

7UM511 Generator protection relay (version V3)

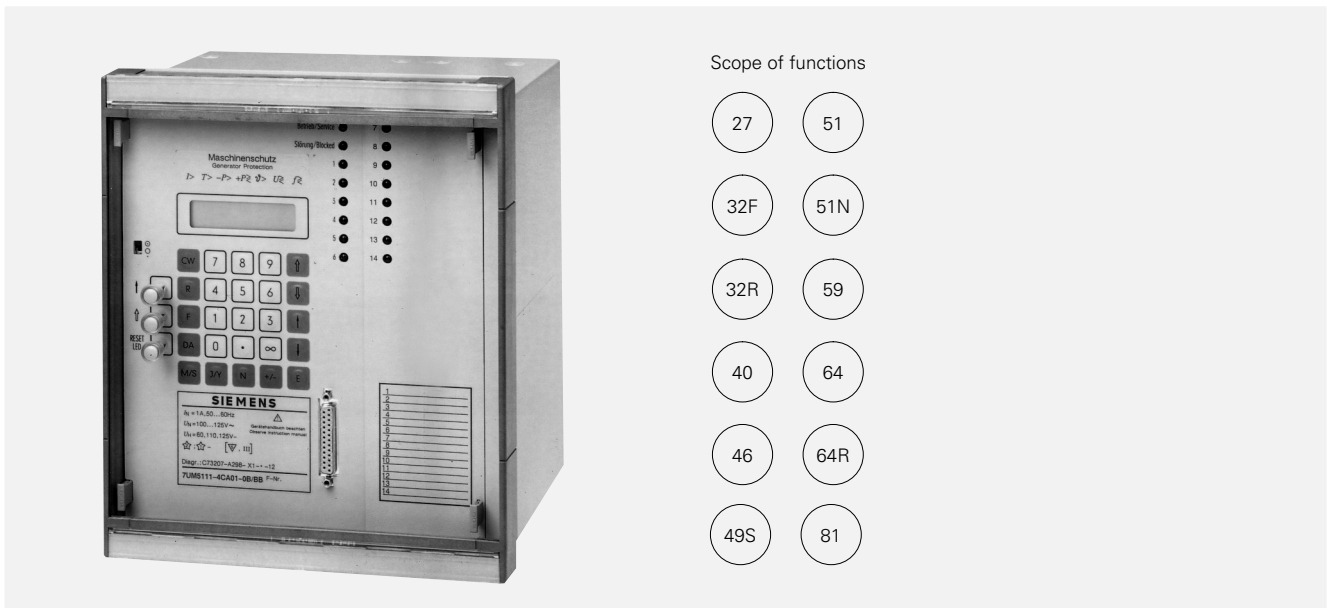


Fig. 1
7UM511 generator protection relay (version V3)

Application

The 7UM511 is a numerical generator protection relay offering a practical combination of protection functions for generators. The device provides all the necessary protection functions for small generators of the type used in emergency diesel generating sets or private power plants. The unit also serves as a basic module for more comprehensive protection systems based on the 7UM51 series for large generators. The 7UM51 protection system is supplemented by the 7UT51 differential protection units.

The protective functions integrated in the device allow use of the 7UM511 as system disconnecter.

Design

The compact device contains all components required for:

- Measured-value acquisition and evaluation
- Operation and display
- Indication and command output
- Acquisition of binary signals
- Serial data transfer
- Auxiliary power supply.

The device can be supplied with housings for flush or surface mounting. The version for control panel mounting or cubicle mounting is supplied with connection terminals at the rear of the device and is available with or without a glass cover.

The version for control panel mounting is equipped with 100 screw terminals accessible from the front.

Functions

The following protection functions are implemented:

- Overcurrent-time protection (with undervoltage seal-in)
- Single-phase overcurrent protection (can be implemented as rotor earth-fault protection)
- Stator overload protection
- Underexcitation protection
- Overvoltage protection
- Undervoltage protection
- Overfrequency protection
- Underfrequency protection
- Reverse power protection
- Forward power monitoring
- Unbalanced-load protection
- Stator earth-fault protection V_0
- Direct injection (for separate protection equipment)
- Trip circuit monitoring.

Measurement method

The influence of harmonics, high-frequency transients, transient direct current components and differing CT saturation levels are suppressed to a large degree by the use of powerful microprocessors and complete digital signal processing (measured-value acquisition, measured-value conditioning and measured-value processing).

Availability and precise measurement even with varying frequencies are assured by automatic follow-up of the sampling frequency for the range 10 to 68 Hz.

Several of the integrated protection functions make use of variables that are available in the form of symmetrical components. A change in the phase sequence, as is used in reversal in pumped-storage power plants, must be communicated to the 7UM511 protection device to ensure that the symmetrical components are correctly formed. A binary signal input can be assigned this switchover function.

Generator Protection

7UM511 Generator protection relay (version V3)

Serial interfaces

The relay is equipped with two serial interfaces. The interface at the front is suitable for connection of an AT-compatible PC. The program DIGSI is available as a convenient way of making settings, evaluating fault recordings and faults, and commissioning. The interface located at the rear of the device is available either as an isolated RS 232 interface or as a fibre-optic interface. It is intended for use either as a system interface for connection to the SINAUT LSA substation control and protection system to a central protection data unit (protocol according to VDEW/ZVEI recommended), or as an operator interface for connecting a PC.

