Description

The SIPROTEC 7UT87 transformer differential protection has been designed specifically for the protection of multi-winding transformers (up to 5 sides). Furthermore, it is to be used where numerous measuring points (up to 11 3-phase current measuring points) are required. Another application is simultaneous protection of 2 parallel transformers (additional fast backup protection). The SIPROTEC 7UT87 is the main protection for the transformer and contains many other protection and monitoring functions. The additional protection functions can also be used as backup protection for subsequent protected objects (such as short cables and lines, reactance coil (shunt reactors)). With its modular structure, flexibility, and the high-performance DIGSI 5 engineering tool, SIPROTEC 7UT87 offers future-oriented solutions for protection, control, automation, monitoring, and Power Quality – Basic.

Main function	Up to 3 differential protection functions with additional stabilization (in different transformer function groups); up to 5 restricted ground-fault protection functions.
	For auto transformer applications, 2 differential protection functions can be processed in an Auto transformer function group.
	Interoperability of SIPROTEC 4 and SIPROTEC 5 line protection devices when using the line differential protection function in the 7UT85, 86, 87
Usable measuring points	11 x 3-phase current measuring points, 11 x 1-phase current measuring points, 11 x 3-phase and 11 x 1-phase voltage measuring points
Inputs and outputs	2 predefined standard variants with 20 current transformers, 4 voltage transformers, 15 to 27 binary inputs, 22 to 38 binary outputs
Hardware flexibility	Flexibly adjustable and expandable I/O quantity structure within the scope of the SIPROTEC 5 modular system.
Housing width	2/3 × 19 inches to 2/1 × 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 modules
- Full compatibility between IEC 61850 Editions 1, 2.0, and 2.1

Functions

DIGSI 5 permits all functions to be configured and combined as required and as per the functional scope that has been ordered. In SIPROTEC 7UT87, 2 transformer function groups can be used.

[SIP5_GD_SS_LED_W3, 2, --_--]

Figure 2.11/12   SIPROTEC 7UT87 Transformer Differential Protection (2/3 Device = Standard Variant Q1)

- Transformer differential protection for multi-winding transformers with versatile, additional protection functions (multi-winding transformers are typical in power-converter applications (such as HVDC))
- Transformer differential protection for phase-angle regulating transformers of the single-core and 2-core types, and special transformers
- Transformer-protection applications with up to 11 3-phase current measuring points
- Simultaneous differential protection for 3 parallel transformers (such as 3 two-winding transformers)
- Universal usability of the permissible measuring points
- Applicable from average up to extra-high voltage
- Protection of standard power transformers, auto transformers, short lines, cables, shunt reactor, and motors
- Typical properties of a transformer differential protection such as flexible adaptation to the transformer vector group, control of inrush and overexcitation processes, safe behavior in case of current-transformer saturation with different degrees of saturation
- Fault locator plus for accurate fault location with inhomogeneous line sections and targeted automatic overhead-line section reclosing (AREC)
- Arc protection
- Voltage-controller function ANSI 90V for two-winding transformers, three-winding transformers, and grid coupling transformers with parallel control (master/follower, circulating reactive current minimization)
- Adaptive adaptation of the operate curve to the transformer tap position
- Increased sensitivity with ground faults near the neutral point through a separate restricted ground-fault protection
- Point-on-wave switching

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- Additional current and voltage inputs can be added for standard protection functions, such as overcurrent, voltage, frequency, protection etc.

- Dynamic voltage control (DSR) for adaptation of the voltage set point value using a characteristic curve that depends on the power direction with a large infeed of renewable energies.

- Graphical logic editor to create high-performance automation functions in the device

- Up to 4 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)

- Reliable data transmission via PRP and HSR redundancy protocols

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

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

- 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, interruptions; TDD, THD, and harmonics

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

- Frequency tracked protection functions over a wide frequency range (10 Hz to 90 Hz) and the option to assign the protection functions in a single device to different **frequency tracking groups**.

