ground-fault protection is guaranteed by the neutral-point transformer with load resistor. The 100 % stator ground fault with 20-Hz infeed is provided, in order to warrant 100 % protection range. This requires the accessories 7XT33 and 7XT34 and a miniature current transformer. The rotor ground-fault protection is implemented as a power-frequency coupling and is based on a resistance measurement. A 7XR61 + 3PP1336 must be provided as accessory. 1 base module and 2 expansion modules (such as standard variant AA3 + an additional IO201) are required as minimum device hardware. *Figure 2.13/5* also shows the internal functional structure of the device. To locate the faulty piece of equipment more rapidly, stand-alone differential protection is provided for the generator and for the transformer. This affects the function-group size and circuiting. In addition, the circuit-breaker failure protection and the synchronization function are provided in the **FG Circuit breaker**. A 1-channel parallel connection function (synchronization) with adjustment commands for speed (frequency) and voltage is available. The synchronization function can be used to release manual synchronization.

All connections are preset in the application template. 350 function points are required for the application template. To use additional functions, the number of function points may need to be increased.

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FG	Function group	24	Overexcitation protection
MP	Measuring point	32R	Reverse-power protection
CB	Circuit breaker	40	Underexcitation protection
BI	Binary input	46	Unbalanced-load protection
BO	Binary output	51V	Voltage-dependent overcurrent protection
Ctrl	Control	59	Overvoltage protection
RL	Load resistor	59TH	Stator ground-fault protection with 3rd harmonic
		64	Rotor ground-fault protection
		64F	Rotor ground-fault protection
		81	Frequency protection
		87	Transformer differential protection

[dw_appl_04_legend, 1, en_US]

Figure 2.13/5   Protection of a Power Unit (Application Template: Enhanced Generator Unit Connection)

ANSI	Function	Abbr.	Available	Application Templates				
				1	2	3	4	5
	Expandable hardware quantity structure	I/O	■					
	Process bus client protocol (hint: PB client requires a separate ETH-BD-2FO plug-in module, from V8.0)	PB client	■					
	IEC61850-9-2 Merging Unit Stream (hint: Each stream requires a separate ETH-BD-2FO plug-in module, from V8.0)	MU	■					
21T	Impedance protection for transformers	Z<	■				■	■
24	Overexcitation protection	V/f	■	■	■	■	■	■
25	Synchrocheck, synchronization function	Sync	■				■	
25	Synchronization function with adjusting commands	Sync	■					
27	Undervoltage protection: "3-phase" or "positive-sequence system V1" or "universal Vx"	V<	■	■	■			
27	Undervoltage protection: "3-phase" or "universal Vx"	V<	■					
27R, 59R	Voltage change protection (starting with V8.30)	dV/dt	■					
	Undervoltage-controlled reactive power protection	Q>/V<	■					
32, 37	Power protection active/reactive power	P<>, Q<>	■					
32R	Reverse-power protection	- P<	■	■	■	■	■	■
37	Undercurrent	I<	■					
37	Power-plant disconnection protection	-dP	■					
38	Temperature supervision	θ>	■					
40	Underexcitation protection	1/xd	■		■	■	■	■
46	Negative-sequence system overcurrent protection	I2>	■					
46	Unbalanced-load protection (thermal)	I2² t>	■	■	■	■	■	■
46	Negative-sequence system and overcurrent protection with direction	I2>, ∠(V2, I2)	■					
47	Overvoltage protection, negative-sequence system	V2>	■					
47	Overvoltage protection, negative-sequence system/positive-sequence system	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	■					
49H	Hotspot calculation	θh, I²t	■					
49R	Thermal overload protection, rotor (motor)	θR	■					
49F	Field-winding overload protection	IL² t	■					
49S CG	Stator overload protection with cold gas consideration	θ, I²t	■					
49R CG	Field-winding overload protection with cold gas consideration	θ, IL²t	■					
50/51 TD	Overcurrent protection, phases	I>	■					
	Instantaneous tripping at switch onto fault	SOTF	■					
50HS	Instantaneous high-current tripping	I>>>	■					
50/51 TD	Overcurrent protection with positive-sequence current I1 (from V7.9)	I1>	■					
50N/ 51N TD	Overcurrent protection, ground	IN>	■					
50N/ 51N TD	Overcurrent protection, 1-phase	IN>	■					

