

Description

The SIPROTEC 7UT86 transformer differential protection has been designed specifically for the protection of three-winding transformers (3 sides). It is the main protection for the transformer and contains many other protection and monitoring functions. The additional protection functions can also be used as backup protection for subsequent protected objects (such as short cables and lines, reactance coil (shunt reactors)). The modular expandability of the hardware also supports you in this process. The device supports all SIPROTEC 5 system characteristics. With its modular structure, flexibility, and the high-performance DIGSI 5 engineering tool, SIPROTEC 7UT86 offers future-oriented solutions for protection, control, automation, monitoring, and Power Quality – Basic.

Main function	1 differential protection function (standard) with additional stabilization; up to 3 restricted ground-fault protection functions For auto transformer applications, 2 differential protection functions can be processed in an auto transformer function group. 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	7 x 3-phase current measuring points, 7 x 1-phase current measuring points, 7 x 3-phase and 7 x 1-phase voltage measuring points; expandable to 4 sides
Inputs and outputs	2 predefined standard variants with 12 current transformers, 4 voltage transformers, 11 to 23 binary inputs, 18 to 34 binary outputs
Hardware flexibility	Flexibly adjustable and expandable I/O quantity structure within the scope of the SIPROTEC 5 modular system.
Housing width	1/2 x 19 inches to 2/1 x 19 inches

Benefits

- Safety due to high-performance protection functions
- Purposeful and easy handling of devices and software thanks to a user-friendly design
- Highest availability even under extreme environmental conditions by standard coating of the modules
- Cybersecurity in accordance with NERC CIP and BDEW Whitepaper requirements
- 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.

- Transformer differential protection for three-winding transformers with versatile, additional protection functions; expandable to 4 sides
- Transformer differential protection for phase-angle regulating transformers of the single-core type and special transformers
- Universal usability of the permissible measuring points
- Applicable from average up to extra-high voltage



[SIP5_GD_SS_W3, 2, --, --]

Figure 2.11/10 SIPROTEC 7UT86 Transformer Differential Protection (1/2 Device = Standard Variant P1)

- 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
- Adaptive adaptation of the operate curve to the transformer tap position
- Increased sensitivity with ground faults near the neutral point through a separate restricted ground-fault protection
- Point-on-wave switching
- Additional current and voltage inputs can be added for standard protection functions, such as overcurrent, voltage, frequency, protection etc.
- 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
- 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)

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- 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 to evaluate the systems, 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 are available in DIGSI 5 for standard applications. These include basic configurations and default settings that you can use straight away, or as a template for adjustments depending on the application. The available measuring points

make varied applications possible. Before ordering a device, please configure the application with DIGSI 5. The table **Function overview** shows the functional scope of the device. Use the [configurator](#) to determine the necessary function points.

Application Templates

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

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

Application Examples

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

Three-winding transformer basis

- Differential protection

Auto transformer with stabilizing winding

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

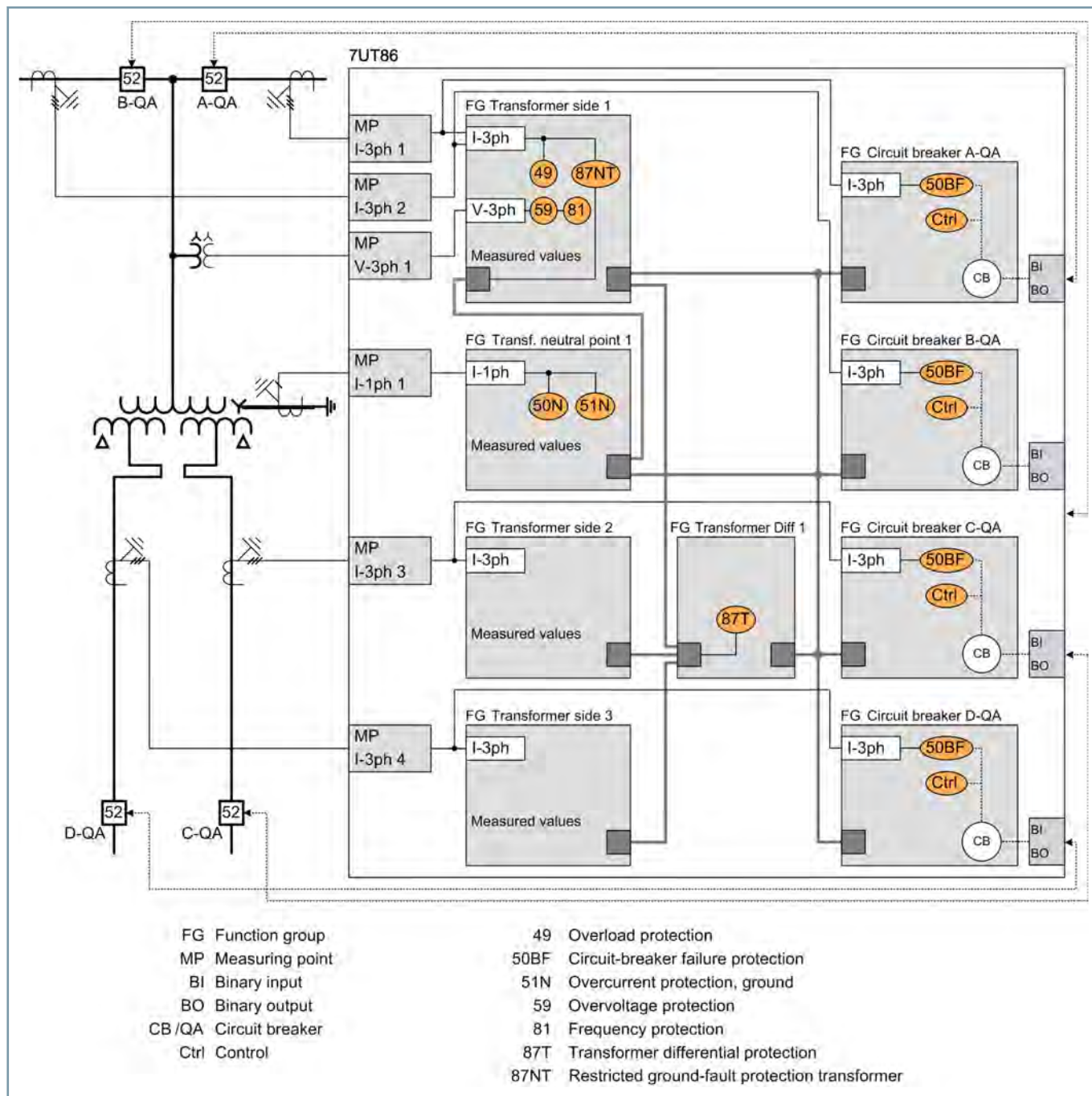
Three-winding transformer in breaker-and-a-half layout