Settings

All setting parameters are entered with menu guidance via the integrated operator and display panel or a PC. They are written to a non-volatile memory so that they are not lost even if the supply voltage is interrupted.

Self-monitoring

All important components such as the hardware and software are continuously monitored and any irregularities in the hardware or in the program sequence are detected and signalled. This significantly improves the reliability and availability of the protection system.

Overcurrent-time protection (ANSI 51)

This protection function comprises two stages. The first stage generally serves as short-circuit and back-up protection for upstream relays such as differential protection and distance protection.

An undervoltage stage maintains the excitation when the current falls below the starting threshold and at the same time the voltage drops because the excitation system can no longer be sufficiently supplied.

The second stage can be implemented, for example, as a high-speed stage for low-voltage generators or for constant voltage generators.

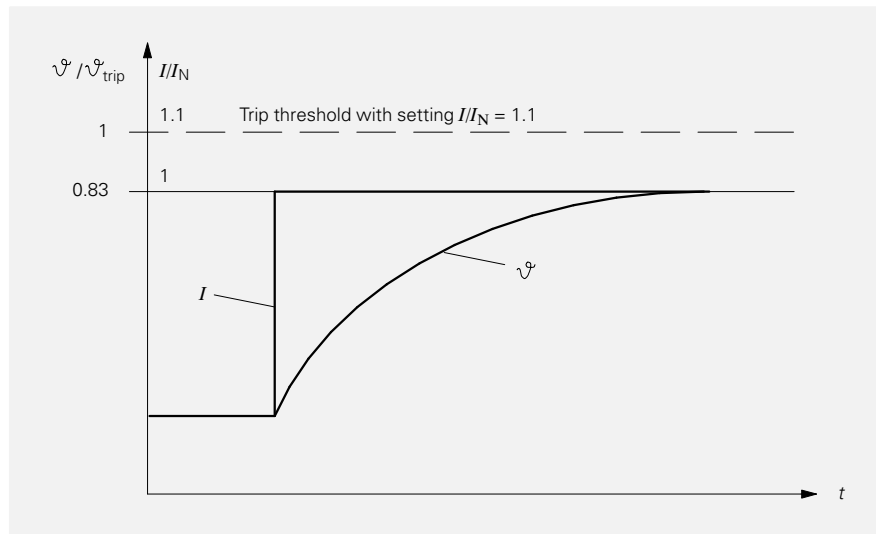


Fig. 2 Calculation of temperature from the phase currents according to the mathematical model

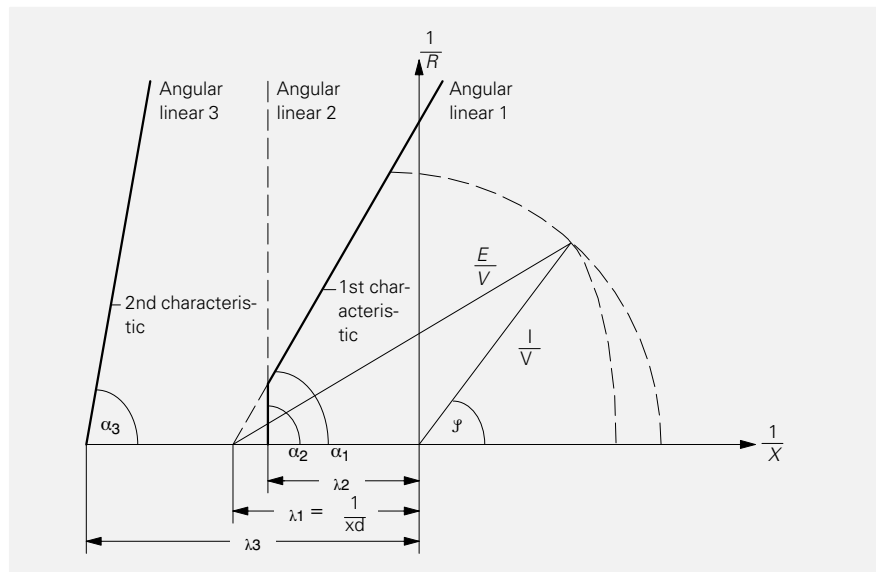


Fig. 3 Admittance diagram with the response characteristics for the static and dynamic stability limit

Single-phase overcurrent-time protection (ANSI 51N or ANSI 64R)

This single-phase overcurrent protection can be implemented as a stator earth-fault protection. This function detects the earth-fault current limited by an impedance.

This protection system is so sensitive that it can also be used as a rotor earth-fault protection with the relevant accessories. A measuring-circuit monitoring function is available for this application.

Stator overload protection (ANSI 49)

The task of the overload protection is to protect the stator windings from high, continuous overload currents. All load cycles are evaluated by the mathematical model used. The thermal effect of the effective current value forms the basis of the calculation. The ambient temperature or the temperature of the coolant can be injected as a proportional voltage to achieve adaptation to the prevailing conditions; otherwise a constant ambient temperature is assumed. By monitoring the minimum voltage, a wire break at the input for the temperature injection is detected. If this input is suitably connected, 4 mA to 20 mA transducers can also be used for temperature acquisition.