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

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

- Auxiliary functions for simple tests and commissioning

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

Applications

- Protection of special transformers (phase shifters, FACTS and converter transformers, electric arc furnace transformers, HVDC transformers)

- As backup protection for motor and generator differential protection applications

- For the protection of short cables and lines

- Voltage control for two-winding and three-winding transformers with parallel control

- As additional line protection function such as distance and line differential protection
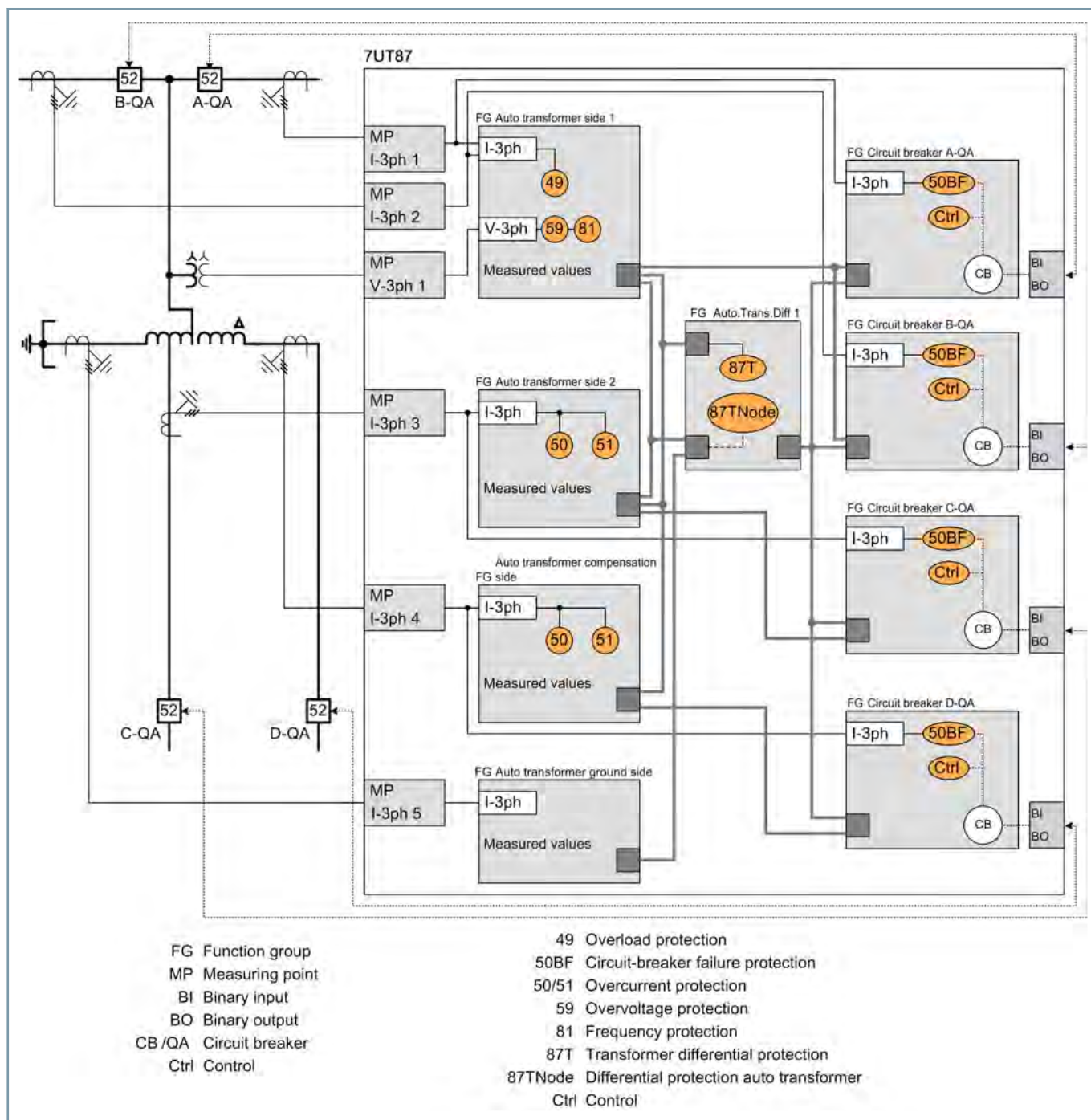
Application Templates