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Generator Protection – SIPROTEC 7UM85

ANSI	Function	Abbr.	Available	Application Templates				
				1	2	3	4	5
50 Ns/ 51Ns	Sensitive ground-fault detection for grounded arc suppression coils and isolated power systems including a) 3I0> b) admittance Y0>, c) 3I0-harm> (from V7.8)	INs>	■					
50 Ns/ 51Ns	Sensitive ground-current protection for power systems with resonant or isolated neutral	INs>	■					
	Intermittent ground-fault protection	IIE>	■					
50GN	Shaft-current protection	INs>	■					
50/27	Inadvertent energization protection (to halted generator)	I>, V< dropout	■					
50N DC, 27.59F DC	Direct current/direct-voltage protection	IDC<>, VDC <>	■					■
50	Startup overcurrent protection	I-Anf>	■					
50BF	Circuit-breaker failure protection, 3-pole	CBFP	■				■	■
50RS	Circuit breaker restrike monitoring	CBRM	■					
50L	Load-jam protection	I>L	■					
51V	Voltage-controlled overcurrent protection	t=f(I, V)	■	■	■	■	■	■
59, 59N	Overvoltage protection: "3-phase" or "zero-sequence system V0" or "positive-sequence system V1" or "universal Vx"	V>	■	■	■	■	■	■
59N, 67Ns	Stator ground-fault protection (non-directional, directional)	V0>, ∠(V0, I0)	■	■	■	■	■	■
27TH, 59TH, 59 THD	Stator ground-fault protection with 3rd harmonic	V03.H<, V03.H>; ΔV03.H	■			■		
59N IT	Turn-to-turn Fault Protection	V0>	■					
60	Voltage-comparison supervision	ΔV>	■					
64S	100 % stator ground-fault protection (20 Hz)	RSE<	■				■	■
64F, frated	Rotor ground-fault protection (IRE>, fn)	IRE>	■	■	■	■		
64F, frated	Rotor ground-fault protection (RE<, fn)	IRE<	■				■	
64F (1-3Hz)	Rotor ground-fault protection (1 - 3 Hz)	IRE<	■					■
66	Restart inhibit for motors	I²t	■					
67	Directional overcurrent protection, phases	I>, ∠(V, I)	■					
67N	Directional overcurrent protection, ground	IN>, ∠(V, I)	■					
67N	Directional ground-fault protection in grounded power systems	IN>, ∠(V, I)	■					
67 Ns	Sensitive ground-fault detection for grounded arc suppression coils and isolated power systems including a) 3I0> b) V0>, c) cos/sine Phi, d) transient ground fault, e) Phi(V, I), f) admittance		■					
	Directional tripping stage with one harmonic; hint: this stage also requires the function "67Ns sensitive ground-fault detection for grounded arc suppression coils and isolated power systems"	∠(V0h,I0h)	■					
	Directional Intermittent Ground-Fault Protection	IIEdir>	■					
68	Power-swing blocking	ΔZ/Δt	■					
74TC	Trip-circuit supervision		■	■	■	■	■	
78	Out-of-step protection	ΔZ/Δt	■				■	■
74CC	Single circuit monitoring (from V7.9)		■					
81	Frequency protection: "f>" or "f<" or "df/dt"	f<>; df/dt<>	■	■	■	■	■	■
81 AF	Abnormal frequency protection	fBand	■					
81U	Underfrequency load shedding	f<(ULS)	■					
	Vector-jump protection	Δφ>	■					
87B	Busbar differential protection for the 7UM85 (starting with V8.01)	ΔI	■					