7UM511 Generator protection relay (version V3)

Underexcitation protection (ANSI 40)

The load angle is calculated as the complex admittance derived from the generator terminal voltage and current. This protection prevents damage due to loss of synchronism resulting from underexcitation. The protection function provides two characteristics for monitoring static and dynamic stability. Monitoring of the exciter voltage ensures fast response of the protection on exciter failure.

The positive sequence systems of current and voltage are used to calculate the variables. This ensures that the protection always operates correctly even with asymmetrical network conditions.

Overvoltage protection (ANSI 59)

This protection prevents insulation faults that result when the voltage is too high. The protection function uses the positive-sequence components of the voltages and is therefore independent of the neutral point displacement caused by earth faults. This protection function is implemented in two stages.

Undervoltage protection (ANSI 27)

Undervoltage protection compares the positive-sequence components of the voltages with a lower limit value. This function is used for asynchronous machines and pumped-storage sets and prevents the voltage-related instability of such machines.

Frequency protection (ANSI 81)

The 7UM511 protection relay includes a four-stage frequency protection. Each stage can be implemented either as an overfrequency or underfrequency protection. The complicated algorithm successfully filters out the fundamental waves and determines the frequency extremely precisely even if the voltage is distorted.

Reverse power protection (ANSI 32)

The reverse power protection monitors the direction of power flow and responds when the mechanical energy fails because then the drive energy is taken from the network. This function provided by the 7UM511 can be used for operational shutdown of the generator but also prevents damage to the steam turbines. The reverse power is calculated from the positive-sequence systems of current and voltage. Asymmetrical network faults do not therefore cause reduced measuring accuracy. The position of the emergency trip valve is injected as binary information and is used to switch between two switch-off command delays.

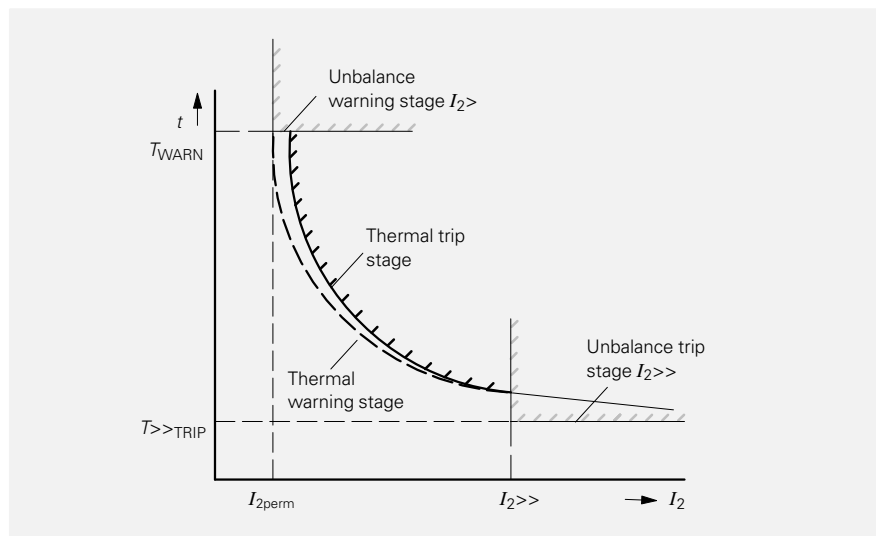


Fig. 4
Trip range of the load unbalance protection

Forward power monitoring (ANSI 32)

Monitoring of the power produced by a generator can be useful for starting up and shutting down generators. One stage monitors violation beyond one limit value while another stage monitors violation below another limit value. The power is calculated using the positive-sequence component of current and voltage.

Unbalanced-load protection (ANSI 46)

Asymmetrical current loads in the three phases of a generator cause a temperature rise in the rotor because of the reverse field produced.

This protection detects an asymmetrical load in three-phase machines. It functions on the basis of symmetrical components and evaluates the negative phase-sequence system of the phase currents. The thermal processes are represented in a mathematical model. Warning and triggering stages that can be set separately compare the calculated overtemperature against relevant threshold values. In addition, the load unbalance is evaluated by an independent stage which is supplemented by a time-delay element.

Stator earth-fault protection (ANSI 64)

Earth faults manifest themselves in generators that are operated in isolation by the occurrence of a displacement voltage in the generator neutral point which is equivalent to a zero-phase sequence system in the phase-to-earth voltage.

The 7UM511 protection relay calculates the zero-phase system of the phase-to-earth voltage and compares the resulting displacement voltage with a settable limiting value. This provides earth-fault protection for up to 95% of the stator winding.

Direct injection

Direct injection of the 7UM511 protection relay is a function used for the acquisition of digital information. This digital information is entered in the fault indication memory. They can influence the LEDs "alarm relay" and "command relay". Each "direct injection" can delay the effect of the digital information with an individual timer. The function "direct injection" is used to process information from the Buchholz protection or machine commands.

Trip circuit monitoring

The 7UM511 protection relay can monitor two trip circuits (circuit-breaker coils including supply conductor) for correct functioning. If a fault is detected in the monitored circuits the protection relay outputs an indication.