Application templates are available in DIGSI 5 for the applications of the device 7UT87. The application templates contain the basic configurations, required functions, and default settings. All application templates, which were described for the devices 7UT82, 7UT85, and 7UT86, can be implemented in 7UT87.

Application Examples

- Auto transformer with stabilizing winding in a breaker-and-a-half layout (*Figure 2.11/13*)

- Possible application of SIPROTEC 7UT87 in a power plant (up to 7 3-phase current measuring points) (*Figure 2.11/14*)

- Protection of 2 parallel transformers with one SIPROTEC 7UT87 (*Figure 2.11/15*)

- Protection of an inverter transformer (*Figure 2.11/16*)

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[dw_autotrans, 2, en_US]

Figure 2.11/13   Application Example: Protection of an Auto Transformer with Stabilizing Winding in Breaker-and-a-Half Layout

the *Figure 2.11/13* shows the template for the protection of an auto transformer that is connected to a breaker-and-a-half layout. The special feature of this application is that the current on the neutral-point side is directly recorded per phase. A separate nodal-point differential protection via the auto winding reliably records ground faults and turn-to-turn faults. The classic differential protection is assigned over the entire transformer (auto and stabilizing winding). Both functions run in the Auto

transformer function group. This type of execution gives you a redundant differential protection with supplementing responsivity. A separate restricted ground-fault protection is not required. In addition, a voltage transformer is available on the upper-voltage side. Here, for example, voltage and frequency limits can be monitored. The required protection settings are made as required by the system.
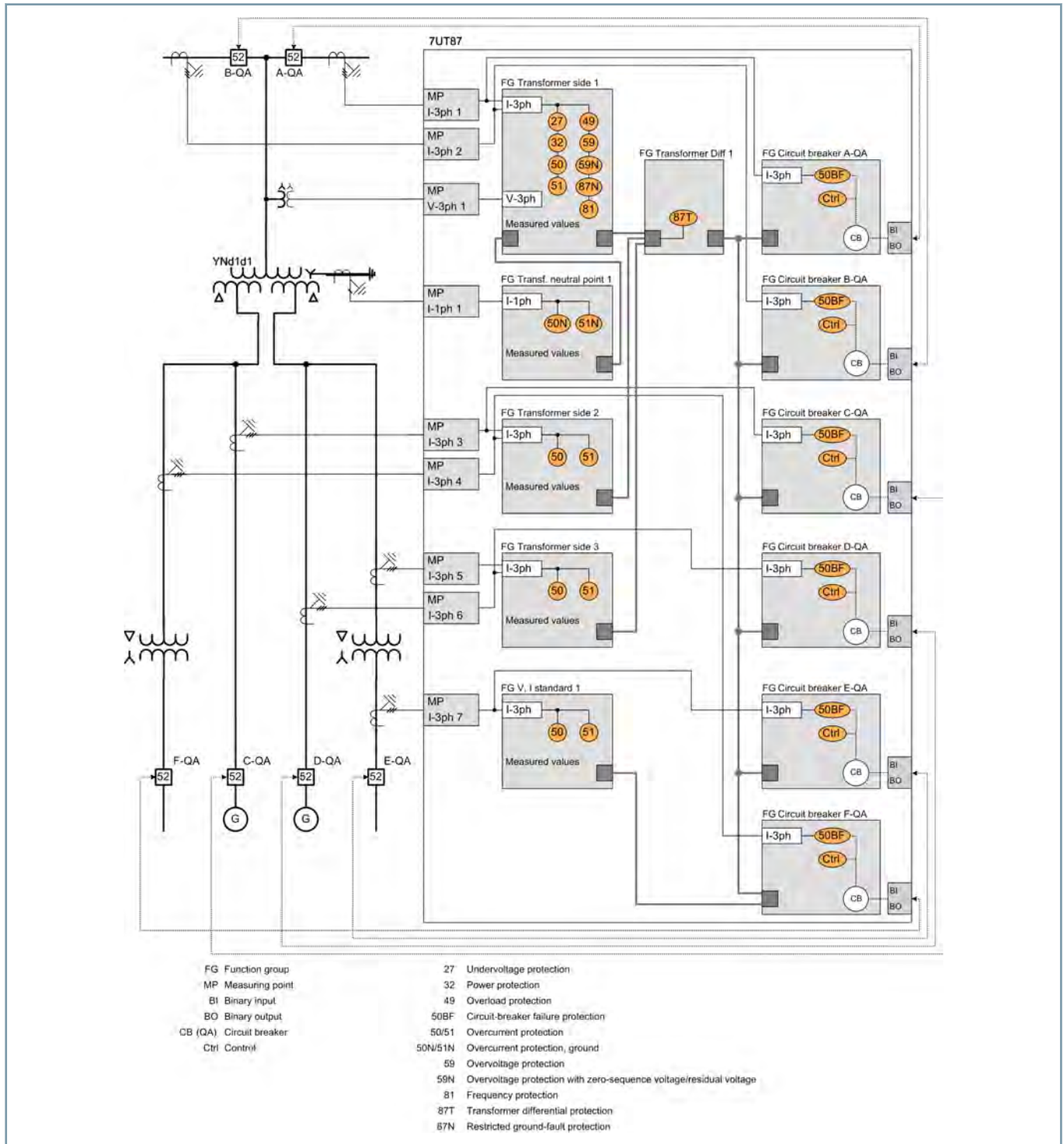
Transformer Differential Protection – SIPROTEC 7UT87

