SIEMENS

Generator protection relay 7UM515

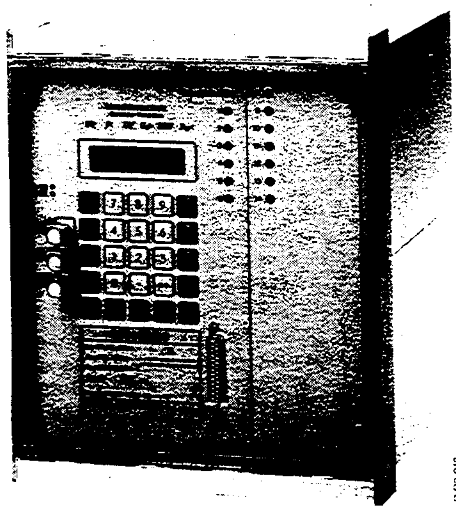

Fig. 1
Generator protection relay 7UM515

Application

The 7UM515 is a digital protection relay which is mainly used for larger generators in block connection. In the majority of cases it is used in combination with other units from the 7UM51 and 7UT51 series, whereby some functions can be used to provide redundant protection.

Construction

The unit is of compact construction and comprises all components for:

- Measured value acquisition and evaluation
- Operator and display panel
- Alarm and command outputs
- Binary input options
- Serial interfaces
- Auxiliary voltage DC/DC converter.

Two casing models are available. The model for panel flush mounting or cubicle mounting has rear connection terminals. The model for panel surface mounting has 100 screw terminals accessible from the front.

Protection functions

The unit contains the following integrated protection functions:

- 100 % stator earth-fault protection
- Rotor earth-fault protection (with 1 to 3 Hz bias)
- Earth-fault protection $U_0 >$
- Interturn short-circuit protection $U_w >$
- Overexcitation protection U/f
- Overvoltage protection
- Undervoltage protection
- Overfrequency protection
- Underfrequency protection.

Measurement method

The influence of superimposed harmonics and high-frequency transients is suppressed by the use of a powerful microprocessor and complete digital signal processing (measured value acquisition, measured value conditioning and measured value processing). High measurement accuracy is achieved by the use of process imaging based on physical models.

Operational readiness and correct measurement even with varying frequencies (during run-up and shut-down) are guaranteed by an automatic follow-up of the sampling frequency for the range of 10 to 70 Hz.

Serial interfaces

The relay is equipped with two serial interfaces.

The operator interface at the front is suitable for connection of an AT-compatible personal computer. An operator program DIGSI is available for convenient and clear setting, evaluation of fault records and data, as well as for commissioning.

The system interface is either available as an isolated V. 24 interface or as a fibre optic interface for connection to the substation control system LSA 678 or to a central protection data unit (protocol according to DIN 19244).

Settings

All setting parameters are input either via the integrated operator and display panel or a personal computer. The operator is guided through the setting process. The parameters are written into non-volatile memories so that the settings remain secure even when the supply voltage is disconnected.

Self monitoring

All important hardware and software components are monitored continuously. Any irregularities in the hardware or in the program sequence are detected and alarmed. This significantly improves the security and the availability of the protection system.

100 % stator earth-fault protection

In order to detect earth-faults in close proximity to the star point, a 20 Hz bias voltage is used as shown in Fig. 5. This voltage creates an earth current in the event of an earth fault.

The vector values ($\underline{U}_{20\,Hz}$; $\underline{I}_{20\,Hz}$) are determined from the input values $u_{20\,Hz}$ and $i_{20\,Hz}$ via a digital filter and used to calculate the fault resistance to earth. Frequencies deviating from 20 Hz are suppressed. If a correction angle is input, it is possible to compensate the phase-angle error of the current and voltage transformers as well as of the earthing or neutral earthing transformer.

The trip characteristic has two stages (alarm, trip).

A failure of the 20 Hz voltage is detected and the resistance measurement stopped. The earth-current supervision remains active and initiates an independent, time-delayed trip if the setting value is exceeded.