Status measurements

The values acquired and calculated by the device such as primary and secondary conductor current and voltage, earth current, neutral voltage, positive-sequence components of active and reactive power, frequency, active power, reactive power, power factor, current-voltage angle, rotor displacement angle, exciter voltage, calculated conductor-related overtemperature, coolant temperature, negative phase-sequence components of the phase currents, overtemperature resulting from load unbalance and the direction of rotating field can be displayed on the LC display or on a PC.

Generator Protection

7UM511 Generator protection relay (version V3)

Fault recording

Depending on the parameters set, either recording of current (display of input variables) or rms values (one value for each period) is implemented in the protection relay. The maximum duration of time during which faults are recorded depends on the recording frequency. Several faults can be recorded (max. 8) in a memory one after the other. This number which can be set also depends on the number of faults. The lead time and overtravel time and triggering event (start of fault recording with activation and triggering) can be set to meet different demands. The recorded fault data can be transferred either to the SINAUT LSA substation control and protection or to a PC where they are then analysed.

Trip matrix/trip circuits

The device is equipped with five trip relays. These can be arbitrarily assigned to the protection functions described above by parameterization (software matrix). Furthermore, each protection function can be switched "ON" or "OFF" via the operator panel. A third "blocked" position permits commissioning of the unit with the local indications and the alarm relay circuits operative, but without tripping the circuit-breakers. With the many parameterized possibilities provided, testing of and alterations to the circuit-breaker operation can be performed during commissioning, as well as during normal operation without the need for rewiring.

Indication memory

The device provides detailed data for analysing faults and checking operating states. All the indication memories listed below are protected against power supply loss.

- Time
A battery-backed clock is provided as standard and synchronized via a binary input or system interface. All indications are assigned a time and date.
- Fault indications
The indications of the last three faults are can be accessed at any time.
- Operational indications
All indications that are not directly connected to a fault are stored in the operational indication memory.

Assignable alarm relays, LEDs and binary inputs

Alarm relays and LEDs can be freely assigned by the user to provide user-specific output and display of indications. The LED displays are protected against loss of power.

All binary inputs are also freely assignable and each input can be assigned to several logical inputs.

7UM511 Generator protection relay (version V3)

Technical data

Input circuits	<p>Rated current</p> <p>Rated voltage, can be parameterized</p> <p>Rated frequency, can be parameterized</p> <p>Thermal overload capability</p> <p>in voltage path, continuous</p> <p>in current path, continuous</p> <p>≤ 1 s</p> <p>≤ 10 s</p> <p>in earth-fault path, continuous</p> <p>≤ 1 s</p> <p>≤ 10 s</p> <p>DC inputs</p> <p>Power consumption</p> <p>in voltage path at $V_N = 100$ V</p> <p>in current path at $I_N = 1$ A</p> <p>at $I_N = 5$ A</p>	<p>1 or 5 A</p> <p>100 to 125 V AC</p> <p>50/60 Hz</p> <p>140 V AC</p> <p>$4 \times I_N$</p> <p>$100 \times I_N$</p> <p>$20 \times I_N$</p> <p>15 A</p> <p>300 A</p> <p>100 A</p> <p>60 V DC</p> <p><0.3 VA</p> <p><0.1 VA</p> <p><0.5 VA</p>
Voltage supply with integrated converter	<p>Rated auxiliary voltage V_{aux}</p> <p>Permissible tolerance of rated auxiliary voltage</p> <p>Power consumption</p>	<p>24, 48 V DC or 60, 110, 125 V DC or 220, 250 V DC</p> <p>-20 to +15 %</p> <p>max. 20 W</p>
Setting ranges Overcurrent-time protection (ANSI 51)	<p>Current $I>$, $I>>$</p> <p>Trip delay, reset delay</p> <p>Resetting ratio</p> <p>Response time</p> <p>Undervoltage seal-in $V<$</p> <p>Starting hold time on undervoltage</p> <p>Resetting ratio</p>	<p>0.1 to $8 \times I_N$</p> <p>0 to 32 s</p> <p>0.95</p> <p>approx. 50 ms</p> <p>20 to 100 V</p> <p>0 to 32 s</p> <p>1.05</p>
Single-phase overcurrent protection (ANSI 51N)	<p>Current $I_{E>}$</p> <p>Trip delay, reset delay</p> <p>Reset ratio</p> <p>Response time</p> <p>Measuring circuit monitoring current $I_{E<}$</p> <p>Delay (not settable)</p> <p>Reset ratio</p>	<p>10 to 1 000 mA</p> <p>0 to 32 s</p> <p>0.9</p> <p>approx. 50 ms</p> <p>2 to 50 mA, (setting 0 mA prevents indication output)</p> <p>2 s</p> <p>1.1</p>
Stator overload protection (ANSI 49)	<p>k factor (acc. to IEC 255-8-2)</p> <p>Thermal time constant τ</p> <p>Warning temperature (referred to release overtemperature)</p> <p>Overtemperature at rated current</p> <p>Coolant temperature (not settable)</p> <p>Voltage proportional to temperature</p>	<p>0.5 to 2.5</p> <p>30 to 32 000 s</p> <p>70 to 100 % $\vartheta/\vartheta_{off}$</p> <p>40 to 100 °C</p> <p>40 °C</p> <p>0 to 10 V DC</p>
Underexcitation protection (ANSI 40)	<p>Distance of the trip characteristic from the coordinate origin in the admittance plane: $\lambda_1, \lambda_2, \lambda_3$</p> <p>Slope angle: $\alpha_1, \alpha_2, \alpha_3$</p> <p>Trip delay (with/without excitation voltage), reset delay</p> <p>Reset ratio</p> <p>Response time</p> <p>Exciter voltage scan</p>	<p>0.25 to 3</p> <p>50 to 120°</p> <p>0 to 32 s</p> <p>0.95</p> <p>≤ 100 ms</p> <p>0.5 to 8 V DC</p>
Overvoltage protection (ANSI 59)	<p>Voltage $V>$, $V>>$</p> <p>Trip delay, reset delay</p> <p>Reset ratio</p> <p>Response time</p>	<p>30 to 180 V</p> <p>0 to 32 s</p> <p>0.95</p> <p>approx. 50 ms</p>
Undervoltage protection (ANSI 27)	<p>Voltage $V<$</p> <p>Trip delay, reset delay</p> <p>Reset ratio</p> <p>Response time</p>	<p>20 to 100 V</p> <p>0 to 32 s</p> <p>1.05</p> <p>approx. 50 ms</p>