Since the SIPROTEC 7UT87 is intended to be used for special applications, you must create your own application template as a function of the application. Save this template with the device. To ease your work, you can use an available template and modify it as required. The following examples may help you:

Example 1:

This example requires a large number of 3-phase current measuring points for a complex application in the power-plant area. *Figure 2.11/14* shows a possible configuration.

[dw_7-messstellen, 2, en_US]

Figure 2.11/14   Possible Application of SIPROTEC 7UT87 in a Power Plant (up to Seven 3-Phase Current Measuring Points)
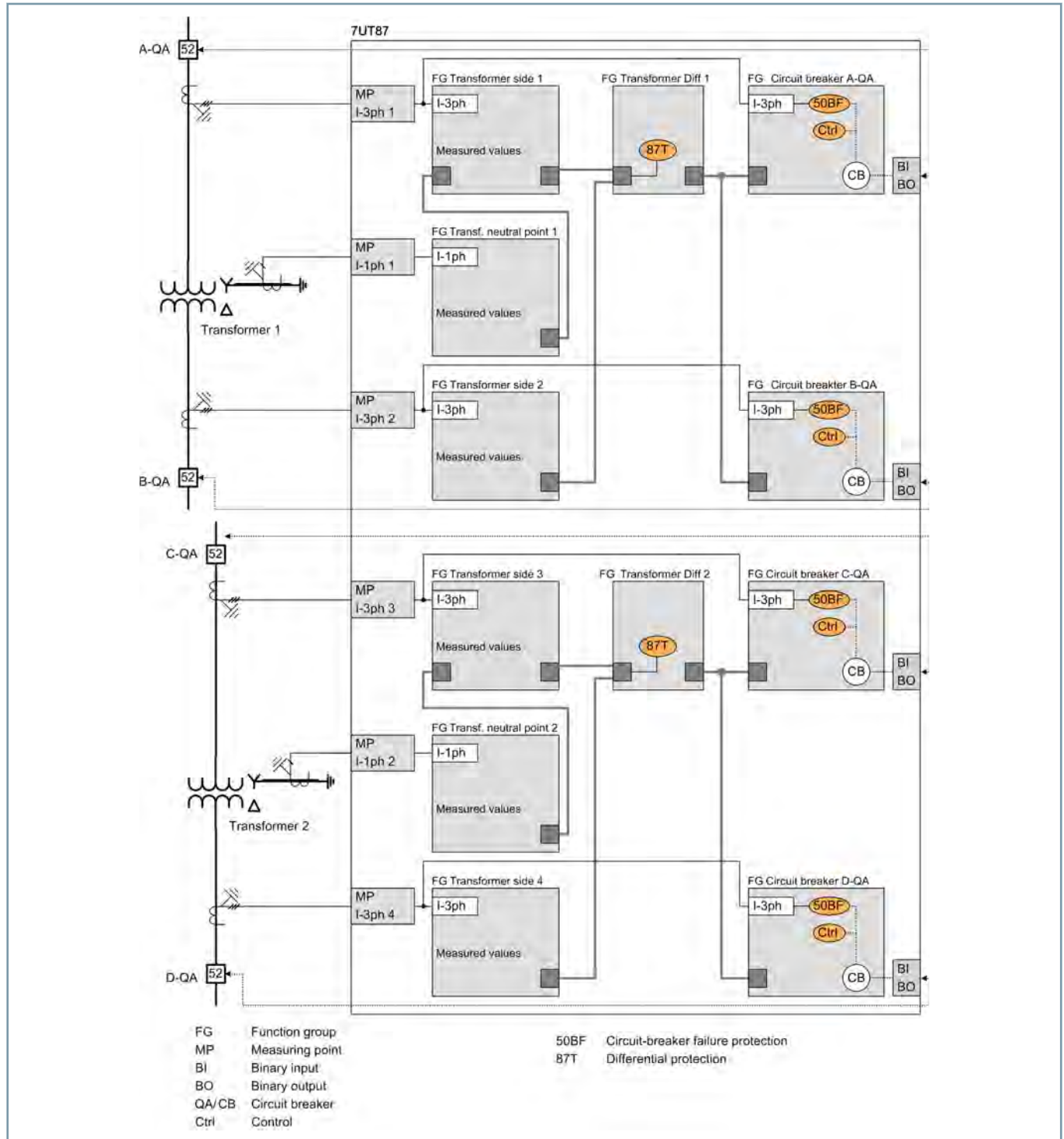
Example 2:

Another example (*Figure 2.11/15*) is a powerful functional redundancy with parallel transformers. The differential protection function is doubled. 1 protection device is used for each transformer. 2 differential protection functions run in each