Interturn short-circuit protection

The zero-sequence voltage is used to detect interturn short-circuits in generators. The fundamental wave is evaluated whereby harmonics are suppressed by filter algorithms. A matched input transmitter provides the high sensitivity.

Fig. 2 shows the basic connection for detecting interturn short-circuits. The star-point of the voltage transformer is connected via a high-voltage cable to the star-point of the generator. The voltage transformers must not be earthed on the primary side, since an "earth-fault" would lead to an earth short-circuit.

Rotor earth-fault protection

This protection function detects earth-faults in the excitation circuit.

In order to eliminate the effect of earth capacitances in the excitation circuit, a DC voltage with constantly changing polarity (1 to 3 Hz) is connected via a series coupling unit to bias the excitation circuit. Thus, with each change in polarity, a charging current flows through the earth capacitances via the coupling unit and the measurement shunt. The voltage $U_{measured,\,REF}$ measured at the measurement shunt, is filtered digitally in order to suppress interference values. The decayed measured voltage is used for resistance calculation.

Very large resistance values can thus be recognized independent of the location of the earth fault.

The trip characteristic is of two-stage design (alarm, short-time trip). Furthermore, the protection can be used to detect interruptions in the measurement circuit (e. g. transition between brushes and slip rings).

Earth-fault protection

Earth-faults are detected by evaluating system-frequency neutral displacement voltages. In the example in Fig. 5, the protection detects earth-faults on the busbar section between the generator circuit-breaker and the auxiliary supply/block transformers when the generator circuit-breaker is open. If the generator circuit-breaker is closed, the earth-fault protection can also be used as a back-up protection for stator earth-faults. The voltage amplitude which can be evaluated provides protection of approximately 90 % of the stator winding.

By using a digital filter, the fundamental wave of the zero displacement voltage is evaluated and any harmonics are suppressed. Tripping can be time delayed.

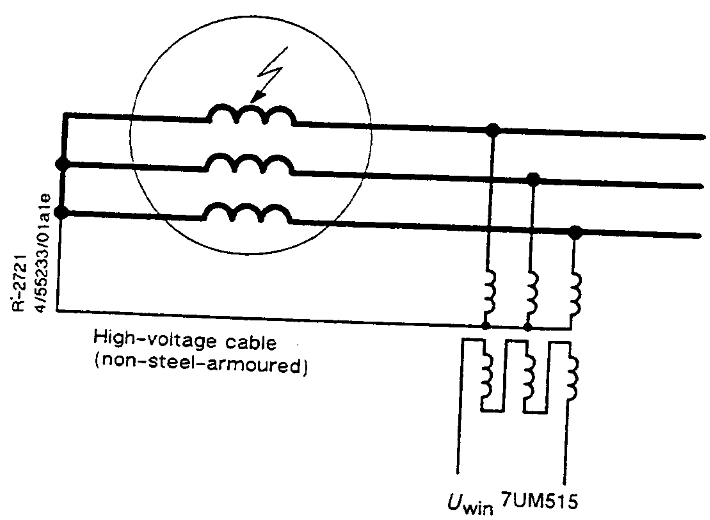

Fig. 2
Block diagram of interturn short-circuit protection

Overexcitation protection

The overexcitation protection detects impermissibly high flux density in transformers, in particular in block transformers. This flux density is caused by a voltage increase and/or a frequency decrease, the consequence of which are saturation of the iron core and high eddy current losses.

Power station block transformers are particularly endangered when they are suddenly disconnected from the network at full load.

The overexcitation protection calculates the quotient of voltage and frequency which is proportional to the flux density. A thermal replica (1st order differential equation) is used to simulate the heating process. The permissible heating characteristic can be described by 6 sets of co-ordinates (intermediate values are interpolated). Thus, any *U/f* characteristic specified by the transformer manufacturer can be set. The alarm characteristic can be set as a percentage of the trip characteristic. In addition to the thermal characteristic, an adjustable, definite-time overexcitation stage (refer to Fig. 3) is also provided.