Generator Protection

7UM511 Generator protection relay (version V3)

Technical data (cont.)

Setting ranges (cont.) Frequency protection (ANSI 81)	Number of stages	4
	Frequency f_1, f_2, f_3, f_4	40 to 65 Hz
Reverse power protection (ANSI 32)	Number of repeat measurements (one repeat measurement $3/f$)	2 to 10000
	Response time	approx. 60 ms + time for measurement
	Undervoltage blocking $V<$	40 to 100 V
	Reset ratio of blocking	1.05
	Reverse power $-P>$ (referred to SN)	-30 to -0.5 %
	Trip delay (with/without emerg. trip), reset delay	0 to 32 s
Forward power monitor (ANSI 32)	Reset ratio	0.6
	Response time	approx. 350 ms
	Upper power limit violation $+P>$ (referred to SN)	1 to 120 %
	Reset ratio	0.9
Unbalanced-load protection (ANSI 46)	Lower power limit violation $+P<$ (referred to SN)	0.5 to 120 %
	Reset ratio	1.1
	Trip delay, reset delay	0 to 32 s
	Response time at 50 Hz	Setting: precise approx. 350 ms Setting: fast approx. 60 ms
	Warning level $I_{2>}$ (referred to I_N)	3 to 30 %
	Warning delay	0 to 32 s
Stator earth-fault protection (ANSI 59N)	Thermal time constant	100 to 2500 s
	Thermal warning level (referred to triggering overtemperature)	70 to 99 %
	Trip stage $I_{2>>}$ (referred to I_N)	10 to 80 %
	Reset ratio	0.95
	Trip delay, reset delay	0 to 32 s
	Response time of the independent characteristic	approx. 50 ms
	Displacement voltage	5 to 100 V
Direct injection	Reset ratio	0.7
	Trip delay, reset delay	0 to 32 s
	Response time	approx. 50 ms
Phase-sequence reversal	Number	4
	Trigger delay t_1, t_2, t_3, t_4	0 to 32 s
	Reset delay t_1, t_2, t_3, t_4	0 to 32 s
	Response time	<15 ms
Response tolerances under rated conditions	Response time	200 ms (on condition that $I < 0.1 \times I_N$ and $V < 0.1 \times V_N$)
	Current	≤ 3 % of setting value
Status measured values	Voltage	≤ 3 % of setting value
	Active power	≤ 0.25 % of SN or 3 % of setting value
	Reverse power	≤ 0.25 % of SN or 3 % of setting value
	Forward power (Setting: Precise)	≤ 0.50 % of SN or 3 % of setting value
	Forward power (Setting: Fast)	≤ 0.50 % of SN or 3 % of setting value
	Times	≤ 10 ms
	Display of values	$V_{PH1-E}, V_{PH2-E}, V_{PH3-E}, V_{PS/PH-PH}, V_0$ $I_{PH1}, I_{PH2}, I_{PH3}, I_{PS}, I_0$ $P/SN, Q/SN$ $\cos \phi$ ϕ, THETA I_2 I_{2TH} $V_{EXCIT.}$ f $\theta/\theta_{trip}, \theta_{COOLANT}$
Fault data acquisition	Phase angle, rotor displacement angle	
	Out-of-balance load Reverse current Overcurrent temperature	
Fault data acquisition	Exciter voltage	
	Frequency	
Fault data acquisition	Overtemperature, coolant temperature	
	Either instantaneous values (12 values per period) or calculated values (1 value per period)	$V_{PH1}, V_{PH2}, V_{PH3}, V_{EXCIT.}, i_{PH1}, i_{PH2}, i_{PH3}, i_E$ $V_{PH1-E}, V_{PH2-E}, V_{PH3-E}, V_{PS}, V_0$ $V_{PS}, I_{PS}, I_{PH1}, I_{PH2}, I_{PH3}, I_E, \cos \phi, f-f_N$

7UM511 Generator protection relay (version V3)

Technical data(cont.)