protection device. The 2nd differential protection function is the backup protection for the parallel transformer. For example, start with an application template of the two-winding transformer and duplicate it. An alternative cost-optimized variant is the use of one device to protect both transformers.
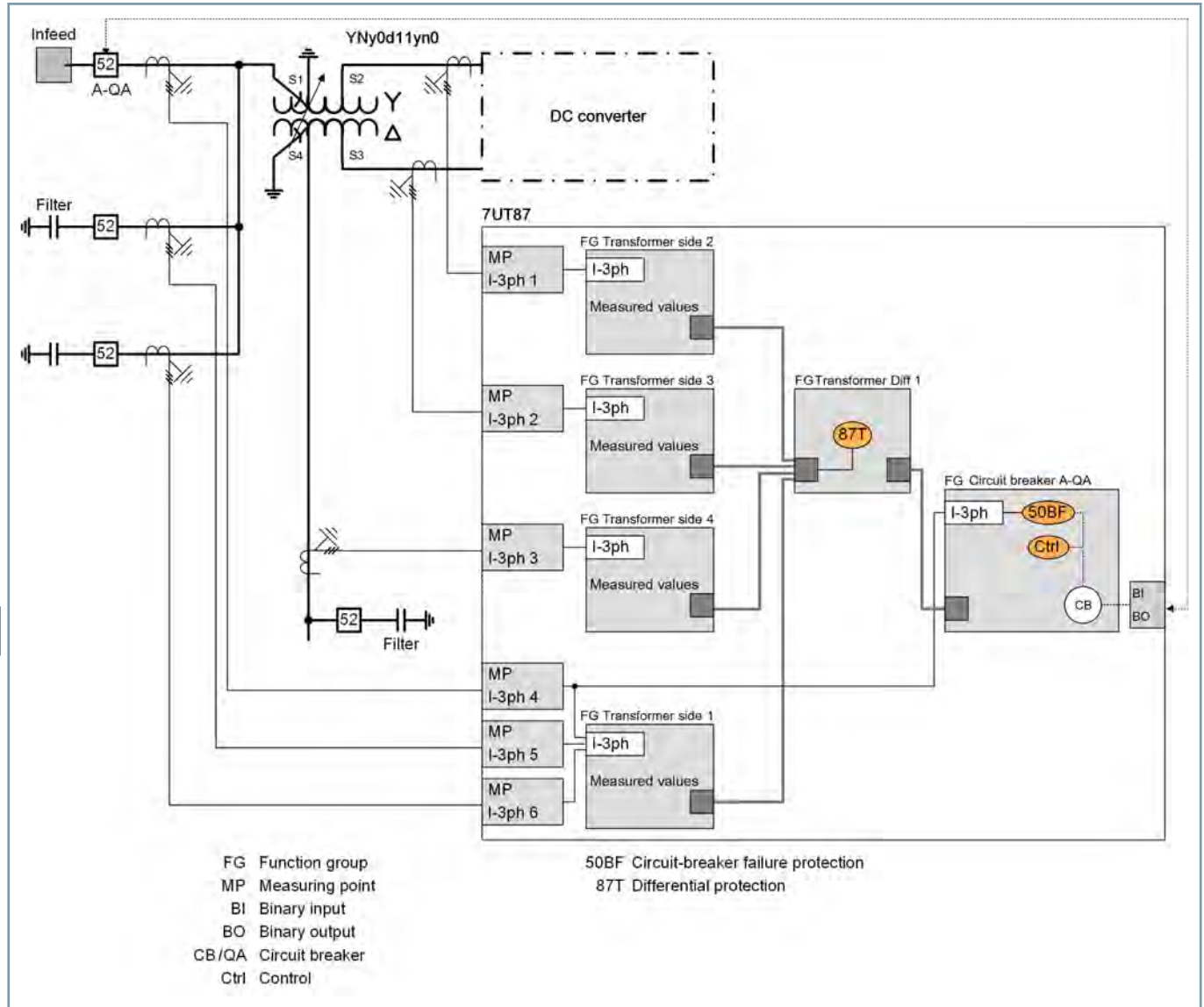

[dw_two-transformer, 2, en_US]

Figure 2.11/15   Protection of Two Parallel Transformers with One SIPROTEC 7UT87

Example 3:

The last example (_Figure 2.11/16_) shows the protection of an inverter transformer. 4 sides and 6 measuring points are required here.

[dw_umrichter-transf, 3, en_US]