Overvoltage protection, undervoltage protection

The three phase-to-phase voltages are measured and the fundamental wave is calculated by means of a digital filter.

The overvoltage protection evaluates the maximum phase-to-phase voltage in order to protect the generator and associated plant against impermissible voltage increases. The voltage increases can be caused by operator faults in case of manual voltage regulator operation or by faulty operation of the voltage regulator itself. The overvoltage protection has two stages.

Undervoltage protection is required in special cases (e. g. pumped storage stations) to ensure a timely disconnection of the generator from the network and to avoid voltage-induced network instability in the event of undervoltage.

The positive sequence system which is calculated from the filtered phase-to-phase voltages, is used for the evaluation. In order to facilitate matching to different applications, an inverse-time trip characteristic has been chosen (refer to Fig. 4). The characteristic can be described by 5 sets of co-ordinates.

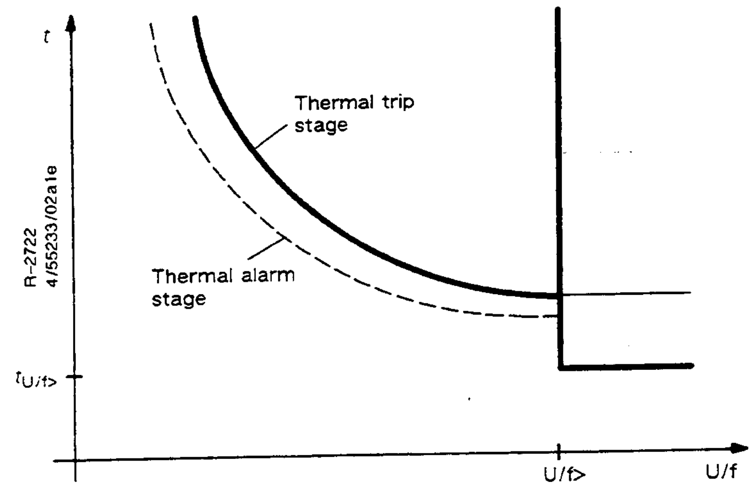

Fig. 3
Trip characteristic of the overexcitation protection

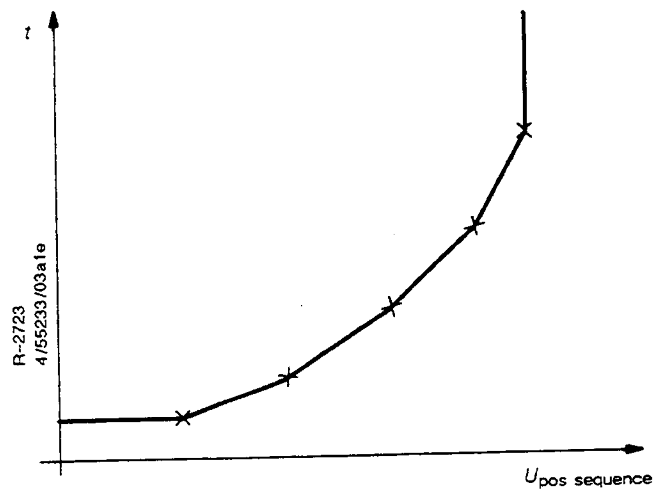

Fig. 4
Trip characteristic of the undervoltage protection

Overfrequency protection, underfrequency protection

Generators, motors and consumers may only be operated within a limited frequency range. The frequency measurement uses the positive sequence voltage system and is based on zero crossing evaluation (fast underfrequency stage) and on evaluation of the angular speed of the positive sequence vector (extremely accurate frequency measurement).

Together with the fast underfrequency stage, an additional time stage can be activated. The extremely accurate frequency measurement is employed for two underfrequency stages and one overfrequency stage. The accuracy (operating range: 40 to 70 Hz) is further increased by an adjustable number of repeat measurements. Tripping is initiated when the counter status has been reached. A time delay can be realized at the same time.

Assignable alarm relays/LED's

In order to provide a user-specific output and indication of alarms the assignment can be effected at liberty by the user.