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ANSI	Function	Abbr.	Available	Application Templates				
				1	2	3	4	5
	Bay		■					
86	Lockout		■	■	■	■	■	■
87T	Transformer Differential Protection	ΔI	■			■	■	
87N T	Restricted ground-fault protection	ΔIN	■					
87M	Differential motor protection	ΔI	■					
87G	Generator differential protection	ΔI	■		■		■	■
PMU	Synchrophasor measurement	PMU	■					
AFD	Arc protection (only with plug-in module ARC-CD-3FO)		■					
	Measured values, standard		■	■	■	■	■	■
	Measured values, extended: Min, max, average		■					
	Switching statistics counter		■	■	■	■	■	■
	PQ – Basic measured values: THD (Total Harmonic Distortion) and harmonic component (starting with V8.01) and THD voltage average values (starting with V8.40)		■					
	PQ – Basic measured values: Voltage unbalance (starting with V8.40)		■					
	PQ – Basic measured values: Voltage changes – monitoring of voltage dips, overvoltages and voltage interruptions (starting with V8.40)		■					
	PQ – Basic measured values: TDD - Total Demand Distortion (starting with V8.40)		■					
	CFC (standard, control)		■	■	■	■	■	■
	CFC arithmetic		■					
	Circuit-breaker wear monitoring	ΣIx, I²t, 2P	■					
	Switching sequence function		■					
	Inrush-current detection		■					
	External trip initiation		■					
	Control		■	■	■	■	■	■
PoW	Point-on-wave switching (starting with V7.90)	PoW	■					
	Circuit breaker		■	■	■	■	■	■
	Disconnector/grounding conductor		■					
	Fault recording of analog and binary signals		■	■	■	■	■	■
	Monitoring		■	■	■	■	■	■
	Protection interface, serial		■					
	Frequency group tracking (from V7.8)		■					
	Cyber security: Role-Based Access Control (from V7.8)		■					
	Temperature recording via communication protocol		■					
	Cyber security: Authenticated network access using IEEE 802.1X (starting from V8.3)		■					
	Transformer side 7UM85		■					
Function point class:				0	100	125	350	275
The configuration and function point class for your application can be determined in the SIPROTEC 5 order configurator at www.siemens.com/siprotec.								

Table 2.13/1   SIPROTEC 7UM85 – Functions, Application Templates

(1) Generator basis

(2) Generator bus connection

(3) Generator unit connection basis

(4) Enhanced generator unit connection

(5) Large generator

Generator Protection – SIPROTEC 7UM85

Standard Variants for SIPROTEC 7UM85		
AA1	1/3, 11 BI, 9 BO, 4 V, 4 I,	
	Housing width 1/3 x 19"	
	11 binary inputs	
	9 binary outputs (1 life contact, 2 standard, 6 fast)	
	4 voltage-transformer inputs	
	3 current-transformer inputs	
	1 sensitive ground-current input	
	Contains the following modules: base module with PS201 and IO202	
AA2	1/3, 7 BI, 14 BO, 4 V, 4 I,	
	Housing width 1/2 x 19"	
	7 binary inputs	
	14 binary outputs (1 life contact, 5 standard, 8 fast)	
	4 voltage-transformer inputs	
	3 current-transformer inputs	
	1 sensitive ground-current input	
	Contains the following modules: base module with PS201 and IO208	
AA3	1/2, 15 BI, 20 BO, 8 V, 8 I,	
	Housing width 1/2 x 19"	
	15 binary inputs	
	20 binary outputs (1 life contact, 7 standard, 12 fast),	
	8 voltage-transformer inputs	
	6 current-transformer inputs	
	2 sensitive ground-current inputs	
	Contains the following modules: base module with PS201 and IO208	
	Expansion module IO202	
AA4	1/2, 11 BI, 16 BO, 7 V, 8 I, 4 MU	
	Housing width 1/2 x 19"	
	11 binary inputs	
	16 binary outputs (1 life contact, 5 standard, 10 fast),	
	7 voltage-transformer inputs	
	6 current-transformer inputs	
	2 sensitive ground-current inputs	
	4 fast measuring-transducer inputs (alternatively 20 mA, 10 V)	
	Contains the following modules: base module with PS201 and IO202	
	Expansion module IO210	
AA5	2/3, 15 BI, 20 BO, 7 V, 16 I, 4 MU	
	Housing width 1/2 x 19"	
	15 binary inputs	
	20 binary outputs (1 life contact, 5 standard, 14 fast)	
	7 voltage-transformer inputs	
	14 current-transformer inputs	
	2 sensitive ground-current inputs	
	4 fast measuring-transducer inputs (alternatively 20 mA, 10 V)	
	Contains the following modules: base module with PS201 and IO202	
	Expansion modules IO210 and IO203	

Table 2.13/2 Standard Variants for SIPROTEC 7UM85

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

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