Figure 2.11/16   Protection of an Inverter Transformer

ANSI	Function	Abbr.	Available	Application Templates								
				1	2	3	4	5	6	7	8	9
	Expandable hardware quantity structure	I/O	■									
	Process bus client protocol (hint: PB client requires a separate ETH-BD-2FO plug-in module, from V8.0)	PB client	■									
	IEC61850-9-2 Merging Unit Stream (hint: Each stream requires a separate ETH-BD-2FO plug-in module, from V8.0)	MU	■									
	IEC61850-9-2 Merging Unit Stream 7SS85 CU (hint: Only for communication with a 7SS85 CU. A separate ETH-BD-2FO plug-in module is required starting with V8.40)	MU	■									
21/21N	Distance Protection	Z<, V< /I>/∠(V, I)	■							■		
21T	Impedance protection for transformers	Z<	■									
24	Overexcitation protection	V/f	■									
25	Synchrocheck, synchronization function	Sync	■									
27	Undervoltage protection: "3-phase" or "positive-sequence system V1" or "universal Vx"	V<	■									
27R, 59R	Voltage change protection (starting with V8.30)	dV/dt	■									
	Undervoltage-controlled reactive power protection	Q>/V<	■									
32, 37	Power protection active/reactive power	P<>, Q<>	■									
32R	Reverse-power protection	- P<	■									
37	Undercurrent	I<	■									
37	Power-plant disconnection protection	-dP	■									
38	Temperature supervision	θ>	■									
46	Negative-sequence system overcurrent protection	I2>	■									
46	Unbalanced-load protection (thermal)	I2² t>	■									
47	Overvoltage protection, negative-sequence system	V2>	■									
47	Overvoltage protection, negative-sequence system/positive-sequence system	V2/V1>	■									
49	Thermal overload protection	θ, I²t	■	■	■	■	■		■	■	■	■
49	Thermal overload protection, user-defined characteristic curve	θ, I²t	■									
49H	Hotspot calculation	θh, I²t	■									
50/51 TD	Overcurrent protection, phases	I>	■	■	■	■	■		■	■	■	■
	Instantaneous tripping at switch onto fault	SOTF	■									
50HS	Instantaneous high-current tripping	I>>>	■									
50/51 TD	Overcurrent protection with positive-sequence current I1 (from V7.9)	I1>	■									
50N/ 51N TD	Overcurrent protection, ground	IN>	■		■							
50N/ 51N TD	Overcurrent protection, 1-phase	IN>	■			■			■	■	■	
50 Ns/ 51Ns	Sensitive ground-fault detection for grounded arc suppression coils and isolated power systems including a) 3I0> b) admittance Y0>, c) 3I0-harm> (from V7.8)	INs>	■									
	Sensitive ground-fault detection via pulse detection; hint: this stage also requires the function 50Ns/51Ns or 67Ns "sensitive ground-fault detection for grounded arc suppression coils and isolated power systems"	IN pulse	■									