Trip matrix/trip circuits

The unit is equipped with five trip relays. These can be arbitrarily assigned to the above-mentioned protection functions by parameterization (software matrix).

Furthermore, each protection function can be switched "ON" or "OFF" via the operator panel. A third "Blocked" mode permits commissioning of the unit with the local annunciations and the alarm relay circuits operative, but without tripping of the circuit-breakers.

With the many parameterizing 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.

Fault event data

If a fault is detected in the protected object, the individual events and the train of measured data are stored in the unit. A choice can be made between recording either instantaneous or rms values.

These data can be read out via the serial interface. Evaluation of the data for fault analysis can then be performed by means of a PC program or a central data evaluation unit.

On-load measurement

The on-load measured values generated in the relay such as voltages, frequency, stator earth current, earth resistances of stator and rotor can be displayed via the LCD display or a personal computer.

Technical data

Input circuits	Rated voltage, can be parameterized	90 to 125 V AC
	Rated frequency, can be parameterized	50/60 Hz
	Burden in voltage path U_N = 100 V	< 0.3 VA
	Thermal overload capability	
	in voltage paths	140 V AC
	in earth voltage path	140 V AC, 300 V AC for ≤ 30 s
	isolating amplifier	60 V DC
	Input resistance of isolating amplifier	approx. 1 MΩ
Voltage supply via integrated DC/DC converter	Rated auxiliary voltage U_H	24 V, 48 V DC or 60 V, 110 V, 125 V DC or 220 V, 250 V DC
	Permissible tolerance	–20 to +15 %
	Power consumption	max. 20 W
Setting ranges		
100 % stator earth-fault protection	Alarm stage $R <$	20 to 500 Ω (secondary value)
	Trip stage $R \ll$	10 to 300 Ω (secondary value)
	Earth current stage $I_{SEF} \gg$	0.02 to 0.8 A
	Undervoltage blocking $U_{20} <$	0.5 to 15 V
	Correction angle	–15 to +15°
	Delay times t	0 to 60 s
	Reset delay t_r	0 to 60 s
Rotor earth-fault protection	Alarm stage $R_E <$	5 to 80 kΩ
	Trip stage $R_E \ll$	0.5 to 10 kΩ
	Delay times t	0 to 60 s
	Reset delay t_r	0 to 60 s
Earth-fault protection	Displacement voltage $U_0 >$	5 to 120 V AC
	Delay time t	0 to 60 s
	Reset delay t_r	0 to 60 s

Technical data (contin.)