Contacts	Potential-free trip contacts Switching capacity Make Break Permissible current Continuous 0.5 s Switching voltage Alarm contacts Switching capacity Make/break Permissible current Switching voltage	3 x 2 S, 2 x 1 S (total of 5 trip relays) 1 000 W or VA 30 W or VA 5 A 30 A 250 A DC 13 20 W or VA 1 A 250 V DC
Displays, signal inputs	LED displays at the front of the device Optocoupler 24 to 250 V DC Current consumption independent of voltage range	16 8 approx. 2.5 mA
Design of device	For panel surface mounting Weight For panel flush mounting/cubicle mounting Weight Degree of protection to EN 60 529	In housing 7XP2040-1 approx. 12 kg In housing 7XP2040-2 approx. 10.5 kg IP 51
CE conformity, regulations	This product is in conformity with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to the electromagnetic compatibility (EMC Council Directive 89/336/EEC). The product conforms with the international standard IEC 255 and the national standard DIN VDE 57 435/part 303. The relay is designed for use in an industrial environment, for installation in standard relay rooms and compartments so that with proper installation electro-magnetic compatibility (EMC) is ensured.	Conformity is proved by tests performed by Siemens AG in line with article 10 of the Council Directive in accordance with the generic standards EN 50081-2 and EN 50082-2.
Insulation tests IEC 255-5, DIN VDE 0435 Part 303	Voltage test (routine test), all circuits excluding auxiliary voltage Voltage test (routine test), auxiliary voltage only Impulse voltage test (type test), all circuits, class III	2 kV (rms value), 50 Hz 2.8 kV DC 5 kV (peak value), 1.2/50 μ s, 0.5 J, 3 positive and 3 negative impulses in intervals of 5 s
EMC tests for noise immunity (Type tests) Standards: IEC 255-22 (product standard) EN 50082-2 (basic specification) DIN VDE 0435 Part 303	High frequency test IEC 255-22-1, Class III and DIN VDE 0435 Part 303, Class III Electrostatic discharge test IEC 255-22-2, Class III and EN 61000-4-2, Class III Radiation with high frequency field, unmodulated IEC 255-22-3 (Report), Class III Radiation with high frequency field, amplitude modulated EN 61000-4-3 Radiation with high frequency field, pulse modulated ENV 50204 / EN 61000-4-3 Fast transient interference/burst IEC 255-22-4 and EN 61000-4-4, Class III Conducted HF, amplitude modulated EN 61000-4-6 Magnetic field with high-voltage equipment frequency EN 61000-4-8, Class IV	2.5 kV (peak value), 1 MHz, $\tau = 15 \mu$ s, 400 impulses per s, length of test 2 s 4 kV/6 kV contact discharge, 8 kV air discharge, both polarities, 150 pF, $R_f = 330 \Omega$ 10 V/m, 27 to 500 MHz 10 V/m, 80 to 1 000 MHz, AM 80 %, 1 kHz 10 V/m, 900 MHz, repetition frequency 200 Hz, duty cycle 50 % 2 kV, 5/50 ns, 5 kHz, burst length = 15 ms, Repetition rate 300 ms, both polarities, $R_f = 50 \Omega$, duration of test 1 min 10 V, 150 kHz to 80 MHz, AM 80 %, 1 kHz 30 A/m continuous, 300 A/m für 3 s, 50 Hz
EMC tests for emitted interference (Type tests) Standards: EN 50081-2 (basic specification)	Radio interference voltage on lines, auxiliary voltage only CISPR 11, EN 55011, limit value class A and DIN VDE 0875 Part 11, limit value class A Interference field strength CISPR II, EN 55011, limit value class A and DIN VDE 0875 Part 11, limit value class A	150 kHz to 30 MHz 30 to 1 000 MHz
Climatic conditions	Permissible ambient temperature during operation during storage during transport Humidity class	-5 to +55 °C -25 to +55 °C -25 to +70 °C Annual average ≤ 75 % relative humidity, on 30 days per year up to 95 % relative humidity, condensation not permissible
Mechanical stress tests IEC 255-21-1, IEC 68-2	Permissible mechanical stress during operation during transport	10 to 60 Hz, 0.035 mm amplitude 60 to 500 Hz, 0.5 g acceleration 5 to 8 Hz, 7.5 mm amplitude 8 to 500 Hz, 2 g acceleration

Generator Protection

7UM511 Generator protection relay (version V3)

Selection and ordering data

7UM511 generator protection relay (V3)	Order No. 7UM511 □ - □ □ B 0 1 - 0 □ B 0
Rated current at 50 to 60 Hz, 100 to 125 V AC 1 A 5 A	↑ 1 5
Rated auxiliary voltage 24, 48 V DC 60, 110, 125 V DC 220, 250 V DC	↑ 2 4 5
Construction For panel flush mounting/cabinet mounting For panel surface mounting For panel flush mounting or cabinet mounting, without glass cover	↑ C D E
Rear, serial interface (suitable for substation control and protection and DIGSI operating program) Electrical Fibre-optic	↑ B C

Accessories

Rotor earth-fault protection Ballast 100/45 V AC (W x H x D in mm) 135 x 170 x 85 Coupling device 2 x 4 µF 196 x 300 x 110 Series resistor 196 x 300 x 146	7XR8500-0 7XR6000 3PP1336-0DZ013002
Operation DIGSI program (suitable for all 7UM..., 7UT..., 7SJ..., 7SA..., ... protection relays) German English Test version: German English Connecting cable protection relay (25-pin) – PC (9-pin); (other versions available on request)	7XS5020-0AA00 7XS5020-1AA00 7XS5021-0AA00 7XS5021-1AA00 7XV5100-2