	Intermittent ground-fault protection	IIE>	■									
50BF	Circuit-breaker failure protection, 3-pole	CBFP	■		■	■	■		■	■	■	■

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Transformer Differential Protection – SIPROTEC 7UT87

ANSI	Function	Abbr.	Available	Application Templates								
				1	2	3	4	5	6	7	8	9
50EF	End-fault protection (hint: For use only in decentralized busbar protection with a 7SS85 CU starting with V8.40)		■									
50RS	Circuit breaker restrike monitoring	CBRM	■									
51V	Voltage-controlled overcurrent protection	t=f(I, V)	■									
59, 59N	Overvoltage protection: "3-phase" or "zero-sequence system V0" or "positive-sequence system V1" or "universal Vx"	V>	■				■		■	■		■
59	Overvoltage protection: "3-phase" or "positive-sequence system V1" or "universal Vx"	V>	■									
60	Voltage-comparison supervision	ΔV>	■									
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		■	■	■	■	■	■	■	■	■	■
74CC	Single circuit monitoring (from V7.9)		■									
79	Automatic reclosing, 3-pole	AREC	■									
81	Frequency protection: "f>" or "f<" or "df/dt"	f<>; df/dt<>	■						■	■		■
81 AF	Abnormal frequency protection	fBand	■									
81U	Underfrequency load shedding	f<(ULS)	■									
	Vector-jump protection	Δφ>	■									
85/21	Teleprotection scheme for distance protection		■									
85/27	Weak or no infeed: Echo and tripping		■									
85/67N	Teleprotection scheme for directional ground-fault protection		■									
86	Lockout		■	■	■	■	■	■	■	■	■	■
87T	Transformer Differential Protection	ΔI	■	■	■	■	■	■	■	■	■	■
87T	Differential protection for special transformers	ΔI	■									
87T Node	Differential protection (nodal point protection for auto transformer)	ΔI nodes	■									■
87T	Differential protection for phase-angle regulating transformers (single core)	ΔI	■									
87T	Differential protection for phase-angle regulating transformers (two core)	ΔI	■									
87N T	Restricted ground-fault protection	ΔIN	■		■	■			■	■	■	
87M	Differential motor protection	ΔI	■									
87G	Generator differential protection	ΔI	■									
87L	Line differential protection for 2 line ends for 7UT8 (communication with 7SD82, 85, 86, 7SL86, 87)	ΔI	■									
	Option for line differential protection with charging-current compensation	ΔI	■									
87 STUB	Stub fault differential protection (for breaker-and-a-half layouts)		■									
90 V	Voltage controller for two-winding transformer		■				■					