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

[Figure 2.11/11](#) shows the template for the protection of a three-winding transformer in a breaker-and-a-half layout. You can recognize the 3 required function groups for the transformer side, the integration of the restricted ground-fault protection, the internal circuiting, and selected functions. In addition, a voltage transformer is available on the upper-voltage side. Here, for example, voltage and frequency limits can be monitored. The required protection settings are made as required by the system.

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[dw_Kat-three-wind, 2, en_US]

Figure 2.11/11 Application Example: Protection of a Three-Winding Transformer in Breaker-and-a-Half Layout

2.11

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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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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	$\Delta V>$	■											
67	Directional overcurrent protection, phases	$I>, \angle(V, I)$	■											
67N	Directional overcurrent protection, ground	$IN>, \angle(V, I)$	■											
67N	Directional ground-fault protection in grounded power systems	$IN>, \angle(V, I)$	■											
67 Ns	Sensitive ground-fault detection for grounded arc suppression coils and isolated power systems including a) $3I0>$ b) $V0>$, c) $\cos/\sin \Phi$, 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"	$\angle(V0h, I0h)$	■											
	Directional Intermittent Ground-Fault Protection	$IIEdir>$	■											
68	Power-swing blocking	$\Delta Z/\Delta t$	■											
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	$\Delta\varphi>$	■											
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	■											
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		■											■
90 V	Voltage controller for two-winding transformer with parallel control		■											

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ANSI	Function	Abbr.	Available	Application Templates										
				1	2	3	4	5	6	7	8	9		
	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	$\Sigma I_x, I^2t, 2P$	■											
	Switching sequence function		■											
	Inrush-current detection		■		■	■	■	■	■	■	■	■	■	■
	External trip initiation		■								■	■		
	Control		■	■	■	■	■	■	■	■	■	■	■	■
PoW	Point-on-wave switching (starting with V7.90)	PoW	■											
	Circuit breaker		■	■	■	■	■	■	■	■	■	■	■	■
	Disconnect/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 7UT86		■											
	Cyber security: Authenticated network access using IEEE 802.1X (starting from V8.3)		■											
Function point class:				0	50	150	30	30	0	30	30	175		

Table 2.11/6 SIPROTEC 7UT86 – Functions, Application Templates

- (1) 3-winding transformer Base (DIFF protection)
- (2) 3-winding transformer 1.5 CB (DIFF protection, SVS, REF)
- (3) 3-winding transformer (DIFF protection, SVS, REF, DIS)

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- (4) Auto transformer (DIFF protection, SVS, REF)
- (5) Auto transformer, 1.5 CB (2 DIFF protection, SVS, voltage protection, frequency protection)
- (6) 2-Winding Transformer Base (DIFF protection)
- (7) 2-Winding Transformer (DIFF protection, SVS, REF)
- (8) 2-Winding Transformer 1.5 CB (DIFF protection, SVS, REF)
- (9) 2-Winding Transformer (DIFF. Protection, Voltage Controller)

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



Table 2.11/7 Standard Variants for Transformer Differential Protection Devices

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