Documentation

German Katalogblatt LSA 2.5.2: Maschinenschutz 7UM511 (Version V3) Handbuch: Maschinenschutz 7UM511 (Version V3)	E50001-K5752-A121-A2 C53000-G1100-C109-1
English Catalog LSA 2.5.2: 7UM511 Generator protection relay (Version V3) Manual: 7UM511 Generator protection relay (Version V3)	E50001-K5752-A121-A2-7600 C53000-G1176-C109-1

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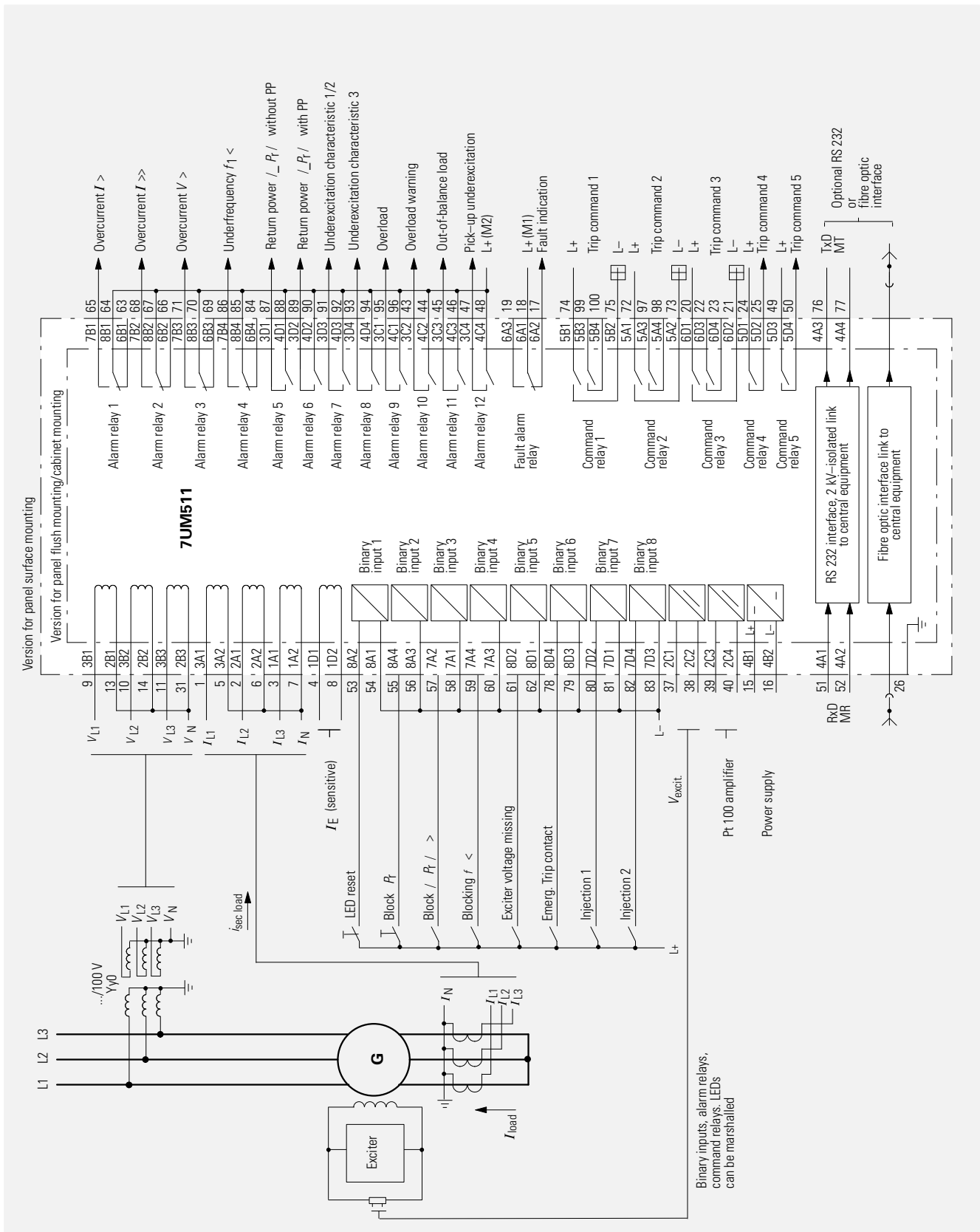


Fig. 5 Connection diagram of the 7UM511 generator protection relay (version V3)