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ANSI	Function	Abbr.	Available	1	2	3	4	5	6	7	8	9
							Application Templates					
90 V	Voltage controller for two-winding transformer with parallel control		■									
	Number of two-winding transformers with parallel control (hint: only together with the function "voltage controller for two-winding transformer with parallel control")		■									
90 V	Voltage controller for three-winding transformer		■									
90 V	Voltage controller for grid coupling transformer		■									
FL	Fault Locator, single-side	FL-one	■									
FL	Fault Locator Plus (from V7.9)	FL plus	■									
PMU	Synchrophasor measurement	PMU	■									
AFD	Arc protection (only with plug-in module ARC-CD-3FO)		■									
	Measured values, standard		■	■	■	■	■	■	■	■	■	■
	Measured values, extended: Min, max, average		■									
	Switching statistics counter		■				■					
	PQ – Basic measured values: THD (Total Harmonic Distortion) and harmonic component (starting with V8.01) and THD voltage average values (starting with V8.40)		■									
	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		■									
	Transformer side 7UT87		■									
	Cyber security: Authenticated network access using IEEE 802.1X (starting from V8.3)		■									
Function point class:				0	30	30	175	0	50	150	30	30

The configuration and function point class for your application can be determined in the SIPROTEC 5 order configurator at www.siemens.com/siprotec.

Table 2.11/8   SIPROTEC 7UT87 – Functions, Application Templates

(1)   2-Winding Transformer Base (DIFF protection)

(2)   2-Winding Transformer (DIFF protection, SVS, REF)

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(3) 2-Winding Transformer 1.5 CB (DIFF protection, SVS, REF)

(4) 2-Winding Transformer (DIFF. Protection, Voltage Controller)

(5) 3-winding transformer Base (DIFF protection)

(6) 3-winding transformer 1.5 CB (DIFF protection, SVS, REF)

(7) 3-winding transformer (DIFF protection, SVS, REF, DIS)

(8) Auto transformer (DIFF protection, SVS, REF)

(9) Auto transformer, 1.5 CB (2 DIFF protection, SVS, voltage protection, frequency protection)

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Standard Variants for SIPROTEC 7UT87		
Q1	2/3, 15 BI, 22 BO, 20 I, 4 V	
	Housing width 2/3 × 19",	
	15 binary inputs,	
	22 binary outputs (1 life contact, 5 standard, 16 fast)	
	20 current transformers	
	4 voltage transformers	
	Contains the following modules: Base module with PS201 and IO203	
	Expansion modules IO208 and IO203.	
Q2	5/6, 27 BI, 38 BO, 20 I, 4 V	
	Housing width 5/6 × 19",	
	27 binary inputs,	
	38 binary outputs (1 life contact, 21 standard, 16 fast)	
	20 current transformers	
	4 voltage transformers	
	Contains the following modules: Base module with PS201 and IO203	
	Expansion modules IO208, IO203, and IO205.	

Table 2.11/9   Standard Variants for Transformer Differential Protection Devices

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

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