Setting ranges		
Interturn short-circuit protection	Displacement voltage U_W >	0.3 to 16 V AC
	Delay time t	0 to 60 s
	Reset delay t_r	0 to 60 s
Overexcitation protection	Overexcitation $\frac{U/U_N}{f/f_N}$ >	1 to 1.5
	Delay time t	0 to 60 s
	Reset delay t_r	0 to 60 s
	U/f characteristic	
	Co-ordinates U/f	1.02 to 1.6
	Associated times	1 to 98 s
	Time factor	1 to 8
	U/f basis	0 to 1
	Alarm stage	70 % to 100 % of U/f characteristic
Overvoltage protection, undervoltage protection	Overvoltage $U>$, $U \gg$	50 to 140 V
	Delay time t	0 to 60 s
	Undervoltage characteristic	
	Co-ordinates $U <$	5 to 95 V
	Associated times	0.1 to 30 s
	Reset delay t_r	0 to 60 s
Overfrequency protection, underfrequency protection	Overfrequency $f >$	40 to 65 Hz
	Underfrequency f_1, f_2 <	40 to 65 Hz
	Number of repeat measurements $f <$, $f >$	5 to 100
	Time delay	1 repeat measurement ≙ 60 ms at 50 Hz
	Undervoltage blocking for $f <$, $f >$	40 to 100 V
	Underfrequency $f \ll$	35 to 65 Hz
	Delay time t ($f \ll$)	0 to 60 s
	Reset delay t_r ($f \ll$)	0 to 60 s
Pick-up tolerances	100 % stator earth-fault protection	
	$R <$, $R \ll$	5 % of set value or 2 Ω
	$I_{SEF} \gg$	3 % of set value or 3 mA
	Rotor earth-fault protection $R_E <$, $R_E \ll$	5 % of set value or 500 Ω
	Earth-fault protection $U_0 >$	3 % of set value
	Interturn short-circuit protection $U_W >$	3 % of set value or 0.1 V
	Overexcitation protection	
	U/f starting	5 % of set value
	U/f characteristic	5 % referred to U/f set value
	Overvoltage and undervoltage protection	3 % of set value or 1 V
	Frequency protection	
	$f >$, $f <$	10 mHz at $f > f_N$
	$f \ll$	100 mHz
	Delay times	1 % or 10 ms
On-load measurement	Indication of values	
	for voltages	U_{L1}, U_{L2}, U_{L3}, $U_{max\ LL}$, $U_{pos\ sequence}$, U_0, U_W, U_{SEF}
	for current	I_{SEF}
	for resistance	R_{SEF}, R_{REF}
	for frequency	f
	for overexcitation	$\frac{U/U_N}{f/f_N}$
	for calculated temperature during overexcitation	thermal replica
Fault recording	Instantaneous values	approx. every 1.67 ms at 50 Hz u_{L1}, u_{L2}, u_{L3}, u_0, u_{REF}, u_W, u_{SEF}, i_{SEF}
	rms values	approx. every 10 ms f, U_{LL}, U_0, $U_{pos\ sequence}$, U_W, U_{SEF}, I_{SEF}, R_{SEF}

Generator protection relay 7UM515

Technical data (contin.)

Contacts	Potential-free trip contacts	(3 × 2, 2 × 1) NO contacts (total of 5 TRIP relays)
	Switching capacity Make	1000 W/VA
	Break	30 W/VA
	Permissible current, continuous	5 A
	0.5 s	30 A
	Switching voltage	250 V DC
	Alarm contacts	total of 13 alarm relays (refer to Fig. 5)
	Switching capacity, Make/Break	20 W/VA
	Permissible current	1 A
	Switching voltage	250 V DC
Displays	LED displays on the front of the unit	16
Inputs	Optocoupler for operating voltage of 24 to 250 V DC	8 (incl. 2 for trip supervision)
	Current consumption independent of voltage range	approx. 2.5 mA
Construction of unit	For panel surface mounting	in casing 7XP20 40-1
	Weight approx.	11.5 kg
	For panel flush mounting, cubicle mounting	in casing 7XP20 40-2
	Weight approx.	10 kg
	Degree of protection acc. to DIN 40 050	IP 51

Selection and ordering data

Generator protection	Order No. **7UM515 0 - □ □ A00-0 □**
Rated auxiliary voltage	
24 V, 48 V DC	**2**
60 V, 110 V, 125 V DC,	**4**
220 V, 250 V DC	**5**
Construction	
For panel surface mounting	**B**
For panel flush mounting or cubicle mounting	**C**
Serial interface	
Isolated, hard-wired	**B**
Integrated fibre optic connection	**C**

Accessories

		Order No.
Stator earth-fault protection		
20 Hz generator	3 AC 100/110 V, W × H × D: (390 × 222 × 312) mm, Weight: approx. 15 kg	**7XT31 10-1**
Band-pass filter 20 Hz	W × H × D: (240 × 270 × 200) mm, Weight: approx. 23 kg	**7XT32 00-0**
Miniature C. T. 400/5 A refer to Cat. NS4 (ASI Group)	W × H × D: (58 × 100 × 70) mm, Weight: approx. 0.5 kg	**4NC1225-2CK20**
Voltage divider on inquiry (ASI Group)	W × H × D: (240 × 270 × 146) mm	**3PP1336-1CZ-V709152**
Rotor earth-fault protection		
Series coupling unit	(Impulse generator for panel surface mounting) 100/110 V AC, W × H × D: (298 × 220 × 253) mm, Weight approx. 2.5 kg	**7XT 7000-0B**
Coupling unit	in casing 3PP133; W × H × D: (240 × 270 × 146) mm	**7XR 6002**