Generator Protection

Dimension drawings in mm

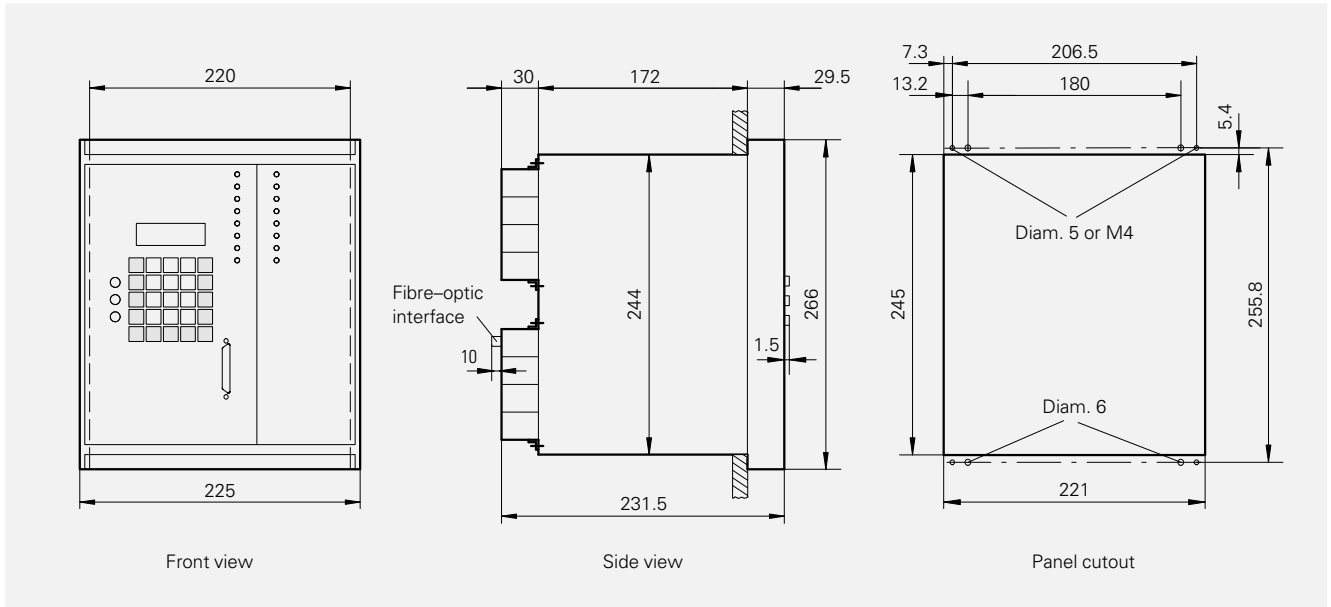


Fig. 6
7UM511 with housing 7XP2040-2 (for panel flush mounting or cubicle mounting)

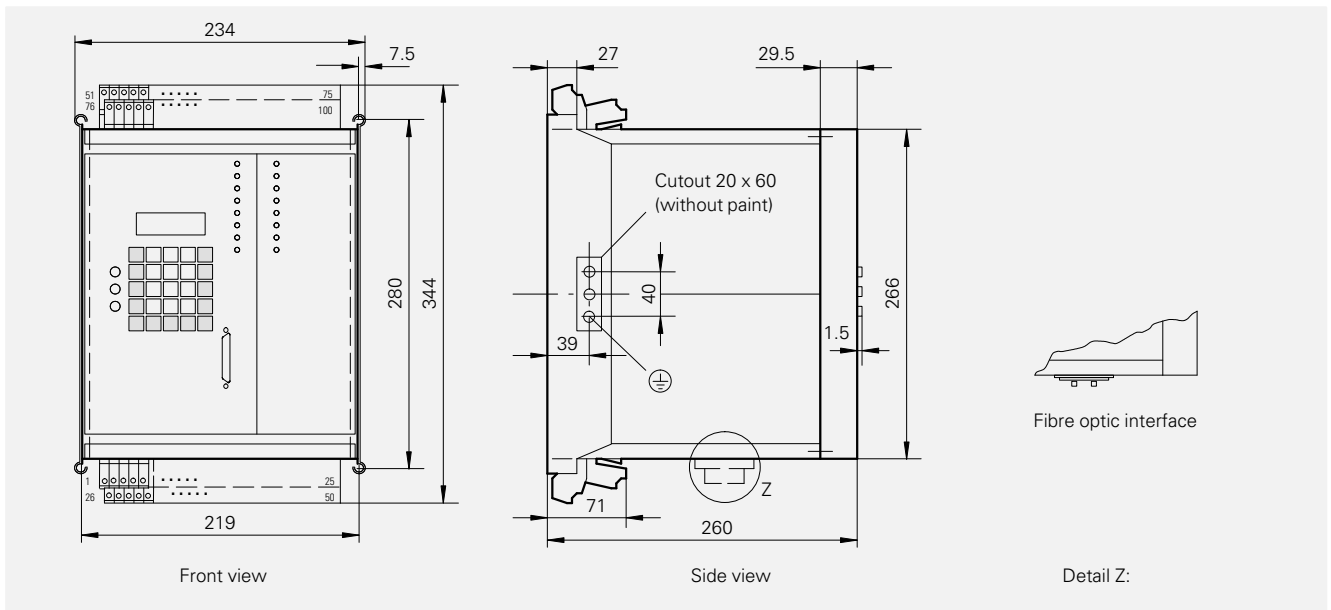


Fig. 7
7UM511 with housing 7XP2040-1 (for panel surface mounting)

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The illustrations are for reference only.

We reserve the right to adjust the prices and shall charge the price applying on the date of delivery.

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Dimensions

All dimensions in this catalog are given in mm.

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Power
Transmission
and Distribution