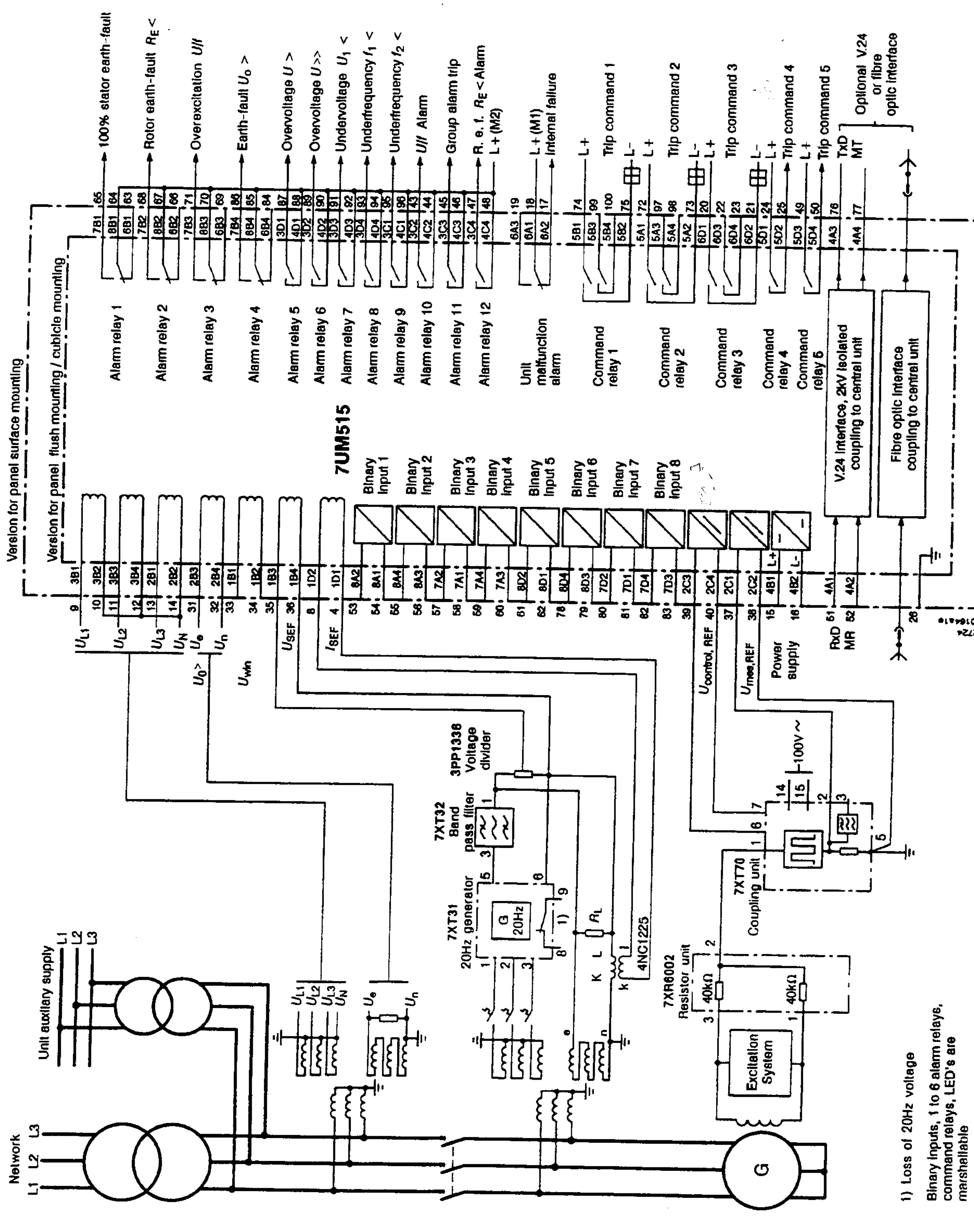

Fig. 5
Connection diagram, generator protection relay 7UM515

Dimension drawings in mm

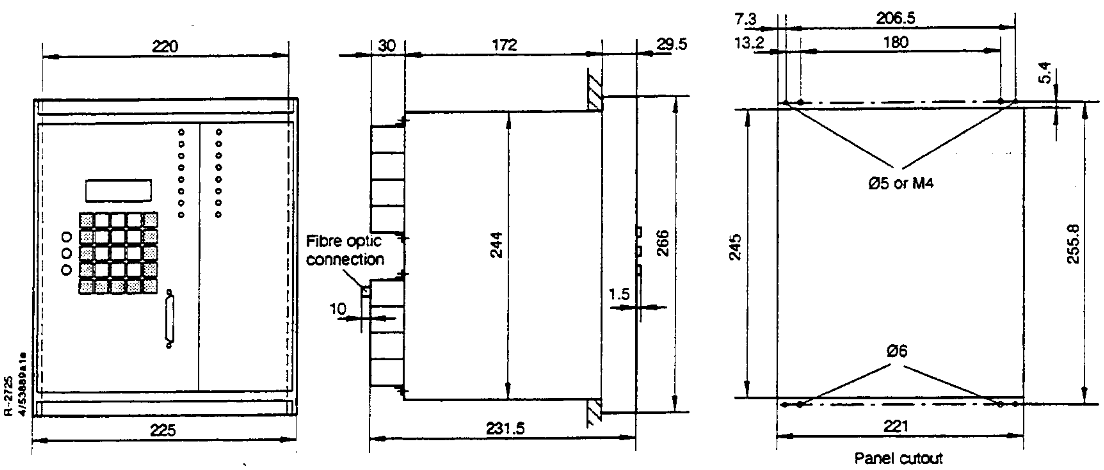

Fig. 6
Panel flush mounting, cubicle mounting

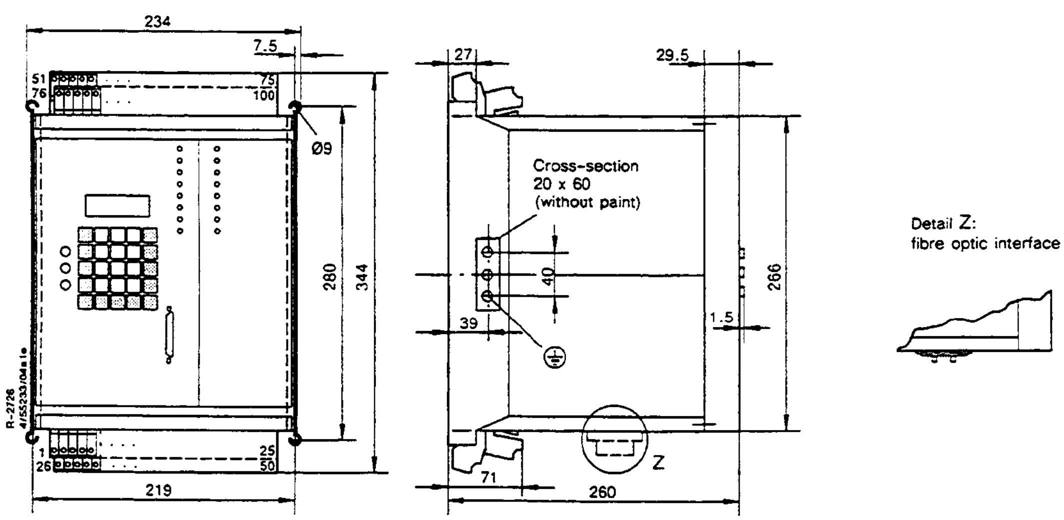

Fig. 7
Panel surface mounting

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Bereich Energieübertragung und -verteilung
Geschäftsgebiet Zähler-, Schutz- und Leittechnik
Postfach 48 06, D-8500 Nürnberg 1
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